Economic Comparison of Power Generation Alternatives for Thorne Bay, Alaska

Final Report

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Alaska Department of Community and Regional Affairs
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Contents

1. Introduction

This study is an economic screening analysis of power generation alternatives for the city of Thorne Bay, a community of about 650 people located on Prince of Wales Island in Southeast Alaska. The City currently operates a municipal utility providing electric service to 190 residential and 40 commercial and small industrial customers. City power is currently generated by three diesel units with a total installed capacity of [600 + 650 + 325] = 1,575 kilowatts (kW).

Three non-diesel alternatives for baseload power are considered in this analysis. The first is an intertie from the Craig-Klawock power grid to Thorne Bay, which would allow Thorne Bay to receive power from the Black Bear Lake hydroelectric project now under construction by Alaska Power and Telephone (AP&T), a regulated investor-owned utility. The second alternative is a wood-waste fired power plant located in Thorne Bay, making use of the wood waste from the Ketchikan Pulp Company (KPC) sort yard. The third alternative is a biomass power plant, also loctaed in Thorne Bay, but fired primarily from municipal solid waste generated on Prince of Wales Island. This plant would also use wood waste, but as a supplemental fuel.

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2. Load Forecast and Economic Assumptions

As a screening study, this analysis makes many simplifying assumptions. The objective of the analysis is to describe those conditions (if any) under which each alternative looks most attractive. The following variables are considered to be critical assumptions for the analysis:

- Future electric loads in Thorne Bay
- The future price of utility diesel fuel
- The net cost of wood waste fuel (handling cost less avoided disposal cost)
- Volume and net cost of Municipal Solid Waste (MSW) burned

Electric load growth and diesel price growth are dealt with using scenario analysis. Three different load growth assumptions and two sets of diesel price projections are combined to form 5 different scenarios. (The low diesel price/high load case is not considered). Each generation alternative is evaluated under each scenario and compared to other generation alternatives under that scenario.

The uncertainties surrounding the net cost of wood fuel and the potential volume and net cost of Municipal Solid Waste (MSW) burned are considered using sensitivity cases and break-even analysis. A sensitivity case is also used to explore the economics of extending an intertie from Thorne Bay to Kasaan.

Electric Load Forecast

Electric energy requirements are measured net of station service but prior to local distribution line losses. Initial peak load is calculated from initial energy using the City's average system load factor of .60 (from 1992 and 1993) . Initial energy requirements assumed for 1994 are shown in Table 1. Imminent new loads are based on discussions with the Thorne Bay City Manager.

The initial loads vary among scenarios to reflect the uncertainty associated with some of the imminent loads. The sewage plant and KPC loads are included in all three cases since they are currently connected to the Thorne Bay electric system. The 50 residential houses and light industry in South Thorne Bay and the State subdivision are included in the high case only since they are not currently connected to the local power grid. The mid case initial load is simply the average of the low and high initial loads.

The three sets of load growth assumptions for the years 1995-2014 are:

Low:	Annual Energy growth = 0.5%,	Peak growth = 0.5%
Mid:	Annual Energy growth = 1.5%,	Peak growth = 1.0%
High:	Annual Energy growth = 3.0%,	Peak growth = 2.0%

Table 1
Initial Load Assessment

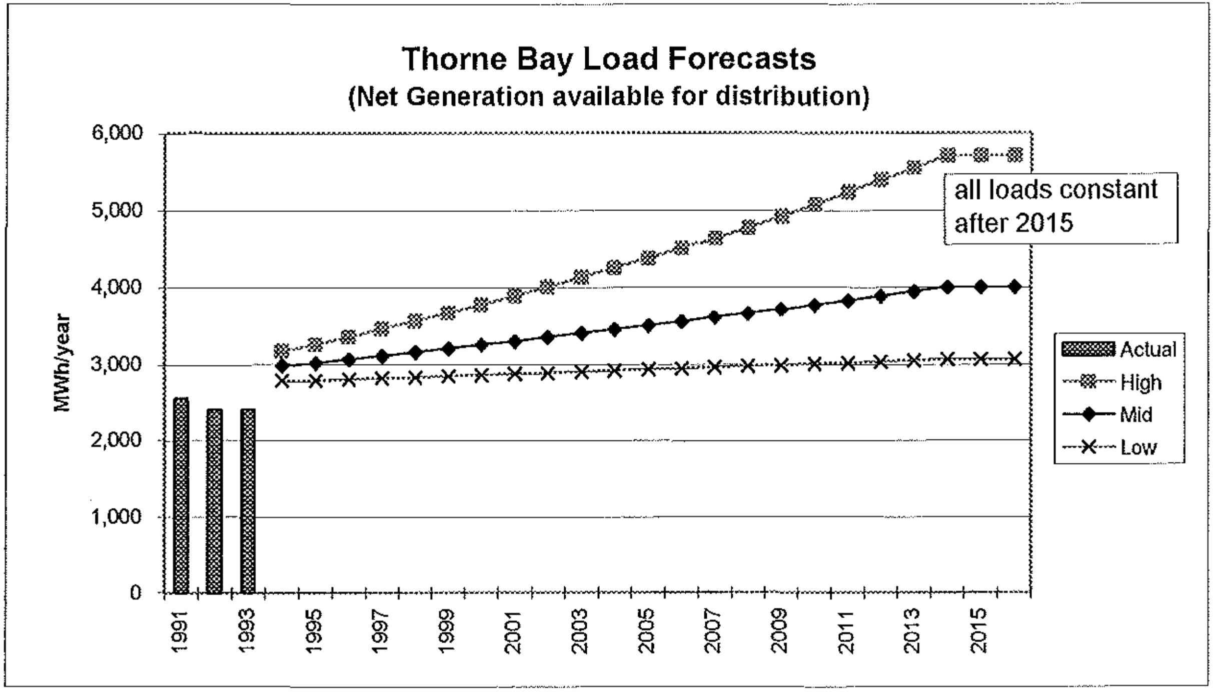
Current Load (1994)	MWh/year
1993 Diesel Gross Generation	2,554
Adjust for Diesel Station Use	(102)
Busbar Energy Requirements	2,452
Adjust to 1994 (1 % growth)	**2,476**

	MWh/year		
Potentially Imminent New Loads	Low	Mid	High
50 Residential @ 5000 kWh/house	0	125	250
1 New Sewage Plant	120	120	120
1 KPC returns to system	150	150	150
1 state subdivision light industry	0	50	100
Subtotals =	270	445	620
line loss 10%	27	45	62
Net Amount Req'd for Distribution System	**297**	**490**	**682**
Total Energy Requirements	2,773	2,966	3,158
Rounded Total Energy Requirements	**2,770**	**2,970**	**3,160**

These three load forecasts bracket a range from essentially flat load growth in the low case to a near-doubling of the load over 20 years in the high case. All loads are held constant beginning in 2015, consistent with Division of Energy policy not to project uncertain growth beyond 20 years.

In the mid and high cases the peak load grows more slowly than the energy requirements, reflecting a presumed increase in the diversity of the load. Our investigations of alternative power plant sizes suggest that for this analysis peak load is not very important in determining system economics, since diesel backup is always maintained and is assumed to be readily available for peaking power.

Figure 1:



Future Price of Diesel Fuel

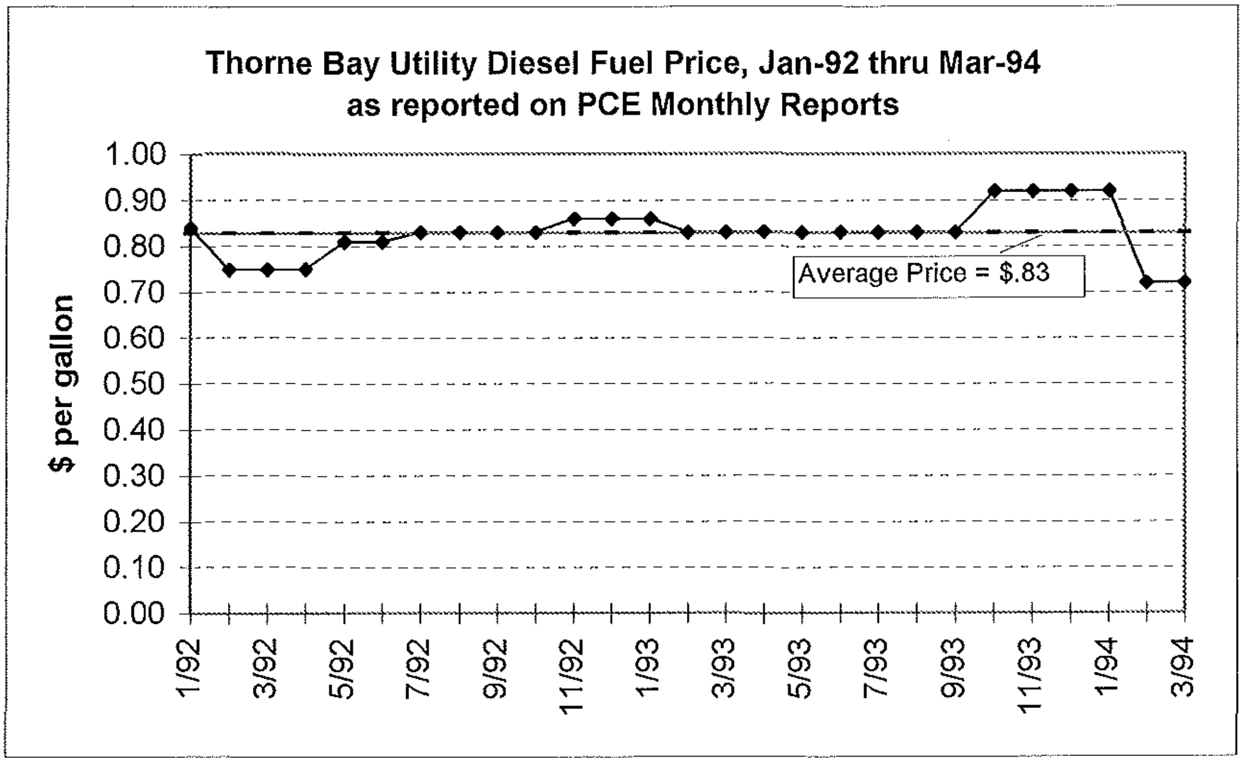
The price of diesel in Thorne Bay has ranged between $.72 and $.92 per gallon during the past two years, as shown in Figure 2. Unfortunately, the two most recent prices include the high and low ends of this range. We have adopted the average price of $.83 per gallon as the initial diesel price.

Two alternative projections of diesel fuel price growth are used. They are taken from the recently completed Sutton-Glenallen Intertie Feasibility Study by R.W. Beck (1994).

Low diesel price increase	0.44% per year (in "real" terms, above inflation)
High diesel price increase	1.73% per year (in real terms)

In our judgment, the low rate of price increase is on the high side of what we consider most likely, given the long-run historical path of crude oil prices. Other, lower price projections would be defensible. We therefore consider the low diesel price projections to be conceptually valid as "mid" range assumptions. To avoid further confusion, however, we will simply use the terms low and high.

Figure 2:



Net Costs of Wood Waste and Municipal Solid Waste

The base case net cost of wood waste is zero. The base case net cost of MSW disposed of by burning in a biomass power plant is -$60 per ton. (In other words, the net tipping fee for MSW disposal is +$60/ton). This figure is consistent with recent disposal costs at nearby permitted landfills, less a deduction of $40/ton for transport costs from other parts of the island to Thorne Bay.[1] Other net costs for wood waste and MSW are considered in the break-even analysis section.

Discount Rate

The analysis is conducted in real 1994 dollars, ignoring inflation. The assumed real discount rate is 4.5%. This is consistent with a "nominal" market interest rate of about 8% and an inflation rate of about 3.5%.

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[1] Richard Smith, Sitka consulting engineer, personal communication, 7/25/94.

3. Generation Alternatives and Dispatch Method

Existing Diesel Units

Installed Capacity:	1,575 kW
Average Fuel Efficiency:	13.4 kWh/gallon
Fixed O&M:	$3.24/kW
Variable O&M:	3.3 cents/kWh
Lifetime:	60,000 hours (approx.)

We assigned the actual Thorne Bay O&M expenses reported in September 1993 to the categories of "fixed" and "variable" O&M as shown in Table 2. Items classified as "fixed" should vary with installed capacity. Items classified as "variable" should vary with energy output. Items classified as General and Administrative (G&A) should not vary when comparing generation alternatives and should be ignored in economic comparisons, although they do count in determining rates.

The major cost component assigned to fixed O&M is insurance for the diesel units priced at 0.4% of installed cost, or about $1.80 per kW. Property taxes are a major part of fixed O&M for private utilities, but are not relevant here since the diesel utility plant is owned by the City.

The key question in diesel cost allocation is how to allocate labor costs. Although power plant labor is typically fixed during any given year, we feel it would be incorrect to assume that labor requirements for diesel operations vary with installed capacity, without regard for how much the diesels are actually operated. This is particularly important for the intertie and biomass alternatives where diesel is used for backup much of the time. It seems reasonable to assume that biomass plant operators could run diesel units for peaking and backup purposes. In the intertie cases, however, diesel must be used for a significant, but varying, portion of energy requirements after about 10 years.

The allocation of labor shown in Table 2 attempts to strike a balance between all of these reasonable assumptions. Zero labor is allocated to fixed O&M, so that non-diesel alternatives are not penalized when diesel serves mostly as backup. One third of current labor expense is allocated to G&A and ignored, reflecting the fact that a significant amount of labor is not directly related to power generation. The other two thirds of labor -- roughly comparable to one full-time position -- is allocated to variable O&M to reflect the fact that when diesels are used for significant energy production -- as opposed to backup -- they require more labor.

Table 2:
Assignment of Diesel O&M Costs to Fixed and Variable Categories

		Allocation of Reported Expense:				
	Reported	Fixed O&M		Variable O&M		
Expense Item	Expense	total $	$/kW	total $	$/kWh	G&A
Personnel	$90,683	$0	$0.00	$60,455	$0.024	$30,228
Parts & Supplies	$9,528	$1,000	$0.72	$7,528	$0.003	$1,000
Repairs & Maint.	$18,562	$1,000	$0.72	$16,562	$0.006	$1,000
General & Admin.	$17,966	$2,493	$1.80		$0.000	$15,473
Total O&M	$136,739	$4,493	$3.24	$84,545	$0.033	$47,701

▨ denotes a direct allocation

New Diesel Units

Unit Size: 600 kW
Fuel Efficiency: 14 kWh/gallon (kWh are net of station use)
Capital Cost: $450/kW (includes $125/kW for emissions equipment)
Fixed O&M: $3.24/kW
Variable O&M: 2.5 cents/kWh
Emissions O&M 1.5 cents/kWh, beginning in 1996
Lifetime: 60,000 hours

New diesel units are assumed to be easier to operate and maintain than existing units. Power planning studies typically assume that variable O&M for new diesels is about 1.0 cents/kWh. This amount does not include labor. Since we are including some labor in our variable O&M figure, as discussed above, the new diesel variable O&M is increased to 2.5 cents/kWh.

New diesel units are added to maintain sufficient reserve capacity to meet peak load with the largest unit out of service. We assume the largest diesel unit will continue to be a 600 kW unit. Diesels are retired after 10 years of primary operation in the all-diesel cases. This figure is based on roughly 6,000 hours of operation per unit per year and a 60,000 hour lifetime. The 325 kW generator remains in service as a standby unit throughout the analysis. In the intertie cases, diesels remain in service for twenty years, which is the time it takes to produce as much cumulative energy as in the all-diesel cases. In the MSW and wood plant cases, existing capacity lasts throughout the planning period. See Appendix A for a more detailed discussion of air emissions issues.

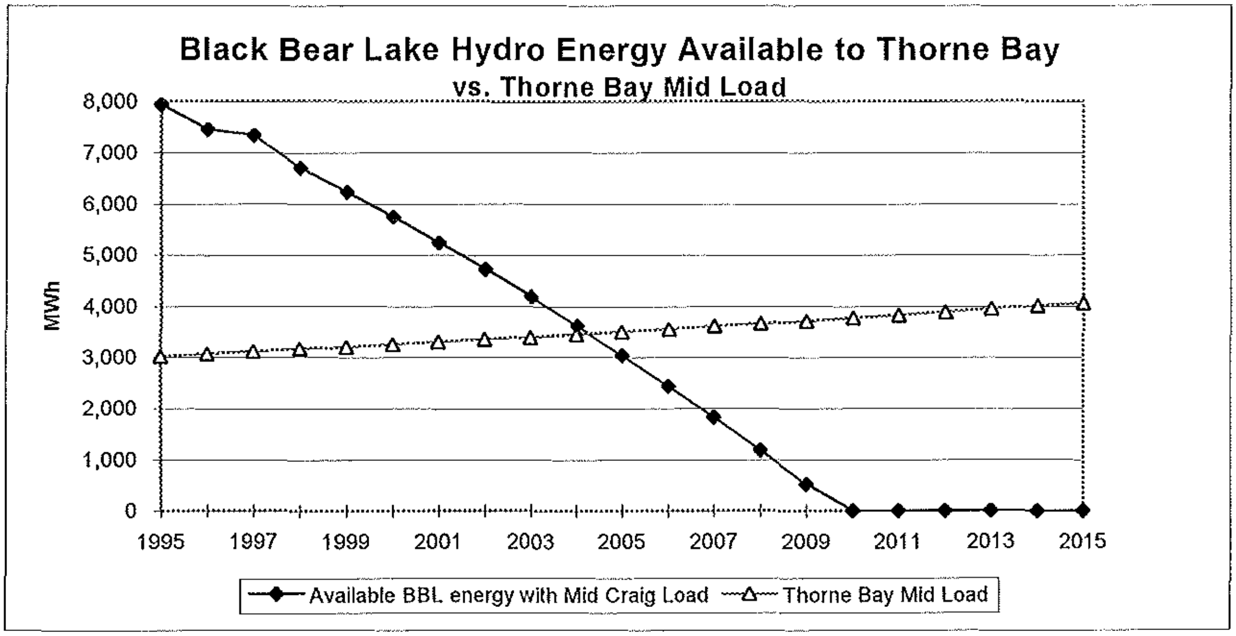
Intertie to Black Bear Lake Hydro

Length: Klawock to Thorne Bay: 21.5 miles
Thorne Bay to Kasaan: 16 miles
Capital Cost: $78,561 per mile
Fixed O&M: $1,178 per mile (=1.5% of capital cost)
Availability: 97% (availability of intertie)

Intertie capital cost is based on estimates from AP&T, adjusted slightly upward to reflect several items, such as contingencies, which we feel should be included in the cost estimate. See Appendix A for a detailed cost breakdown.

Available hydro energy is simply the amount of “surplus hydro” energy shown in the mid case scenario developed by R.W. Beck (1992). This is shown in Figure 3. It is equal to total Black Bear energy *less* unavailability of hydro plant *less* transmission losses *less* energy taken by the Craig-Klawock grid. For simplicity, only this one scenario for available hydro energy is used. The actual amount will vary with water conditions and with loads in Craig and Klawock. We made no explicit check for adequacy of hydro capacity. Hydro energy is assumed to be non-firm, so that diesel installed capacity requirements are unchanged. However, since diesel units are not operated as often, their lifetimes are greatly lengthened and diesel capital costs are thereby reduced.

Figure 3:



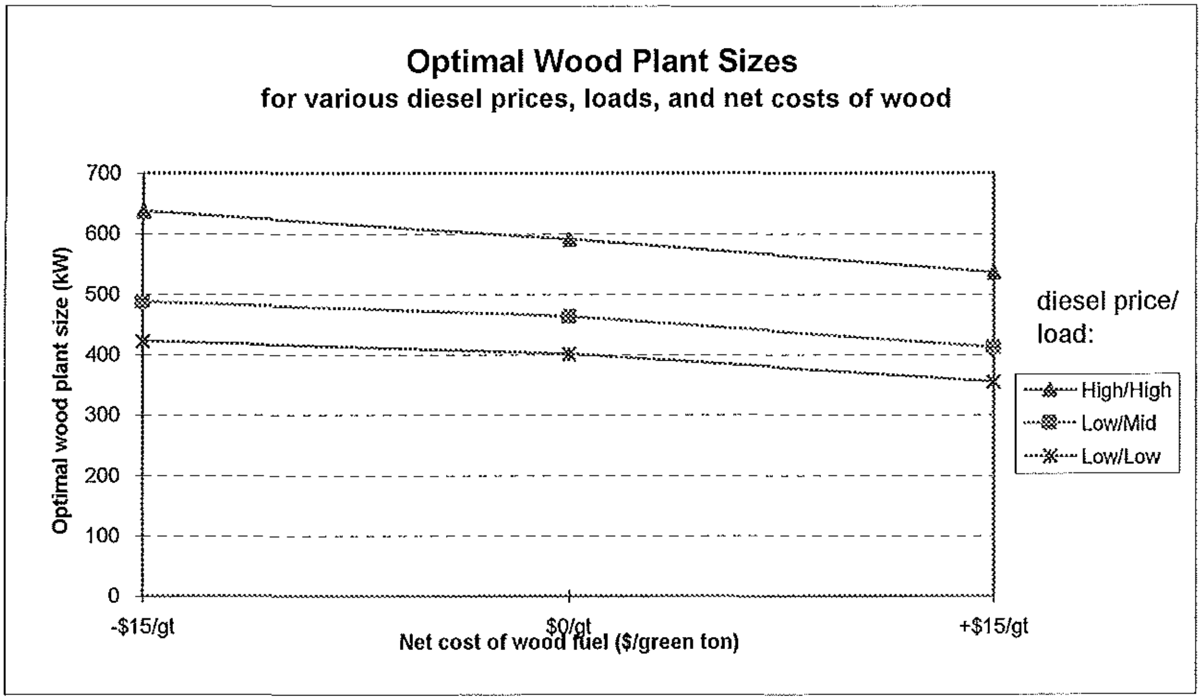
Wood Waste Power Plant

Size: 350-640 kW (varies with scenario)
Lifetime: 30 years
Capital Cost: $3,000/kW
Fixed O&M: $374,400 (all labor--see Appendix A for details)
Variable O&M: 1.5 cents/kWh
Base Net Wood Fuel Cost: $0/green ton (see discussion below)

The wood plant is sized differently for each combination of diesel price and load to produce the highest possible amount of net benefits. A larger plant can displace more diesel, but costs more to build. In addition, the optimal size depends on the net cost of wood, since a larger plant consumes more wood waste. Figure 4 shows how the optimal wood plant size varies. Appendix C contains an additional figure showing how system costs vary with wood plant size.

We assume a zero net wood fuel price for the core scenario analysis because of the difficulty in determining several values associated with fuel handling and disposal. The South Tongass Wood Waste Fuel Resource Assessment suggests positive cost components of about $10 per green ton (gt) for fuel preparation (cleaning sort yard trash and chipping long butts) plus an additional $10/gt for fuel handling. On the other side of the ledger are the avoided costs of landfilling and the environmental benefits of reduced open burning of wood waste which now occurs throughout the year in Thorne Bay. We consider the wood fuel cost issue further in the break-even analysis presented in Section 5.

Figure 4:



Optimal Wood Plant Sizes (kW)

diesel price/ load	net cost of wood fuel -$15/gt	$0/gt	+$15/gt
Low/Low	422	402	354
Low/Mid	487	463	411
Low/High	617	574	504
High/Mid	493	473	433
High/High	637	591	536

Municipal Solid Waste (MSW) Power Plant

Size:	350-640 kW (varies with scenario)
Lifetime:	30 years
Capital Cost:	$3,000/kW plus $1.2 million for scrubbers and additional fuel handling
Fixed O&M:	$374,400 per year (all labor--see Appendix A for details)
Variable O&M:	1.5 cents/kWh
Base Net MSW Fuel Cost:	minus $60/ton (see discussion below)
Initial MSW volume:	3,650 tons/year (4,000 people * 5 lbs/person/day)
Growth rate of MSW volume:	same as electric load growth rate

Under this alternative the biomass plant would burn primarily MSW, and use wood as a supplemental fuel. The capital cost of the plant is increased by the fixed cost of two scrubber units plus $200,000 for additional fuel handling equipment.

The base value for the net cost of MSW for fuel is minus $60/ton. This value is determined as follows:

	Avoided cost of a class 2 municipal landfill[2]	$100/ton
less	Additional transport costs to Thorne Bay[3]	$40/ton
equals	"Netback" disposal fee received at Thorne Bay	$60/ton

Because we use the lower Btu value of 4,000 Btu/lb, no additional handling charges are deducted from this $60 figure. (Fuel handling costs are part of the MSW plant's O&M costs). The assumed volume of MSW (4,000 people * 5 lbs/person/day) is based on the 1991 estimated population of Prince of Wales Island (4,764) less an allowance for persons not sending their trash to the facility. The volume of MSW grows with the electric load since both are based on economic and population growth.

Although in theory the optimal plant size also depends strongly on the available volume and net cost of MSW, these MSW factors are not important to the question of optimal size in this analysis. That is because even the smallest optimal plant sizes for the loads and fuel prices we consider are large enough to consume all of the MSW that will plausibly be available. Therefore it is the cost of the supplemental fuel (wood) that determines the optimal size of the plant. As long as this is true, optimal plant sizes for MSW/wood-fired power plants are the same as those shown in Figure 4 above for plants fueled only by wood. One might conclude that the current Thorne Bay electric load is fairly well-matched to the volume of MSW generated on Prince of Wales Island.

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[2] Richard Smith, personal communication, July 25, 1994. Class 2 landfills are similar to that currently found in Sitka.

[3] Montgomery Engineers (1991) estimated average transport costs to Thorne Bay at $39/ton, compared with $2/ton for local transport (eg, within Klawock). The $37/ton net difference of transporting to a regional facility is adjusted for inflation between 1991 and 1994 to yield $40/ton.

If MSW volumes greatly exceeded those needed to meet Thorne Bay's electric load, one might want to analyze an incinerator, rather than a power plant.

Dispatch Methodology

In the all-diesel cases, the standby unit is always dispatched for a 76 hour "required maintenance" run. The primary unit (the 650 kW unit) is dispatched next and generates energy based on an assumed service factor of 35%. This means that the unit produces 35% of the potential energy produced if it were operated round the clock, every day, at full load. The service factor accounts for scheduled and unscheduled down time, part-load operation, and parallel operation with other generators. The secondary unit serves all remaining energy requirements.

As new diesel units replace the current ones, the dispatch of specific diesel units becomes unimportant since all new units have the same assumed fuel efficiency. Thus "New Diesel" is a generic unit which generates all required energy after accounting for contributions from all other resources.

In the intertie and biomass plant cases, available hydro energy is used first. The assumed intertie availability of 97% reduces slightly the amount of purchased power actually taken. The standby diesel is forced to run for its 76 hours, then the primary and secondary diesels (if still operating), then the new diesel units.

In the biomass plant cases, some care in modeling must be taken when plant capacity is not sufficient to meet peak demand. In years when biomass plant capacity is less than peak demand, an algorithm is used to calculate how much peaking energy must be supplied by diesel units. The algorithm is based on a hypothetical load duration curve constructed to yield the same load factor as that observed at Thorne Bay, about .60.

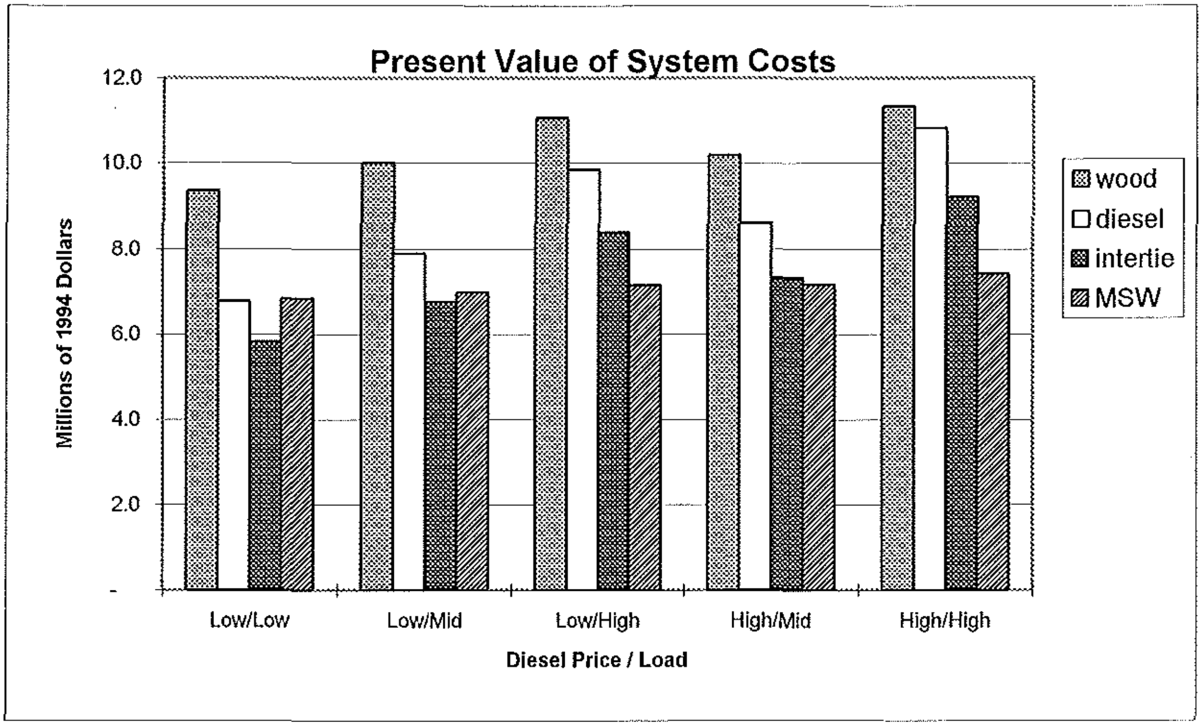
The biomass plants are assumed to have an availability factor of 90%. In practice, this 10% unavailability limits energy production as much or more than the fact that capacity is less than peak load. After the biomass plant energy is accounted for, diesel units are dispatched in the same order as in the intertie cases.

4. Cost Comparison of Alternatives

The core scenario analysis compares the cost of generation plans relying on either intertied hydro power, wood, or MSW/wood with the corresponding all-diesel plan. The analysis is conducted for five combinations of diesel price and load.

Figure 5 shows the present value of system costs for the diesel, intertie, wood waste and MSW alternatives. Over the 35 year planning period, the present value of system costs for the all diesel system ranges from about $7 million to about $11 million, depending on load served and fuel price. The intertie plan costs less than diesel in all scenarios, with a present value of costs ranging from $6 million to $9 million. With costs ranging from $6.8 million to $7.4 million, the MSW alternative is equally or less expensive than diesel under all combinations of diesel prices and loads, but is only cheaper than the intertie under high loads or diesel prices. The net benefits of the MSW plant are entirely due to the revenues (tipping fees) from processing MSW. Finally, the wood waste plant is significantly more expensive than all other alternatives when wood has zero net cost. Its system costs range from about $9.4 million to about $11.3 million.

Figure 5:

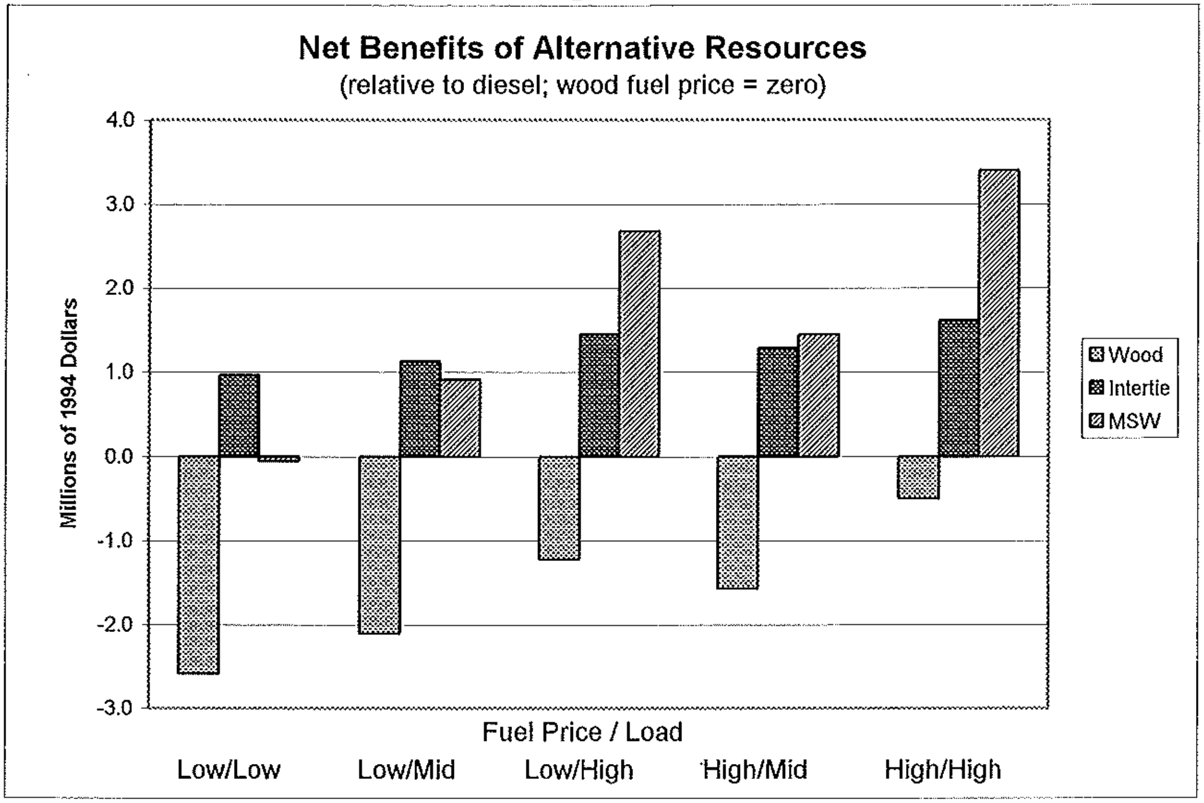


Net Present Value of System Costs
(wood fuel cost = 0, MSW net cost = -$100/ton)
millions of 1994 dollars

diesel price/ load	**diesel**	**intertie**	**MSW**	**wood**
Low/Low	6.8	5.8	6.8	9.4
Low/Mid	7.9	6.8	7.0	10.0
Low/High	9.8	8.4	7.2	11.1
High/Mid	8.6	7.3	7.2	10.2
High/High	10.8	9.2	7.4	11.3

Figure 6 shows the net benefits of the alternative resource cases, relative to the corresponding diesel case. These net benefits are simply the difference between the heights of the bars and the height of the "diesel" bar in the previous figure. The intertie produces net benefits ranging from $1 million to $1.6 million, or about 15% of diesel system costs. The MSW plant produces net benefits between zero and $3.4 million, which amounts to a savings of up to about 30% of diesel costs. The wood waste plant costs between $.5 and $2.5 million more than diesel.

Figure 6:



Net Present Value of Net Benefits (relative to Diesel)
When wood fuel has zero net cost
(millions of 1994 dollars)

diesel price/ load	Wood	Intertie	MSW
Low/Low	-2.6	1.0	-0.1
Low/Mid	-2.1	1.1	0.9
Low/High	-1.2	1.4	2.7
High/Mid	-1.6	1.3	1.4
High/High	-0.5	1.6	3.4

5. Break-even and Sensitivity Analysis

Capital Cost Break-even Analysis

The simplest break-even analysis is the calculation of break-even capital costs for the intertie and biomass alternatives. Except for discounting from 1995 to 1994 dollars, which we ignore here, these break-even capital costs can be computed by simple arithmetic. For example, under the low diesel price, mid load scenario, the wood waste plant has an assumed capital cost of $1.4 million and net benefits of -$2.1 million. Under these conditions the capital cost of the wood plant would have to be (1.4 - 2.1) = negative $700.000. In other words, there is no positive capital cost which makes the wood plant feasible given all the other assumed conditions (remember, again, the assumption of a zero net cost of wood fuel). Table 3 carries out these simple calculations for all of the core scenarios. The table shows that there is substantial leeway for intertie capital costs to exceed the estimates used here. The table also suggests that it may be worth expending a lot of money to build a biomass plant that can burn 3,650 tons of MSW per year.

Table 3:
Breakeven Capital Costs ($ million)

diesel price/ load	Intertie Assumed Cost	**Intertie Breakeven Cost**	MSW Assumed Cost	**MSW Breakeven Cost**	Wood Assumed Cost	**Wood Breakeven Cost**
Low/Low	1.7	**2.7**	2.4	**2.3**	1.2	**(1.4)**
Low/Mid	1.7	**2.8**	2.6	**3.5**	1.4	**(0.7)**
Low/High	1.7	**3.1**	2.9	**5.6**	1.7	**0.5**
High/Mid	1.7	**3.0**	2.6	**4.1**	1.4	**(0.2)**
High/High	1.7	**3.3**	3.0	**6.4**	1.8	**1.3**

Wood Plant Fuel Cost Break-even Analysis

Since the net benefits of the wood waste plant are negative when wood waste has a zero net cost, the wood plant can only break even if wood waste has a negative net cost. Table 4 shows these break-even net costs of wood waste for the wood plant alternative.

Table 4:
Breakeven Wood Fuel Costs

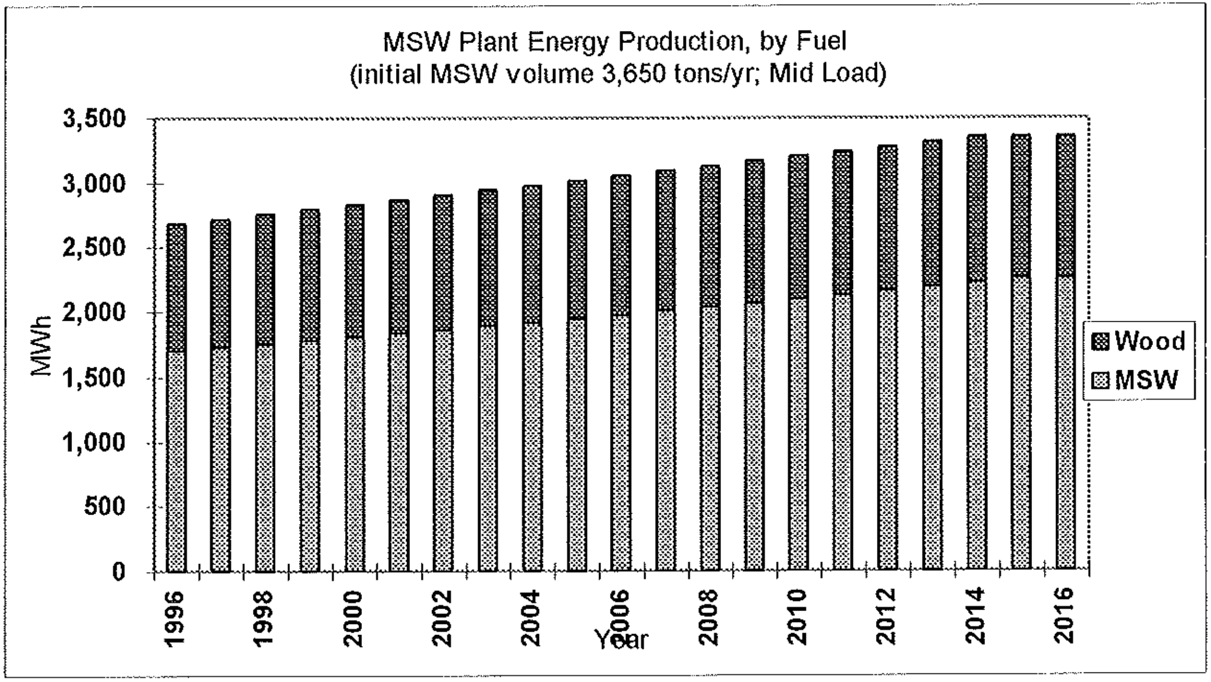
diesel price/ load	breakeven $/green ton
Low/Low	-22.00
Low/Mid	-14.81
Low/High	-6.70
High/Mid	-11.02
High/High	-2.74

note: negative $/ton values indicate the required disposal cost that would have to be avoided by the plant, net of handling costs.

Breakeven Combinations of MSW Net Cost and Wood Waste Fuel Net Cost

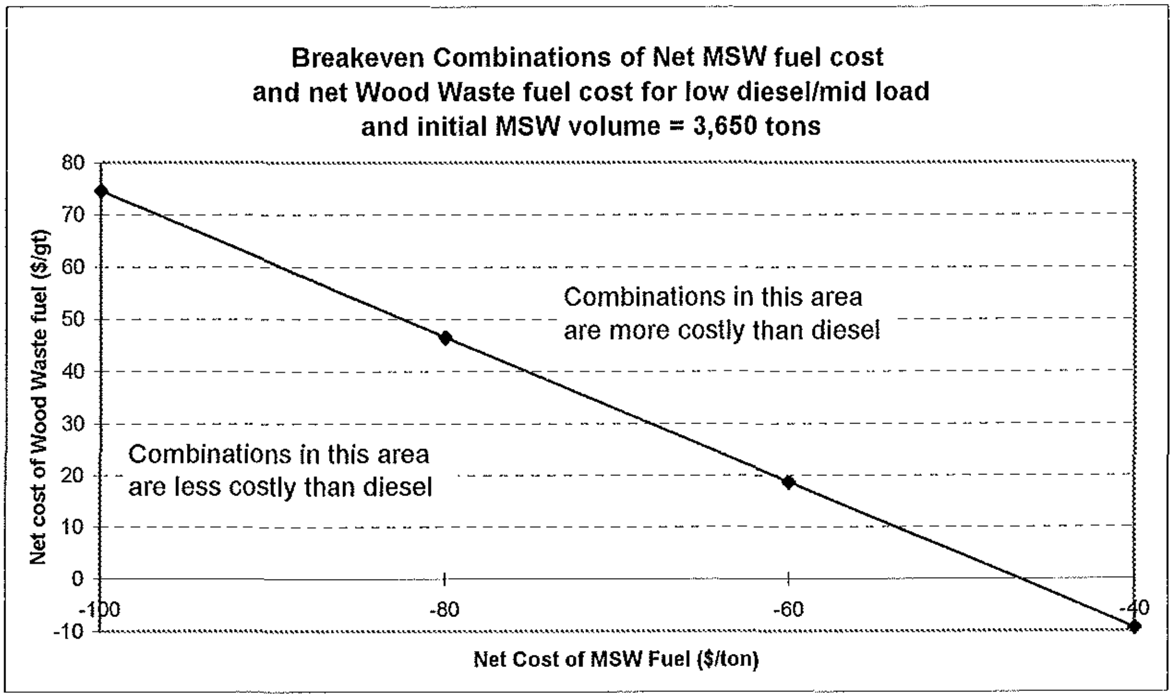
Because the MSW plant must burn some wood waste as a supplemental fuel, there are many combinations of net MSW cost and net wood fuel cost which produce breakeven system costs for the MSW plant. (Breakeven system costs means costs equal to those of the corresponding diesel alternative). Figure 7 shows that if 3,650 tons of MSW are initially burned in a biomass plant under the mid load scenario, then MSW is responsible for about 65% of the electricity generated.

Figure 7:



This means that if the MSW disposal fee is reduced by one dollar, the net cost of wood (per kWh generated) must be reduced by roughly two dollars to compensate. Since wood has a higher Btu value per green ton than does MSW, the required net wood cost per green ton only has to fall about $1.40. This is illustrated in Figure 8, which shows the breakeven combinations of MSW net cost and wood waste net cost for the low diesel price / mid load scenario.

Figure 8:



Breakeven Combinations of MSW and Wood Costs:

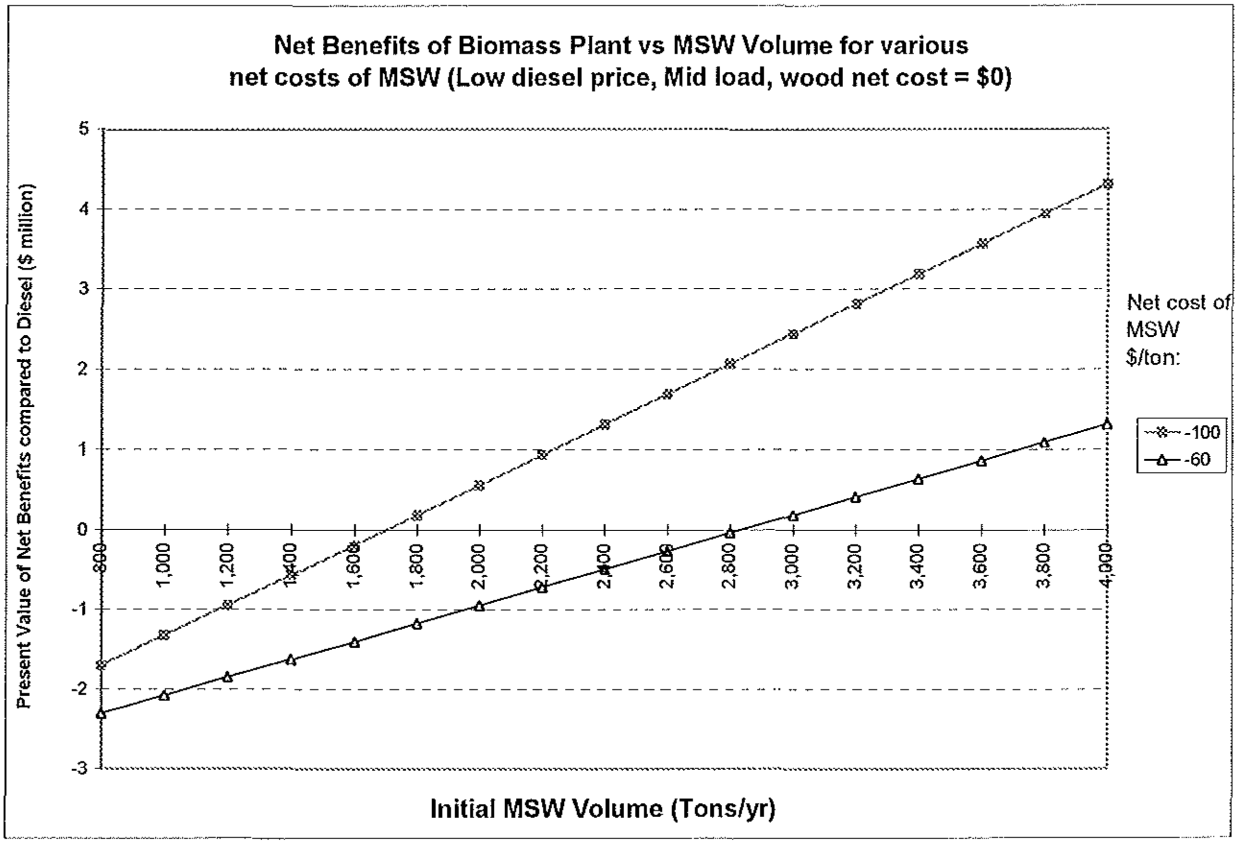
MSW net cost $/ton	**Wood net cost** $/green ton
-100.00	74.49
-80.00	46.53
-60.00	18.56
-40.00	-9.40

The Effect of MSW Cost and Volume on MSW Plant Net Benefits

Since the net benefits of the biomass plant are strongly dependent on the revenues from MSW disposal, it is useful to see how these net benefits vary with different assumed net costs and initial volumes MSW. (Recall that the MSW volume is assumed to escalate at the rate of load growth.) Figure 9 shows this relationship for the low diesel price / mid load scenario. Two different lines are plotted. Each line is based on a different net cost of MSW. The high sensitivity value for the MSW disposal fee is $100/ton, similar to current costs in Juneau ($140/ton) less transport cost to Thorne

$100/ton, similar to current costs in Juneau ($140/ton) less transport cost to Thorne Bay. The low value is $60/ton, the same as the base value, but also similar to current disposal costs for trash barged from Ketchikan to the continental U.S. The assumed net cost of the supplemental wood fuel is held constant at zero. Among other things, the figure shows the breakeven quantities of MSW which would have to be burned to render the MSW plant economic. For example, if MSW has a net cost of -$100/ton, then at least 1,700 tons of MSW would have to be burned in 1996 to render the biomass plant economic compared to diesel. As a second example, If 3,800 tons of MSW were initially available at a net cost of -$60/ton, then the biomass plant would generate about $1 million in net benefits.

Figure 9:



Potential Benefits of Extending the Intertie from Thorne Bay to Kasaan

Because of the great uncertainty about large new loads which might materialize in Thorne Bay or Kasaan, it is most useful to consider this issue using a special sensitivity case. This case examines how much additional benefit could be generated if an additional load suddenly materialized at the Thorne Bay end of the intertie that was just sufficient to take advantage of all of the "excess" Black Bear Lake hydro energy not needed to serve the Thorne Bay mid-case load.

To create this sensitivity case we first computed the available hydro energy that could be delivered to Thorne Bay over and above that needed to serve the mid case load. This energy was then added to the energy requirements, as if a non-firm load developed that was sufficient to use all available surplus hydropower.

The dispatch model was then run using diesel resources to serve this larger load. The diesel cost of serving the larger load was then compared to the diesel cost of serving the mid case load. This difference in diesel costs is the avoidable cost of serving the extra load. It is the maximum gross benefit that could be obtained by connecting additional loads to the Black Bear Lake Hydro energy source.

The gross benefits of avoided diesel costs under this "Extra Load" scenario are $1.9 million. These *maximum possible* gross benefits are only about 20% greater than the estimated capital plus fixed O&M cost of $1.6 million necessary to extend the intertie an additional 16 miles to Kasaan. This exercise tells us that it is difficult to justify extending the intertie to Kasaan for the sole purpose of delivering Black Bear hydropower unless significant large loads materialize there within 2 years. On the other hand, if there are other reasons to extend to Kasaan, this exercise serves to remind that any delay in construction must be weighed against the one-time opportunities to use surplus hydropower energy from Black Bear Lake.

6. Conclusions

Both low-cost energy and low-cost solid-waste disposal are important to the economic growth and well-being of any community. In addition, some power supply options may generate more local employment and income by utilizing local labor and resources in place of imported diesel fuel. Any power plant can deliver electricity at low prices to ratepayers if it is subsidized by someone else. In the long run, however, economic growth for the state as a whole is dependent on choosing options that minimize the overall cost of providing utility services.

The screening analysis presented here demonstrates that both the intertie from Black Bear Lake and the MSW biomass plant show significant net economic benefits (relative to continued use of diesel) to the people of Thorne Bay under a wide range of diesel price and load growth assumptions. The MSW plant could produce significantly higher net benefits than the intertie if the electric load and the available MSW volume grow rapidly (more than 3%/yr). There are many feasible combinations of net MSW cost, MSW volume, and net wood cost which would render the MSW biomass plant economic relative to diesel.

A wood-only power plant would have to earn wood disposal fees of between $2 and $22 per green ton to be economically competitive with diesel. However, the wood plant would have to earn wood disposal fees only slightly less than MSW disposal fees per ton in order to be economically competitive with the MSW power plant.

There is currently sufficient electric load in Thorne Bay to utilize the entire MSW stream from Prince of Wales Island, but to do so the volume of wood burned would be reduced to as little as 3,000 green tons per year. If the intertie to Craig and Klawock were available to export power from Thorne Bay, then there would be sufficient load to utilize far more wood waste while still burning all the available MSW. The benefits of such a regional power plant have not been analyzed here.

A special sensitivity case indicates that there is sufficient available hydro energy from Black Bear Lake to justify an intertie extension to Kasaan, but only if a large load (roughly equal to the entire Thorne Bay load) materializes in Kasaan almost immediately to use this hydro energy while it is available.

Based on the assumptions and analysis developed in this study, the MSW biomass plant shows enough economic promise to warrant serious additional analysis. There are three critical questions which greatly affect its economics. These should be answered before any detailed engineering work is attempted. First, how much volume of MSW could Thorne Bay reasonably expect to receive? Second, what would the net cost of this MSW fuel actually be? This depends on transportation costs and on the actual disposal alternatives available to people in Craig and Klawock. Third, what is the net cost of wood waste fuel likely to be? Sensitivity cases show that even when no MSW is available, if wood waste burned for power can earn a disposal credit of $10 to $15 per green ton, then a biomass plant burning only wood could still be economic compared to diesel.

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Appendix A:

Additional Discussion of Key Assumptions with Supporting Schedules

1. Study Period

1995 - 2030 will cover the economic life of the wood waste and MSW alternatives and allow for sufficient payments on the intertie.

2. Capital Cost Estimates

A. Diesel Generators

Based on vendor quotes and purchase records on file at the APUC, new diesel generators in the 500-750 kW range are being installed in 1993 and 1994 for between $300-350/kW. This price includes a complete generator, switchgear, freight to site, engineering and installation.

The Alaska Department of Environmental Conservation (DEC) anticipates that by late 1995 they will have in place regulations setting a threshold on NOx emissions above which emission controls are likely to be required. This threshold is exceeded by most of today's CAT and Cummins engines above the 550 kW range (740 hp) if they are operating 8760 hours per year and with emissions estimates used by the EPA.

R.W. Beck (1994, see references) typically includes a capital cost of $125/kW to cover air pollution emission control systems on all new and replacement diesel generators.

Therefore, an installed cost of $450/kW is used for new diesel units. For ratemaking, the capital cost will be recovered over 20 years.

New Building. It appears that a new building and switching improvements will be required for the existing diesel generators, whether they are used as prime movers or standby generators. Since all of the alternatives appear to require a new building, it is not considered in the economic comparisons.

Tank Farm. No special allowance for Tank farm modification has been included as part of any alternative.

B. Wood-waste and MSW-fired Steam Plants

Installed capital cost of $3,000/kW for wood only based on estimates provided to us by Division of Energy. DOE estimates relate to previous project analyses of other Alaska projects. Economic life = 30 years.

Additional cost for burning MSW is based on two scrubbers at $500,000 each, plus $200,000 additional fuel handling equipment.

C. Intertie to Black Bear Hydro Project (34.5 kV)

34.5 kV intertie will be constructed along road rights-of-way with limited clearing requirements. Construction cost estimates were obtained from AP&T and adjusted to reflect several additional items such as appropriate contingencies. The adjusted cost is $78,561 per mile and approximately 580 person-hours per mile in direct labor. See cost estimate schedules following this text.

3. Operations and Maintenance Costs

A. Diesels

See allocation of actual 1993 costs in text section 3, Table 2. Beginning in 1996, it is assumed that emission controls will be required costing 1.5 cents/kWh in additional O&M.

B. Wood-waste and MSW- fired Steam Plants

Fixed O&M for the biomass plants consists entirely of labor:

Operations Manager (1,040 hrs/year)
Operating Engineer (2,080 hrs/year)
Boiler Tender / Fuel Pile Tender / Grate Cleaner
(3 shifts = 6,240 hrs/year)
Maintenance (2,080 hrs/year)
Ash & Waste Handling (1,040 hrs/year)
Total = 12,480 hrs @ $30/hr = $374,400

Variable O&M: 1.5 cents/kWh (includes ash & water disposal, water, power, chemicals)

C. Intertie

Annual O&M for the intertie is 1.5% of capital cost, or $1,610/mile.

Thorne Bay		**Intertie Construction Cost Estimate**					
Assumptions:							
1	Road Access generally available along FR 2030 & Black Bear Hydro Access Roads						
2	Prevailing Wage Rates						
3	8 hour days, 40 hour weeks						
4	575	person-hours per mile for construction					
5	21.5	miles					
Labor							
			Base $/hr				
1	Foreman		$31	$31			
1	Lead		$26	$26			
2	Journeyman		$23	$46			
2	Trainee		$15	$30			
1	Operator		$15	$15			
4	Flagger		$15	$60			
11			Subtotal	$208			
	Average Rate		$18.91	$/hr			
	Overhead	43%	$8.13	$/hr			
		Subtotal	$27.04	$/hr			
Equipment							
	Equipment Allowance			$15.00	$/hr		
			Subtotal	$42.04	$/hr		
Total Labor + Equipment					**$519,720**		
Material							
	AP&T Estimate				$376,865		
	Freight to site allowance (AP&T)				$232,055		
					$608,920		
					$	$/mile	
Total Construction (w/o clearing)					**$1,128,640**	$1,963	
A.2	Right-of-Way Clearin		64	ph/mile	$57,847	$2,691	
A.3	Mobilization		5%		$59,324	$2,759	
A.4	Contingencies		10%		$124,581	$5,794	
	Subtotal				$1,370,392	$63,739	
Engineering Services							
C.1	Surveying		64	ph/mile	$57,847	$2,691	
C.2	Transmission Line		5%		$68,520	$3,187	
	Subtotal				$126,367	$5,878	
Right-of-Way & Permitting							
D.1	Permits				$25,000	$1,163	
Subtotal					$1,521,759	$70,779	
Construction Management			5%		$76,088		
Owner Costs			5%		$76,088		
Contingency on Non-Constructio			10%		$15,137		
Total Project Development Cost Estimate					**$1,689,071**	**$78,561**	
					total	$/mile	

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Appendix B:

Dispatch Model Sample Output

This appendix contains sample output from the dispatch and economic analysis model. Three resource plans are presented for the low diesel price / medium load growth scenario. They use all-diesel, intertie power, and the MSW plant, respectively, as the primary power resource. The cases are named D_LM, I_LM, and M_LM, following the naming convention shown below.

It is important to note that in this model capital costs are treated as lump sum expenditures in the year in which a unit comes on line. They may not show up in the years selected for presentation. Capital costs are "smoothed" in the rates impact section of the model, shown in Appendix C.

Model Cases are Named as Follows:

Case Name	Resource	Diesel Price	Load Growth
D_LL	Diesel	Low	Low
D_LM	Diesel	Low	Mid
D_LH	Diesel	Low	High
D_HM	Diesel	High	Mid
D_HH	Diesel	High	High
I_LL	Intertie	Low	Low
I_LM	Intertie	Low	Mid
I_LH	Intertie	Low	High
I_HM	Intertie	High	Mid
I_HH	Intertie	High	High
M_LL	MSW	Low	Low
M_LM	MSW	Low	Mid
M_LH	MSW	Low	High
M_HM	MSW	High	Mid
M_HH	MSW	High	High
W_LL	WOOD	Low	Low
W_LM	WOOD	Low	Mid
W_LH	WOOD	Low	High
W_HM	WOOD	High	Mid
W_HH	WOOD	High	High

Power Supply Dispatch Model

Case D_LM Power Supply Economic Analysis Loads and Fuel Price held constant

	Variable	Units	Present Value	1994	1995	2000	2005	2010	2015	2020	2025	2030
	Peak Demand	kW		566	571	600	631	663	690	690	690	690
	Reserve Req'd	kW		650	650	650	600	600	600	600	600	600
	Total Capacity Req'mts	kW		1,216	1,221	1,250	1,231	1,263	1,290	1,290	1,290	1,290
	Existing Resources	kW		1,575	1,575	1,575	325	325	325	325	325	325
	New Resources	kW		0	0	0	1,200	1,200	1,200	1,200	1,200	1,200
	Surplus/(Deficit)	kW		359	354	325	294	262	235	235	235	235
	Busbar Energy Requirements	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
	Busbar Energy Production, by Unit											
1	Diesel #1 (600 kW -- secondary)	MWh		952	997	1,230	0	0	0	0	0	0
2	Diesel #2 (325 kW -- standby)	MWh		25	25	25	25	25	25	25	25	25
3	Diesel #3 (650 kW -- primary)	MWh		1,993	1,993	1,993	0	0	0	0	0	0
	New Diesel Units	MWh		0	0	0	3,474	3,744	3,975	3,975	3,975	3,975
	Total Energy from Diesel	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
9	Intertie Purchased Power	MWh		0	0	0	0	0	0	0	0	0
10	Wood-Waste Power Plant	MWh		0	0	0	0	0	0	0	0	0
	Total Energy for Distribution	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
	Resource Cost of Power											
	Average Fuel Efficiency	kWh/gal		13.38	13.38	13.37	13.98	13.98	13.98	13.98	13.98	13.98
	Fuel Used	gallons		221,911	225,268	242,824	250,207	269,519	286,039	286,039	286,039	286,039
	Diesel Fuel Price	$/gallon		0.83	0.83	0.85	0.87	0.89	0.91	0.91	0.91	0.91
	Diesel Fuel Cost	1994 $	4,202,350	184,186	187,795	206,924	217,947	239,980	259,201	259,201	259,201	259,201
	Active Existing Diesel Capacity	kW		1,575	1,575	1,575	325	325	325	325	325	325
	Active New Diesel Capacity	kW		0	0	0	1,200	1,200	1,200	1,200	1,200	1,200
	Existing Diesel Fixed O&M	1994 $	53,144	5,103	5,103	5,103	1,053	1,053	1,053	1,053	1,053	1,053
	New Diesel Fixed O&M	1994 $	40,425	0	0	0	3,888	3,888	3,888	3,888	3,888	3,888
	Diesel Variable O&M	1994 $	1,938,006	102,094	103,625	111,634	91,315	98,356	104,378	104,378	104,378	104,378
	Diesel Emissions O&M	1994 $	939,315	0	0	50,743	54,664	58,889	62,502	62,502	62,502	62,502
	New Diesel Capital Cost	1994 $	715,808	0	0	0	0	0	0	0	0	0
	Total Diesel Resource Cost	1994 $	7,889,049	291,383	296,523	374,403	368,867	402,166	431,023	431,023	431,023	431,023
	Intertie Capital Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Intertie Fixed O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Hydro Resource Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Capital Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Fixed O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Variable O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Fuel Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Wood Plant Resource Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Resource Cost of Power	1994 $	7,889,049	291,383	296,523	374,403	368,867	402,166	431,023	431,023	431,023	431,023

Expansion Plan

Case D_LM

	1994	1995	2000	2005	2010	2015	2020	2025	2030
Capacity Surplus/Deficit	359	354	325	294	262	235	235	235	235
Diesel Energy Capability	9,450	9,450	9,450	9,150	9,150	9,150	9,150	9,150	9,150
Diesel Energy Called for	2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
Cumulative Diesel Energy	2,970	5,985	21,749	38,732	57,028	76,678	96,678	116,679	136,680
Diesel Energy Surplus	6,480	6,435	6,202	5,651	5,381	5,150	5,150	5,150	5,150
Largest Unit	650	650	650	600	600	600	600	600	600
	Available Existing Capacity								
Unit 1: CAT 3412	600	600	600						
Unit 2: CAT 3412	325	325	325	325	325	325	325	325	325
Unit 3: CAT 3412	650	650	650						
	Expansion Plan for New Diesel								
Unit 4: New Diesel				1200	1200				
Unit 5: New Diesel						1200	1200		
Unit 6: New Diesel								1200	1200
Unit 7: New Diesel									
Unit 8: New Diesel									
	Expansion Plan for Wood (based on capacity stated in critical assumptions)								
Wood Plant			0	0	0	0	0	0	
	Expansion Plan for Intertie								
Klawock-TB Miles (21.5)									
TB-Kasaan Miles (16)									
Intertie/Hydro net MWh av	0	0	0	0	0	0	0	0	0

Capital Cost Matrix

	1994	1995	2000	2005	2010	2015	2020	2025	2030
Unit 4: New Diesel	0	0	0	0	0	0	0	0	0
Unit 5: New Diesel	0	0	0	0	0	0	0	0	0
Unit 6: New Diesel	0	0	0	0	0	0	0	0	0
Unit 7: New Diesel	0	0	0	0	0	0	0	0	0
Unit 8: New Diesel	0	0	0	0	0	0	0	0	0
Total Diesel Capital Cost	0	0	0	0	0	0	0	0	0
Wood CapitalCost	0	0	0	0	0	0	0	0	0
Klawock-TB Intertie	0	0	0	0	0	0	0	0	0
TB-Kasaan Intertie	0	0	0	0	0	0	0	0	0

Case I_LM

Power Supply Economic Analysis

	Variable	Units	Present Value	1994	1995	2000	2005	2010	2015	2020	2025	2030
	Peak Demand	kW		566	571	600	631	663	690	690	690	690
	Reserve Req'd	kW		650	650	650	600	600	600	600	600	600
	Total Capacity Req'mts	kW		1,216	1,221	1,250	1,231	1,263	1,290	1,290	1,290	1,290
	Existing Resources	kW		1,575	1,575	1,575	1,575	1,575	325	325	325	325
	New Resources	kW		0	0	0	0	0	1,200	1,200	1,200	1,200
	Surplus/(Deficit)	kW		359	354	325	344	312	235	235	235	235
	Busbar Energy Requirements	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
	Busbar Energy Production, by Unit											
1	Diesel #1 (600 kW -- secondary)	MWh		952	997	0	0	1,751	0	0	0	0
2	Diesel #2 (325 kW -- standby)	MWh		25	25	25	25	25	25	25	25	25
3	Diesel #3 (650 kW -- primary)	MWh		1,993	1,993	73	527	1,993	0	0	0	0
	New Diesel Units	MWh		0	0	0	0	0	3,975	3,975	3,975	3,975
	Total Energy from Diesel	MWh		2,970	3,015	97	552	3,769	4,000	4,000	4,000	4,000
9	Intertie Purchased Power	MWh		0	0	3,150	2,947	0	0	0	0	0
10	Wood-Waste Power Plant	MWh		0	0	0	0	0	0	0	0	0
	Total Energy for Distribution	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
	Resource Cost of Power											
	Average Fuel Efficiency	kWh/gal		13.38	13.38	12.97	13.37	13.36	13.98	13.98	13.98	13.98
	Fuel Used	gallons		221,911	225,268	7,512	41,246	282,113	286,039	286,039	286,039	286,039
	Diesel Fuel Price	$/gallon		0.83	0.83	0.85	0.87	0.89	0.91	0.91	0.91	0.91
	Diesel Fuel Cost	1994 $	2,536,307	184,186	187,795	6,401	35,928	251,194	259,201	259,201	259,201	259,201
	Active Existing Diesel Capacity	kW		1,575	1,575	1,575	1,575	1,575	325	325	325	325
	Active New Diesel Capacity	kW		0	0	0	0	0	1,200	1,200	1,200	1,200
	Existing Diesel Fixed O&M	1994 $	74,708	5,103	5,103	5,103	5,103	5,103	1,053	1,053	1,053	1,053
	New Diesel Fixed O&M	1994 $	19,723	0	0	0	0	0	3,888	3,888	3,888	3,888
	Diesel Variable O&M	1994 $	1,173,785	102,094	103,625	3,349	18,963	129,555	104,378	104,378	104,378	104,378
	Diesel Emissions O&M	1994 $	518,623	0	0	1,522	8,620	58,889	62,502	62,502	62,502	62,502
	New Diesel Capital Cost	1994 $	368,087	0	0	0	0	0	0	0	0	0
	Total Diesel Resource Cost	1994 $	4,691,233	291,383	296,523	16,375	68,613	444,741	431,023	431,023	431,023	431,023
	Intertie Capital Cost	1994 $	1,616,327	0	1,689,062	0	0	0	0	0	0	0
	Intertie Fixed O&M	1994 $	447,585	0	25,336	25,336	25,336	25,336	25,336	25,336	25,336	25,336
	Total Hydro Resource Cost	1994 $	2,063,912	0	1,714,397	25,336	25,336	25,336	25,336	25,336	25,336	25,336
	Wood Plant Capital Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Fixed O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Variable O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Wood Plant Fuel Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Wood Plant Resource Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Resource Cost of Power	1994 $	6,755,145	291,383	2,010,921	41,711	93,949	470,077	456,359	456,359	456,359	456,359

Expansion Plan

Case I_LM

	1994	1995	2000	2005	2010	2015	2020	2025	2030
Capacity Surplus/Deficit	359	354	325	344	312	235	235	235	235
Diesel Energy Capability	9,450	9,450	9,450	9,450	9,450	9,150	9,150	9,150	9,150
Diesel Energy Called for	2,970	3,015	97	552	3,769	4,000	4,000	4,000	4,000
Cumulative Diesel Energy	2,970	5,985	6,457	7,414	19,917	39,567	59,568	79,569	99,569
Diesel Energy Surplus	6,480	6,435	9,353	8,898	5,681	5,150	5,150	5,150	5,150
Largest Unit	650	650	650	600	600	600	600	600	600
	Available Existing Capacity								
Unit 1: CAT 3412	600	600	600	600	600				
Unit 2: CAT 3412	325	325	325	325	325	325	325	325	325
Unit 3: CAT 3412	650	650	650	650	650				
	Expansion Plan for New Diesel								
Unit 4: New Diesel									
Unit 5: New Diesel						1200	1200		
Unit 6: New Diesel								1200	1200
Unit 7: New Diesel									
Unit 8: New Diesel									
	Expansion Plan for Wood (based on capacity stated in critical assumptions)								
Wood Plant			0	0	0	0	0	0	
	Expansion Plan for Intertie								
Klawock-TB Miles (21.5)		21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5
TB-Kasaan Miles (16)									
Intertie/Hydro net MWh av	0	0	5745	3038	0	0	0	0	0
Hydro surplus after TB Loa	0	0	2,497	0	0	0	0	0	0

Capital Cost Matrix

	1994	1995	2000	2005	2010	2015	2020	2025	2030
Unit 4: New Diesel	0	0	0	0	0	0	0	0	0
Unit 5: New Diesel	0	0	0	0	0	0	0	0	0
Unit 6: New Diesel	0	0	0	0	0	0	0	0	0
Unit 7: New Diesel	0	0	0	0	0	0	0	0	0
Unit 8: New Diesel	0	0	0	0	0	0	0	0	0
Total Diesel Capital Cost	0	0	0	0	0	0	0	0	0
Wood CapitalCost	0	0	0	0	0	0	0	0	0
Klawock-TB Intertie	0	1,689,062	0	0	0	0	0	0	0
TB-Kasaan Intertie	0	0	0	0	0	0	0	0	0

Power Supply Dispatch Model

Case M_LM		Power Supply Economic Analysis										
	Variable	Units	Present Value	1994	1995	2000	2005	2010	2015	2020	2025	2030
Peak Demand		kW		566	571	600	631	663	690	690	690	690
	Reserve Req'd	kW		650	650	650	600	600	600	600	600	600
	Total Capacity Req'mts	kW		1,216	1,221	1,250	1,231	1,263	1,290	1,290	1,290	1,290
	Existing Resources	kW		1,575	1,575	1,575	1,575	1,575	1,575	1,575	1,575	1,575
	New Resources	kW		0	0	463	463	463	463	463	463	0
	Surplus/(Deficit)	kW		359	354	788	807	775	748	748	748	285
Busbar Energy Requirements		MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
Busbar Energy Production, by Unit												
1	Diesel #1 (600 kW -- secondary)	MWh		952	997	0	0	0	0	0	0	1,840
2	Diesel #2 (325 kW -- standby)	MWh		25	25	25	25	25	25	25	25	25
3	Diesel #3 (650 kW -- primary)	MWh		1,993	1,993	392	454	537	619	619	619	1,993
	New Diesel Units	MWh		0	0	0	0	0	0	0	0	143
	Total Energy from Diesel	MWh		2,970	3,015	417	479	562	644	644	644	4,000
	Intertie Purchased Power	MWh		0	0	0	0	0	0	0	0	0
	Biomass Energy from MSW	MWh		0	0	1,809	1,949	2,100	2,262	2,262	2,262	0
	Biomass Energy from Wood	MWh		0	0	1,022	1,070	1,107	1,094	1,094	1,094	0
	Total Biomass Energy	MWh		0	0	2,831	3,019	3,207	3,356	3,356	3,356	0
	Total Energy for Distribution	MWh		2,970	3,015	3,248	3,499	3,769	4,000	4,000	4,000	4,000
Resource Cost of Power												
	Average Fuel Efficiency	kWh/gal		13.38	13.38	13.35	13.36	13.38	13.39	13.39	13.39	13.38
	Fuel Used	gallons		221,911	225,268	31,208	35,868	42,000	48,117	48,117	48,117	298,958
	Diesel Fuel Price	$/gallon		0.83	0.83	0.85	0.87	0.89	0.91	0.91	0.91	0.91
	Diesel Fuel Cost	1994 $	1,192,410	184,186	187,795	26,594	31,244	37,397	43,603	43,603	43,603	270,908
	Active Existing Diesel Capacity	kW		1,575	1,575	1,575	1,575	1,575	1,575	1,575	1,575	1,575
	Active New Diesel Capacity	kW		0	0	0	0	0	0	0	0	0
	Existing Diesel Fixed O&M	1994 $	95,253	5,103	5,103	5,103	5,103	5,103	5,103	5,103	5,103	5,103
	New Diesel Fixed O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Diesel Variable O&M	1994 $	628,095	102,094	103,625	14,318	16,474	19,312	22,143	22,143	22,143	136,316
	Diesel Emissions O&M	1994 $	194,624	0	0	6,508	7,488	8,778	10,065	10,065	10,065	62,502
	New Diesel Capital Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Diesel Resource Cost	1994 $	2,110,382	291,383	296,523	52,524	60,309	70,590	80,913	80,913	80,913	474,830
	Intertie Capital Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	Intertie Fixed O&M	1994 $	0	0	0	0	0	0	0	0	0	0
	Total Hydro Resource Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	MSW Plant Capital Cost	1994 $	2,372,111	0	0	0	0	0	0	0	0	0
	MSW Plant Fixed O&M	1994 $	5,835,942	0	0	374,400	374,400	374,400	374,400	374,400	374,400	0
	MSW Plant Variable O&M	1994 $	777,069	0	0	46,158	49,227	52,289	54,718	54,718	54,718	0
	MSW Plant Fuel Cost	1994 $	0	0	0	0	0	0	0	0	0	0
	MSW Disposal Credit	1994 $	(4,117,613)	0	0	(239,464)	(257,971)	(277,908)	(299,386)	(299,386)	(299,386)	0
	Total MSW Plant Resource Cost	1994 $	4,867,510	0	0	181,094	165,656	148,782	129,732	129,732	129,732	0
Total Resource Cost of Power		1994 $	6,977,891	291,383	296,523	233,617	225,966	219,371	210,645	210,645	210,645	474,830
	target breakeven cost		7,889,049									

	Case M_LM									
	Expansion Plan	1994	1995	2000	2005	2010	2015	2020	2025	2030
Regime:	Diesel Surplus/Deficit	359	354	788	807	775	748	748	748	285
Diesel life = 10 years	Diesel Energy Capability	9,450	9,450	9,450	9,450	9,450	9,450	9,450	9,450	9,450
(60,000 hrs @ 6000 h/yr)	Diesel Energy Called for	2,970	3,015	417	479	562	644	644	644	4,000
	Cumulative Diesel Energy	2,970	5,985	7,969	10,232	12,867	15,960	19,181	22,401	42,402
	Diesel Energy Surplus	6,480	6,435	9,033	8,971	8,888	8,806	8,806	8,806	5,450
	Largest Unit	650	650	650	600	600	600	600	600	600
		Available Existing Capacity								
runs 10 more years	Unit 1: CAT 3412	600	600	600	600	600	600	600	600	600
lasts forever as standby	Unit 2: CAT 3412	325	325	325	325	325	325	325	325	325
runs 10 more years	Unit 3: CAT 3412	650	650	650	650	650	650	650	650	650
		Expansion Plan for New Diesel								
new diesel runs 10 years	Unit 4: New Diesel									
	Unit 5: New Diesel									
	Unit 6: New Diesel									
	Unit 7: New Diesel									
	Unit 8: New Diesel									
		Expansion Plan for Wood (based on capacity stated in critical assumptions)								
	Wood Plant			463	463	463	463	463	463	
		Expansion Plan for Intertie								
	Klawock-TB Miles (21.5)									
	TB-Kasaan Miles (16)									
	Intertie/Hydro net MWh av	0	0	0	0	0	0	0	0	0
	Capital Cost Matrix									
		1994	1995	2000	2005	2010	2015	2020	2025	2030
	Unit 4: New Diesel	0	0	0	0	0	0	0	0	0
	Unit 5: New Diesel	0	0	0	0	0	0	0	0	0
	Unit 6: New Diesel	0	0	0	0	0	0	0	0	0
	Unit 7: New Diesel	0	0	0	0	0	0	0	0	0
	Unit 8: New Diesel	0	0	0	0	0	0	0	0	0
	Total Diesel Capital Cost	0	0	0	0	0	0	0	0	0
	MSW CapitalCost	0	0	0	0	0	0	0	0	0
	Klawock-TB Intertie	0	0	0	0	0	0	0	0	0
	TB-Kasaan Intertie	0	0	0	0	0	0	0	0	0

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Appendix C:

System Costs and Biomass Plant Sizes

The following two charts show the relationship between the present value of system costs and the size of the MSW waste and MSW plants, respectively. As mentioned in the text, the optimal size of the MSW plant is the same as the optimal size of the MSW plant when the plant is big enough to burn all available MSW fuel. The second chart shown here therefore assumes that there is enough MSW volume to satisfy the entire needs of the plant, in order to see how MSW price affects plant sizing.

There are three lines shown, corresponding to three different assumptions about the net cost of MSW fuel or the net cost of MSW fuel. Each line initially drops at first because additional MSW plant capacity takes advantage of economies of scale in plant labor. Each line eventually turns up as the additional capital cost is not spread over very much additional energy production.

As the net cost of fuel decreases, it pays to build a larger plant.

The most interesting thing about the chart is the relatively flat shape of the curves. This shows that it is not critical to guess the optimal size of the biomass plant perfectly. For example, when MSW fuel has a zero net cost, being off by up to 40% does not affect the present value of system costs by more than about $400,000.

Figure C-1:

System Cost vs. Biomass Plant Size when MSW is the only Fuel (low diesel/mid load, various net costs of MSW)

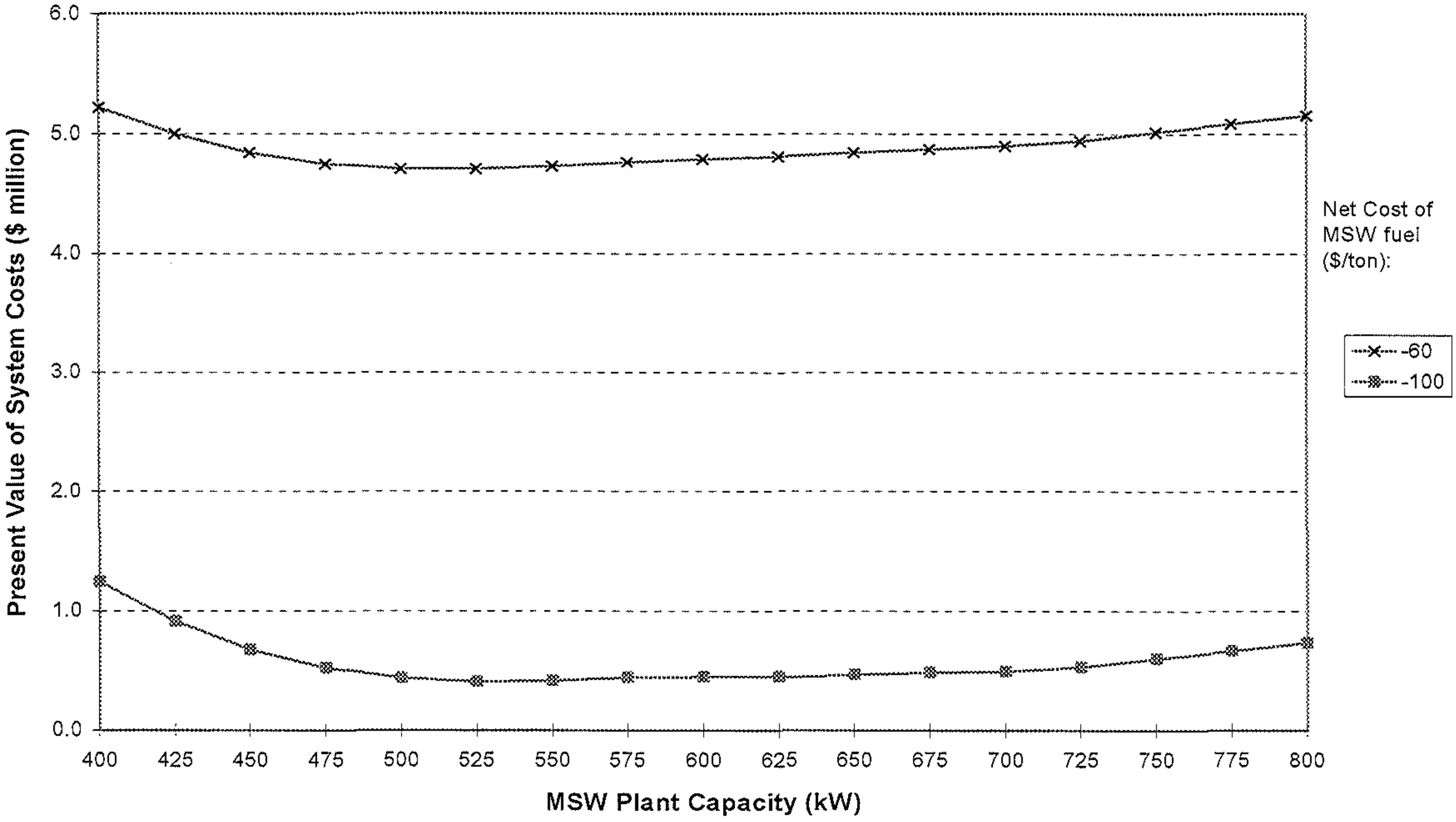

Figure C-2:

System Cost vs. Wood Plant Size for various net costs of wood waste when wood waste is the only fuel. (low diesel/mid load)