RECOGNIZING AND DEFINING PRODUCTIVITY GAINS AS PART OF ELECTRICAL DSM INSTALLATIONS IN THE PAPER INDUSTRY

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For paper mills in the Pacific Northwest, competition for human and financial project resources is heated. Mill project engineers struggle every day to satisfy their mill's current operational needs. At the individual mill level, project engineering and support staff have been reduced across the region over the last 5 years[1]. Mill production levels are reported daily and reviewed by local and headquarters management. Mills in the same company producing similar products are constantly compared to one another. Reductions in public timber harvest levels and increased exports of raw wood and chips have caused a dramatic increase in raw material prices and forced a region wide focus on productivity and cost control. Implementation of the EPA cluster rule format for mill emissions is expected to receive priority for capital funding of retrofit for the rest of the decade.[2]

On a corporate level, the paper industry is most concerned with waste stream reductions, providing additional recycled fiber content, reducing free chlorine used in bleaching processes and increasing production levels[3]. Concern with energy is focused on finding advantage in the deregulation of the electric industry, co-generation and new uses for historically inexpensive gas. Conservation and Demand side management (DSM) programs have a difficult time competing in this environment.

The current cyclical recovery in paper market prices[4] has not resulted in increased availability of capital for retrofit projects. Increases are planned industry wide in spending for new machines and for environmental spending[5]. Competition for remaining dollars is decided based on rate of return for many companies, especially for projects costing more that \$50,000-\$100,000[6].

Production increases are viewed by management as the most rewarding activities. For example, when a 600 ton per day liner board mill adds 1% to its production, it has made an additional \$864,000 per year at today's liner board prices. Unscheduled paper machine outages of 7 hours monthly would reduce production by the same amount. At typical north west industrial rates of 2.5 cents/kwh[7], a DSM project would need to save about 34,500,000 kwh annually to avoid the same amount of energy charges. An industrial DSM project this size could cost 3-7 million dollars. Examples of new annual capacity in the paper industry are being built for an average of \$950 per annual ton[8 9]. A 1% production increase (6 tons per day) would cost 2.05 million dollars at this rate.

Documenting productivity benefits arising paper industry DSM project applications will require clearing several hurdles. First, typical on site analysis of benefits for prospective plant projects always demonstrate a clear focus that addresses an existing problem or issue. An example of this connection would be increasing chip truck dump capacity by adding a new conveyer. A new conveyor would allow 20 additional trucks to be dumped per day. In a mill where daily chip receiving is limited to Monday throughout Friday, this increase might mean an additional day of full production. This kind of direct connection is typical of current project engineer presentation to mill management. When a project engineer uses more complicated benefit explanations for a project, considerable extra uncertainty is introduced into the analysis. If DSM is one of the benefits, measurement of the DSM benefit potential is required. Given the difficulty of accurately assessing DSM potential by utility and program professionals[10] it is unlikely to be lightly accepted by industry management.

The presentation of DSM projects by program staff has varied considerably over time. For Bonneville programs early programs presentations emphasized that DSM projects presented no risk to the industry. No process changes were recommended[11] [12] only changes in electrical equipment such as motors or lighting. The lack of process orientation was emphasized as an advantage and the benefits to industry were described as more efficient production. This point of view omitted productivity increases for three reasons.

1. Current productivity information regarding DSM application specific basis did not exist and the DSM implementor and the industry was unwilling to spend the money to develop it. Industry does not typically fund projects or technical analysis that stop at identification of DSM or productivity benefits[13]. Without funding by the DSM implementor or the industry projects, with good chances of success are always replaced by projects that are guaranteed success. Plant staff get fired or demoted otherwise.

2. Any time a process change is proposed it contains considerable production risk. Production stoppages are very expensive.

3. Product quality information is considered confidential by mill management. Definition of the appropriate variables is difficult without the cooperation of the ill.[14]

Efforts to include productivity in DSM work will require reversing these positions.

CONSERVATION PROJECT AT THE INTERNATIONAL PAPER- GARDINER, OREGON MILL

International Paper (IP) is a large multinational wood products company with sales of over $15 Billion per year. The company operates one mill in the Pacific Northwest at Gardiner on the central Oregon Coast. The Gardiner mill began working to establish a long term conservation agreement with Bonneville Power Administration in 1989. An electric energy audit completed in late 1991 identified 13 energy conservation measures in the mill. The measures were initially estimated to cost $3 million and to save about 12.5 million Kwh. This savings amounts to approximately 3% of the mills annual consumption of electricity. Additional budget review reduced the estimated cost to about $2.25 million. Mill management was very interested in pursuing this group of projects and was also certain that the return on investment was inadequate to independently qualify for corporate budget allocations.

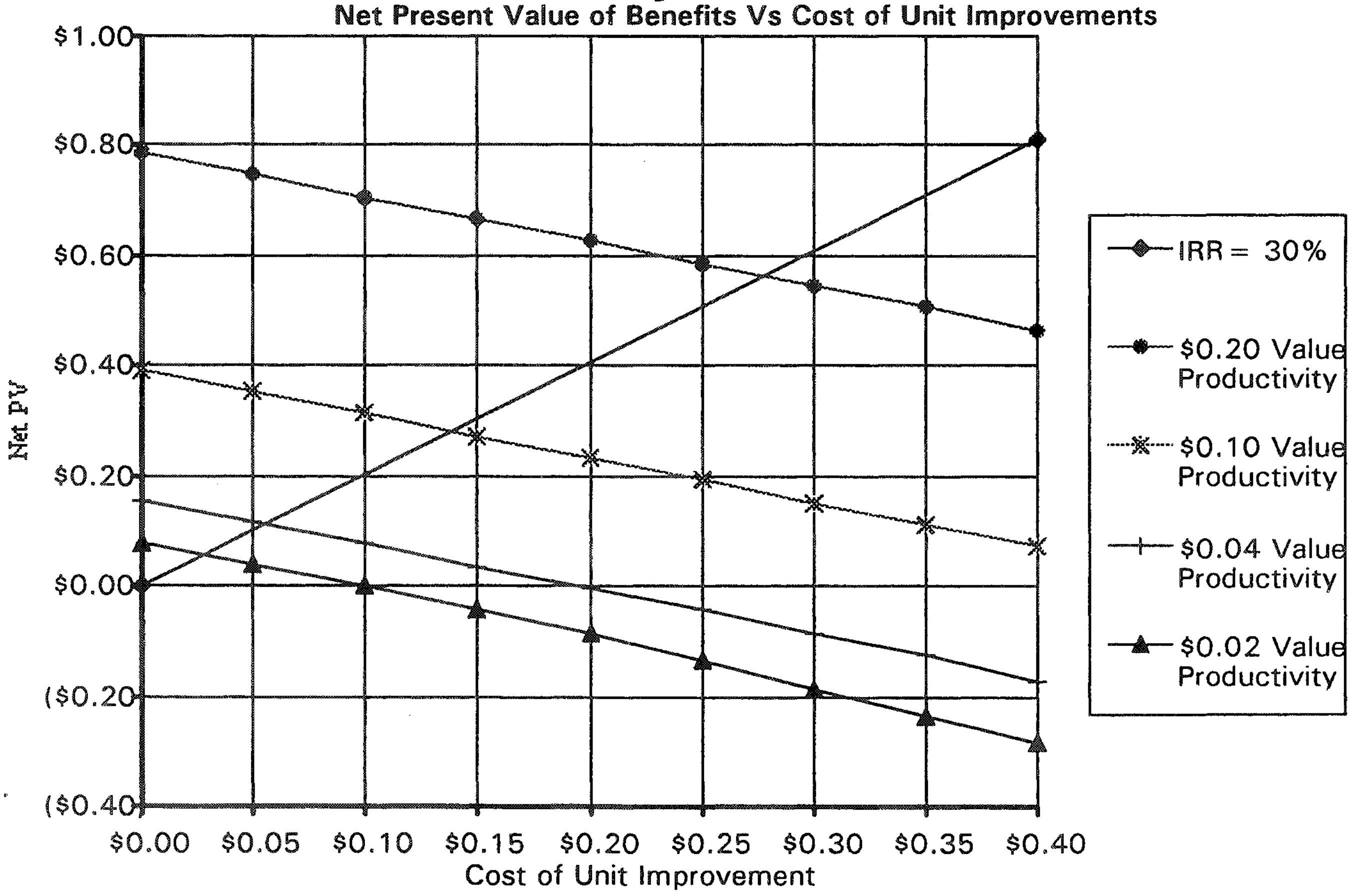
At the time, the existing Bonneville Power Administration industrial conservation program did not offer incentives high enough to make this project attractive to Gardiner mill management. However, projects of this size were needed to meet regional conservation acquisition targets. The Bonneville requirement to meet the acquisition target, while paying as little as possible, lead to an innovative and higher cost approach. Additional funding discussions regarding this project began by asking IP staff, "how much money would we have to offer to meet your internal rate of return targets"? These discussions were based on the assumption that completion could take 2-3 years and that Bonneville incentive payments would take place after equipment was in place. Since the time values of the project benefits were benchmarked to the date of capital allocation by IP, it was clear that the total nominal incentive payments would total at or near 100% of the project cost.

As part of earlier discussions, IP had provided information about the methodology they would use to answer the question. Corporate wide, IP uses a standardized Discounted Cash Flow (DCF) methodology to determine internal rate of return for capital projects. The DCF analysis required a thorough review of the cash impacts of a proposed capital project. The initial cooperate capital commitment was listed as the first item in the analysis. Productivity increases could also be included in the model.[15]

To support the Bonneville analysis of these projects, methods of determining internal rate of return for capital investments were investigated.[16] A spread sheet model was constructed similar to the DCF methods presented by IP. This resulted in a spreadsheet model that used much of the structure of a standard income statement projected over the capital life of the project. The basic income statement accounting equation of Revenue - Expenses = Net income (or loss)[17] was used for each year. The initial capital outlay was shown as an initial negative cash flow. The net after tax cash income for each year is then discounted to present value.[18] The internal rate of return is also calculated using the stream of nominal annual after tax cash flows. Detailed analysis of project evaluation criteria is provided in Chan and Park.[19] Appendix 1 provides additional discussion of the details of this model and the industry assumptions used to establish tax and expense levels.

Figure 1 summarizes the results of a typical set of assumptions used in this type model. All the values in Figure 1 are shown on an annual basis. The x axis shows the current cost of unit improvements. These improvements could include DSM projects or productivity enhancements. The cost of new paper machine capacity would be $0.47 on the x axes of figure 1 and the cost of conservation would range from $0.05 to $0.20. The y axis shows the net present value in current dollars for the proposal. This is the current value of the after tax income produced by the proposed project. The single line sloping upwards to the right represents a 30% IRR investment criterion. In order to qualify for project capital, a project is required to produce a net present value that places the project above 30% IRR. In Figure 1, a project costing $0.20 per "annual unit" saved or produced would need to generate $0.40 of net present value. Finally, the lines sloping down to the right represent the effects of 4 different productivity options. The $0.20 line (indicated by solid circles) represents the NPV for adding one pound (per year) of $400 per ton paper production. As the costs vary from $0.0 to $0.40 per pound, the NPV for each additional pound drops. Figure 1 shows that when the $0.20 project costs more than about $0.275 the project will have an IRR of less than 30%. The remaining three "value of productivity" lines can be used approximate the real value of electricity on a $/kwh per year [20]basis. Looking at the $0.04 line, it can be seen that conservation may not cost a company more than about $0.05 per Kwh, if the 30% IRR criteria is to be met.

Figure 1
Net Present Value of Benefits Vs Cost of Unit Improvements



Since the y-axis is scaled in dollars of current year net present value (NPV), the distance between the productivity lines and the 30% IRR lines indicated the dollar value required to make low productivity value projects attractive to industry.

In the case of DSM projects, industrial electricity prices clearly need to be very high to meet the 30% IRR criteria on their own. Benefits to the Gardiner mill included in the DCF calculation consisted of the proposed acquisition payments from Bonneville and the reduced electric bills to the mill. The potential for productivity gains was discussed at this time. It was generally between the IP project engineer and Bonneville staff that productivity gains were likely. In fact, end uses that limited mill productivity, were selected for investigation at the energy review stage. Unfortunately, lack of data collection and reporting equipment prevented quantification of these benefits. Energy consumption base lines were extremely difficult to determine in this industrial environment[21]. Systems to develop central reporting of Kwh were not in place at the time the capital allocation proposal was completed. Even if the energy data were available, it might not have been made available for the project application due to confidentiality concerns of plant management. The accuracy of the energy data was the major concern of plant management. They knew incentive payments from Bonneville were dependent on achieving the expected energy savings. Their response was to require extremely conservative energy modeling of the conservation measures under review. Bonneville staff agreed to these conservative estimates given the cost required to develop more accurate consumption data.

The number of different conservation measures to be installed added complexity to the determination of productivity benefits. Eleven separate applications were included in the final project. These applications affected major portions of the facility including the lime kiln, boiler and steam generation, pulp mill and paper mill. Since the measures affected successive processes, the problem of productivity analysis seemed larger than the determination of energy conservation potential. It was a problem to be returned to when and if possible. Despite the significant energy savings, the IRR for the package of 11 projects was insufficient to qualify for corporate financing on its own merits. Even with apparent 100% DSM incentive, IP calculated this project had an IRR of less than 25%.

This project was finally approved by Bonneville in early 1994 and by IP shortly afterward. Installation of all eleven measures started in September 1994 and is expected to be completed in July 1995.[22]

Analysis of the primary stock pump

The measure with the largest single conservation potential at the IP mill was the adjustable speed drive (ASD) application on the primary stock pump. The primary stock pump is arguably the heart of the paper mill. Typical stock pump operating flows range from 40,000-80,000 GPM. A combination of 36-inch and 12-inch stainless steel control valves was being used to obtain this flow range. The pump has an impeller diameter of about 35 inches and is driven by a 1500 hp synchronous electric motor. The retrofit measure included the electrical equipment required to replace the existing starter cabinet with an adjustable speed drive. Significant changes to the large stainless steel piping were included in the project. Integration costs for connecting the new equipment to the mill control system were also included. Energy savings were estimated to be 2,772,000 Kwh per year and the cost of this measure was initially about $350,000. In terms of Figure 1, the primary stock pump had an estimated cost of unit improvement of $0.1263. Electricity costs at the mill were between $0.02 and $0.04. Reading Figure 1 at this intersection it is seen that the NPV for the primary stock pump is between -$0.01 and $0.09. The required NPV for a 30% IRR is $0.21 at this cost.[23]

What productivity increase would be required to meet the 30% IRR?

This is conveniently done with a spread sheet version of an income statement model. Entering the DSM project cost and the appropriate electricity rate along with the value of productivity allows the use of a goal seek function to determine the unit productivity increase quickly. The productivity increase result for the primary stock pump project is 0.32.

The same result can be shown graphically using Figure 1. Using the $0.02 value of productivity line in Figure 1 where it intersects the $0.12 cost of unit improvement line at approximately -$0.01 NPV (approximately -3% IRR) to approximate the primary stock pump. The difference between the project NPV and the 30% IRR NPV is then $0.22. This is the amount of NPV that must be made up by productivity improvements to meet the 30% IRR criteria. This occurs at the same total project cost of $0.12.

For the cash flow assumptions inherent in Figure 1, we can use the value of productivity lines to determine the extra production required to make up the $0.22 difference. Looking at the $0.20 value of productivity line, we see at the $0.12 cost line a NPV of about $0.69. This is the NPV of a 20 year stream of productivity changes that raised additional revenue of $0.20 each year. We need an additional $0.22. Dividing $0.22 by $0.69 gives 0.3188. This indicates that an additional production of about 0.32 units per year at a unit price of $0.20 would be sufficient to yield a 30% IRR for this project. This ratio provides approximately the same result as the spread sheet calculation. To convert this result to a tons per year value, the 0.32 units per year value is interpreted to mean that for each unit of DSM (Kwh saved by the primary stock pump in this example) 0.32 unit of additional productivity is required to meet the 30% IRR criteria. For this example, productivity is measured in pounds of paper on an annual basis. Since the primary stock pump was projected to save 2,772,000 Kwh per year the productivity increase required is 2,772,000 times 0.32 or 887,040 pounds of additional paper production per year. This translates to 4,435 tons per year or 12.6 tons per day[24]. For the 600 tons per day mill discussed earlier, this requires a 2% productivity increase.

How did the primary stock pump ASD actually perform?

The energy savings summary in Appendix 2 shows the primary stock pump actually producing 5,719,960 kwh saved per year. The actual cost of the measure was approximately $750,000. This results in an actual unit cost of $0.131. From Figure 1, and keeping in mind the previous analysis of the stock pump we can observe a NPV of about negative $0.015 ($0.03).[25] We have a gap between the DSM net value and the 30% IRR target net value of about $0.23 The NPV of the $0.20 productivity line at the actual cost is about $0.68. The productivity change required. is given by $0.23 divided by $0.68 or 0.3382 (0.3364). Comparison with the spreadsheet numbers in parenthesis show good agreement even with the errors involved with reading Figure 1.

Multiplying the actual savings of 5,719,960 by 0.3382 gives the productivity increase required or 1,934,692 pounds per year. This translates to 2.7 tons per day of additional production required at the Gardiner mill based on process improvements provided by the primary stock pump ASD. This would require a 0.03% improvement in productivity at Gardiner.

Did the project productivity gains actually observed result in an additional 2.7 tons per day of production?

The Gardiner mill provided some representative information that allowed some analysis of the down time in the paper mill due to paper machine stoppages. These stoppages are recorded as flat line's intervals on a strip chart. The chart is recording basis weight and percentage moisture content of the paper sheet. Strip charts are available for twelve hours of operation before the ASD retrofit and ten hours after the ASD installation. Given the scale of the strip charts, a machine stoppage must be at least three to five minutes long to show up on the trace. These traces were interpreted to indicate a noticeable reduction in machine stoppages shown in the after retrofit data. Five stoppages were identified in the before data, totaling approximately 20-30 minutes over a twelve hour period. Two stoppages were identified in the after data totaling approximately ten minutes over a ten hour period.

Assuming the primary stock pump was the cause[26], the improvements shown on the strip chart would result in an additional 36 minutes of machine operation per day. This additional operating could result in as much as an additional 22.5 tons per day of paper produced. This is equivalent to 2.5 % productivity increase for the Gardiner mill. Given the initial criteria, it seems the stock pump ASD easily exceeded the criteria of 2.7 tons per day required to bring the project up to a 30% IRR.

On per annual unit basis, the productivity increase was 2.76. From the spread sheet, IRR = 247% for the stock pump measure including productivity and DSM benefits!!!.

This example shows the tremendous leverage available for DSM projects when productivity is included. Of course, the data used to demonstrate this benefit is only sufficient to illustrate the point. This analysis works best when long term data on operating hours is available and in electronic form. On the other hand, the Gardiner mill has been setting production records ever since the stock pump ASD was installed in January 1994. The mill now exceeds its daily and monthly production target on a regular basis. Unfortunately, the mill is unable to release the details of this increase. The paper machine operators also comment on the improvements in the paper machine since the ASD was installed. The operators like the ability to set a control knob and get a stable flow through the primary stock pump. Before the installation of the ASD considerable operating time was spent stabilizing stock flow while the paper machine was brought up to production speed. This reduction in time spent hunting for the proper control point was not included above.

It seems clear that inclusion of productivity gains in the initial presentation of the stock pump ASD evaluation would have had a positive impact on financing the project. To sell the concept to mill and corporate management would have required documenting down times for the paper machine prior to the ASD installation. If the paper machine was shown to be down for one or two hours per day due to sheet breaks or bad flow control, a reduction of 36 minutes could be made attractive. This example demonstrates one use of the analysis method presented here. Using the unit productivity value in the determination of IRR and NPV allows what if situations evaluated. Questions like, "how long does a production line have to be down each day to present the opportunity for productivity improvements" can be answered. Then mill management can be presented with direct questions about down time and given information about the possible benefits. Relating to mill and production people on issues like down time provides an avenue to deal with their concrete, day-to-day problems. In my experience, providing solutions to those problems is critical to building long term commitments with industries.

How do safety and environmental benefits fit into this method of analysis?

Safety is usually tracked as the number of lost time accidents occurring in a mill over time. Determining the amount of lost time avoided by installation of DSM measures would require a significant additional data collection task. Some times operational considerations can contribute to an insight regarding safety. For example, reduced paper machine down time is apparently a result of the installation of the primary stock pump ASD at Gardiner. The most common cause of the paper machine stopping is breakage of the sheet. Sheet breakage causes a mess called a "hayout." Operators are required to dig out the heap of paper under and around the machine in order to clear the rotating machinery. Digging out the machine requires workers to enter areas that are hot and leaves them exposed to confined, dangerous areas of the mill. An initial discussion of safety benefits would try to discover how injuries related to "hayouts" might be tracked. Mill time keeping records may even document the number of hours spent digging out the paper machine. If the injury logs are available, a unit cost of injury might be developed to include in an income statement model. At the least, credit for lowering the hours spent digging out the paper machine might be achieved. When calculated on their own net present value of safety benefits should also be discounted at less than 15% and hurdle IRR values should be less than 30%. The income statement model presented here does not accommodate different discount and hurdle IRR rates, so combinations of safety and productivity benefits should be discounted at 15% and IRR hurdles set at 30%. This is based on the idea that the discount rate and IRR should be set to the standard for the highest return benefit.

Environmental benefits, from industries point of view, amount to avoiding production disruptions and penalties. Projects are funded because of a policy commitment by management. Some current trends in the paper industry may assist analysis of these benefits. Reductions in water intake and effluent outflows are becoming important. The paper industry has discovered that reducing these flows makes environmental compliance easier. Since this effort is related to flow reduction, it also opens the door for determination of the energy reductions accomplished at the same time. The energy savings involved in reducing intake and outflow pumping and fan work is considerable. These projects could also benefit from the lower discount and IRR hurdles that should be applied to environmental projects.

Appendix 1

Income statement model description
An income statement spreadsheet calculates before tax revenue, depreciation expense taxes and net income. The model discussed in this paper includes a starting negative cash flow representing the commitment of capital dollars to a specific project. It is assigned time zero. All other cash flows are made relative to this time. The model discussed here assumes that the first savings occur in the second year and that they continue for 20 years. This cash flow series was selected to represent the typical sequence of events involved in a medium size capital project in a paper mill. Bigger projects should include a longer period between the initial commitment and the initial benefit.

An accelerated straight line depreciation over 10 years is assumed in this paper. However, many other possibilities exist depending on the financial circumstances the investing company. The project is expected to last for 20 years and begins producing income during the second year. Depreciation begins in the first year, and lasts 9 and 1/2 additional years. This allows the benefits of 1/2 year depreciation to be taken in the first year.

Additional assumptions for avoided electrical costs, operation and maintenance charges, insurance, property taxes are estimated for the life of the project. Useful life of capital projects varies between companies and is generally set at the depreciable life. Note that individual companies may have several classes of capital. Investment models can be constructed to select the optimum depreciation schedule for property based on expected company performance.

Cash flows for the annual expenses and charges are summed up and an annual before tax cash flow is calculated. A 39% state and federal income tax charge is applied to the annual cash flow minus the depreciation expense to determine the annual tax expense. The modeling used here assumes that all income and expenses occur at the margin for the company and that the company expects to be profitable and pay income taxes. Of course this is not always true and company investment models probably take these issues into account.[27] The net nominal annual cash values determined in this way are then used as input to a spread sheet to determine the IRR. IRR numbers generated from this model are representative of the numbers provided by the company. Many assumptions may differ, including depreciation that change the final IRR number. Standard assumptions of 3% of capital costs, annual and O and M charges, 5%; property tax, 4% inflation; and a 15% corporate discount rate are used throughout this paper.

The approximation methods presented in this paper are useful for quick evaluations of projects only. It is always better to develop a complete income statement model and use numbers from that model for investment work. For example, the values of productivity lines in figure 1 are assumed to be straight and parallel. They are not straight or parallel for the example presented here.

Figure 2

INTERNATIONAL PAPER COMPANY, Gardiner, Oregon

Preliminary Verification Review April 3, 1995 / K. Ball & J. Saez

ECM No.	Description	Baseline Usage (kW)	Projected Usage (kW)	Actual Usage (kW)	Baseline Energy Usage (kWh/yr.)	"Verified" Energy Usage (kWh/yr.)	"Verified" Energy Savings (kWh/yr.)	Projected Energy Savings (kWh/yr.)	Projected Operating Time (hours/yr.)
1	Liquor Make-Up Pump	269	186	NR	2,260,000	NR	NR	700,000	8,415
3	Reject Refiner	316	119	47	2,710,000	403,777	2,306,223	1,690,000	8,591
6	Dilution Transfer Pump	66	0	0	568,000	0	568,000	568,000	8,591
8	Filtrate to Diffuser Pump	134	122	NR	1,150,000	NR	NR	101,000	8,591
10	High Density Dilution Pump	106	10	28	909,000	240,548	668,452	824,000	8,591
11	Primary Stock Pump	134	94	82	1,148,000	704,462	443,538	345,000	8,591
13	Primary Fan Pump	1,106	783	440	9,500,000	3,780,040	5,719,960	2,772,000	8,591
14	Stock to Refiners Pump	142	95	121	1,219,000	1,039,511	-179,489	401,000	8,591
15	Filtered White Water Pump	77	14	4	657,000	34,364	622,636	538,000	8,591
17	#3 Rec. Boiler Sec. Air Fan	138	60	161	1,187,000	1,383,151	-196,151	675,000	8,591
18	#1 Rec. Boiler Sec. Air Fan	90	49	46	770,000	395,186	374,814	350,000	8,591
19	Lime Kiln ID Fan	256	195	305	2,201,000	2,620,255	-419,255	528,000	8,591
					24,279,000	**10,601,294**	**10,267,706**	**9,492,000**	

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[2] "No End in Sight" Joan Laatz, The Oregonian, Portland, Oregon, Page B16, November 2, 1993.

[3] "Officials say Mill Modernization May Keep Longview Off Ghost List"; Jim Kadera, The Oregonian, Portland Oregon, page D12, April 14, 1993.

[4] "Paper Industry begins 1995 on a Roll"; Christopher J. Chipello, The Wall Street Journal Western Edition, Page B6, January 9, 1995.

[5] "Issue focus: Capital Spending Plans: 1993-5"; Carl Espe, Pulp and Paper, January 1994, Pages 59-64. This article discusses the decrease in environmental spending in 1993. See also[3] for discussion of the reductions in some facilities going on at the same time new capacity is added at others.

[6] Projects as small as $1,000,000 may require CEO approval, even in very large companies. When total capital budgets are over $100 million this could require significant, expensive, executive time.

[7] Rates paid by industrial facilities in the Pacific Northwest range from 2.5 cents/Kwh to 4 cents/Kwh depending on the providing utility. Most industries expect to see rate reductions in the near future as retail wheeling is implemented.

[8] "Issue focus: Capital Spending Plans: 1993-5"; Carl Espe, Pulp and Paper, January 1994, Pages 59-64. These prices reflect installation of new and rebuilt paper machines.

[9] "News Scan: Willamette starting up Campti machine"; Pulp and Paper, March 1995, Page 19.

[10] See "An Overall Assessment of the Energy $avings Plan Program Completed to date (1989-1992)", G.E. Spanner, D. Brown, Pacific Northwest Laboratory; PNL-8446. UC-310 (5/93) for a discussion of the impact of industrial conservation projects. Additional project specific evaluations are available form Bonneville Power Administration Portland, Oregon.

[11] Indeed, DSM project personnel often do not have process specific knowledge

[12] The issue of if and when to pay for analysis of DSM potential through energy reviews was discussed at length during the development of Bonneville industrial DSM programs. It was decided to limit potential audit costs to a on time $0.0005/per kwh of annual consumption

[13] Such projects do not have measurable benefits and as such, have an unacceptable IRR. This is a significant roadblock for DSM projects requiring capital expenditures. Capital project budgets set firm limits to project spending. Exceeding those limits can limit career advancements.

[14] At one site the author has seen a daily mill newsletter that summarizes key productivity and quality data. Requests to review or cite the newsletter have been declined. Mill photographs are likewise carefully reviewed. Mill and corporate approvals may be needed depending on the type of information being requested.

[15] With this information, negotiation centered on how to structure a contract that would meet the corporate IRR minimum of 30% at least cost to Bonneville. This amount turned out to be roughly twice the standard program acquisition payment or about 20-21 levelized mills/kwh (1990 $'s)

[16] Engineering Economics; Ollie Smidt, Telephony Publishing Corp. 53 West Jackson Blvd. Chicago, Ill 60604, chapter 10.

[17]Advanced Engineering Economics; Chan S. Park and Gunter P. Sharp-Bette, John Wiley, 1990 Page 15.

[18]15% is a standard industry value for a discount rate used in this way.

[19]Advanced Engineering Economics; Chan S. Park and Gunter P. Sharp-Bette, John Wiley, 1990, page's 201-237.

[20]The Kwh per year unit is 1/8760000 fraction of 1 average megawatt

[21]Complete metered end use date for large motors operating at 2300 volts and above presents large difficulties. Single phase on-line current measurements of these loads are possible through the low voltage current transformers driving the starter cabinet panel meter. Most cabinets only have one phase tapped in this way. Adding a transformer would require shutting down that cabinet and motor, unhooking a cable and adding a second step down transformer. These connections, if routed through the panel door could provide current information to a power recorder. Usually these small transformers are not of instrument quality. This still leaves the issue of obtaining full buss voltage for the recorder. Connecting to medium voltage switch while "hot" is difficult to accomplish within safety regulations.

[22]A summary of the total energy savings for the Project is shown in Appendix Two. The summary was prepared by Kevin Ball, Braco Energy Services, Portland, Oregon and Jose Saez, International Paper Company. The total capital cost of the project was $2,020,000.

[23]Using figure 1 on the same basis for the total project would produce a cost of unit improvement of $0.21 and a required NPV of about $0.40 for a 30% IRR. To be funded by IP, an electricity price of more than $0.10 per Kwh would be required.

[24] Using an operating year of 352 days per year and 2000 lb. Per ton.

[25] Numbers in parenthesis following each value are taken from spread sheet model and are presented for comparison.

[26] Discussions with plant control experts pointed out the strip chart data, best reflected the improvements in flow and sheet consistency delivered by the primary stock pump ASD. It is impossible to rule out contributions of other DSM measures installed as part of this project.

[27] The 1993 National Energy Policy act exempted part of utility payments to industry from federal income taxes