Distributed Resources: A Potentially Economically Attractive Option to Satisfy Increased Demand on Okanogan County Electric Cooperative's "Mazama Feeder" Line*

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Disclaimer

This preliminary study assesses the feasibility of using distributed resources in the Okanogan County Electric Cooperative. This report is not an engineering study that will support final decisions for specific actions to be taken by the Co-op. As of the report date printed here, this report has not been presented to the Co-op's Board of Directors.

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Executive Summary

Objective

When we talk about "distributed resources," we are referring to producing electricity where it will be consumed, rather than producing it at some distant facility and then transporting it over electric power lines. In this report, we use a detailed set of assumptions to evaluate the technical and economic feasibility of using distributed resources to supply the energy needs of 1,500 new homes in the Mazama Valley. The specific homes are on the Mazama Feeder—a part of Okanogan County Electric Cooperative's electric distribution system.

The three distributed resources that we consider in this report are energy-efficient appliances, cogeneration, and photovoltaics. *Energy-efficient appliances* include devices such as fluorescent lights, high-efficiency refrigerators, and propane dryers.[1] *Cogeneration technologies* produce electricity and usable heat at the same time; for example, rather than running a generator just to produce electricity, the heat released during the generation process is captured and then used. *Photovoltaic (PV) technologies* convert sunlight directly to electricity with no moving parts.

Alternative to Feeder Upgrade

We constructed a computer model—based on the characteristics of the Mazama Feeder—that can be used to assess the technical and economic benefits of a variety of distributed resource scenarios. The distributed resource alternative that we have focused on here is the following:

(1) A moderate level of energy-efficiency appliances for each new home,
(2) Two megawatts (MW)—or 2,000,000 watts—of propane-based cogeneration, which is enough power to supply the water-heating and space-heating needs of 1,000 new homes,
(3) Propane heating (without cogeneration) to supply the water- and space-heating needs for the remaining 500 new homes, and
(4) Five-hundred kilowatts (kW)—or 500,000 watts—of photovoltaics.

Our results indicate that customer demand on the Mazama Feeder would still double even if all of the homes used propane space-heating and water-heating and energy-efficient appliances. Adding cogeneration turns the Feeder from one that distributes more electricity in the winter (a "winter peaking" feeder) to one that distributes more electricity in the summer (a "summer peaking" feeder). Using PV addresses the summer-peaking problem and brings the Feeder's peak to within the current load levels.

[1] While the energy efficiency appliances were focused on in this report, there is also the importance of building homes that are efficient in terms of their heat consumption regardless of the type of heating fuel used.

The Co-op would own the cogeneration, and one-third of the 1,500 new homes would each own, on average, a utility-intertied 1-kilowatt (1,000-watt) PV system.[2] Currently, the Co-op charges customers a "system access fee" to connect to the electric distribution system. However, as an incentive to encourage PV installations, the Co-op would waive the service access fee for customers who install a 1-kilowatt or larger PV system.

Conclusions

Our primary conclusion is that using distributed resources provides better economics than upgrading the Mazama Feeder to a transmission level. According to our preliminary economic analysis, this upgrade, which would enable the Feeder to carry more electricity, has a net present value (NPV)[3] of negative $1.2 million. This is based on the assumption that the entire cost of the line upgrade and new substation is incurred all at once. The alternative of providing electricity to customers locally by using distributed resources has an NPV of positive $0.2 million. By our analysis, therefore, the Co-op can save $1.4 million by using distributed resources.[4]

Next Steps

For new homes on the Mazama Feeder, the Co-op could take the following next steps:

(1) Efficiency—Encourage or require all new homes to have a reasonable level of energy efficiency. For example, the building "envelope" should be tightly sealed and well insulated, and homeowners should use fluorescent lighting, high-efficiency refrigerators, and propane clothes dryers, where feasible.

(2) Cogeneration—Work with Arrowleaf and other developer, and the Lost River and Edelweiss home-owners associations to install a cogeneration technology such as district heating, rather than electric or propane heating. The Co-op would operate the cogeneration units and sell the cogenerated heat to customers for 20% below the cost of electric heat. This could be the Co-op's first step into the propane business.

(3) Propane Space and Water Heating—Encourage all other new homes on the Mazama Feeder to use propane for their space heating and water heating. The Co-op could either supply propane or arrange bulk buying for customers to lower the propane cost.

(4) Photovoltaics—Waive the system access fee (which is about $1,000 per home) for any customer who installs a PV system that is 1 kilowatt or greater. The Co-op could also work with housing developers and architects to help them offer such systems to their customers as a feature on new homes.

To reiterate, this preliminary economic analysis suggests that the Co-op should seriously consider using distributed resources to satisfy the increased demand on the Mazama Feeder. We recommend that the Co-op hire a qualified engineering firm to validate the findings of our preliminary report.

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[2] PV panels for a 1 kW system occupy about 100 square feet. The DC electrical output is converted to AC power and connected to utility distribution system using a sine wave inverter.

[3] NPV, or net present value, is an economic evaluation approach that discounts cash flows that occur over time so that various alternatives can be compared.

[4] The costs used in this preliminary feasibility study are only estimates. These costs could change substantially when cost proposals are actually made. These costs will be known with a greater degree of certainty after an engineering study is performed.

Background—The Benefits of Distributed Resources and Microgrids

The National Renewable Energy Laboratory (NREL) has been evaluating energy applications that use distributed resources—in other words, producing electricity close to where it is consumed, rather than producing electricity at a distant facility and then transporting it considerable distances over electric power lines. These distributed resources—to be described in more detail in our report—include energy efficiency, cogeneration, fuel cells, micro-hydro, and photovoltaics (PV).

One application of distributed resources is to help handle customers' demand for electricity on an electric utility's transmission and distribution system. Meeting this demand defers the costs associated with expanding the transmission system. Another application identified by NREL is to use distributed resources as part of a micro-grid—a set of power generators that supplies the power demand of a group of customers. Using distributed resources to relieve "capacity constraints" (the first application) may actually help utilities transition into micro-grids (the second application).

NREL sees micro-grids as potentially attractive from several perspectives. First, locating (or siting) resources where the electric loads occur reduces the normal losses in power that occur when transmitting and distributing electricity over long power lines. Second, micro-grids may have lower costs because they can reduce the capital, operation, and maintenance costs of a transmission system. Third, micro-grids may be highly reliable because many small generating units are used to satisfy demand, and it is highly unlikely that all units will fail at the same time.

Preliminary research sponsored by NREL suggests that micro-grids may benefit rural electric cooperatives, particularly ones that provide electrical service to isolated communities. With this in mind, our study of the potential use of distributed resources by rural electric cooperatives is a combined effort between NREL and the Okanogan County Electric Cooperative, Inc.

Introduction—The Co-op and Its Customers

The Okanogan County Electric Cooperative (the Co-op) serves 2,100 members, with 2,450 electric meters, and has about 400 miles of distribution lines in a rural community in the Methow Valley in the state of Washington. The Co-op currently receives all of its power from the Bonneville Power Administration (BPA). The Co-op has a peak electricity demand in the winter of 13 megawatts (13 million watts), and each year, it purchases 42,000 megawatt-hours (MWh)[5] of electricity, sells[6] about 39,000 MWh of electricity, and has revenues of $2 million.

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[5] Demand, measured in MW, is the amount of electricity consumed at one point in time. Peak demand is the maximum of all demands throughout the year. Annual electricity consumption, measured in MWh, is the sum of demand at each point in time over the entire year.

[6] Sales are less than purchases due to losses in distributing the electricity.

One "feeder" line, which is part of the Co-op's electric distribution system, serves customers in the Mazama Valley. Table 1 shows the composition of customers connected to this Mazama Feeder.

Table 1. Composition of Customers on the Mazama Feeder

Customer Class	Number of Customers	Consumption (MWh/yr)	Consumption (%)
Residential	166	2,352	42
Small Commercial	42	897	16
Large Commercial	1	362	6
Irrigation	17	227	4
Seasonal Residential	298	1,766	32
Total	524	5,604	100

The Problem—Meeting the Demand of New Customers

The Mazama Feeder accounts for less than 15 percent of the Co-op's total electricity consumption. But almost half of the Co-op's increase in demand is occurring on this one feeder, with the growth primarily in new residential customers (Meader, 1998). Furthermore, about 1,000 new homes could be built in three housing developments (Arrowleaf, Lost River, and Edelweiss), and there may be lots for 500 other homes in the area. This addition of 1,500 new homes would almost double the number of homes in the Co-op's service territory, and it is uncertain how fast the new houses will be built.

Based on sample end-use load data from BPA, it is assumed that a new house would consume 18,000 kilowatt-hours per year of electricity. This value compares well with existing houses in the area. If 1,500 such houses were built, consumption of electricity from the feeder would increase by about 500 percent and consumption for the whole Co-op would increase by 70 percent.

The Co-op anticipates that the capacity of the Mazama Feeder—the amount of electricity that the feeder can carry—will need to be upgraded in the near future. It will cost an estimated $2.3 million to build a transmission line from the Winthrop substation to Mazama and a new substation near Mazama (Meader, 1998).[7] This cost is about $160,000 per mile for 14 miles.

Objective—To Assess the Distributed Resources Alternative

Our objective is to assess the use of distributed resources as an alternative to upgrading the feeder to satisfy the increase in demand on the Mazama Feeder. Our study assesses

[7] This estimate is extrapolated from other similar projects. No engineering study or cost analyses have been done.

the technical and economic feasibility of using distributed resources to supply electricity to the Co-op's customers. Although a wide range of distributed technologies could be used, we focus on the use of three: energy efficiency, cogeneration, and photovoltaics.

Energy efficiency includes devices such as fluorescent lights (rather than incandescent lights) and high-efficiency refrigerators, and fuel switching from electric dryers to propane dryers. *Cogeneration technologies* produce electricity and usable heat at the same time; for example, rather than running a generator or fuel cell just to get electricity, the heat released during the generation process is captured and then used. *Photovoltaic (PV) technologies* convert sunlight directly to electricity with no moving parts.

Approach—First, Determine the Existing Load

The ideal way to perform this analysis is to have detailed information on electric load. This information would include hourly electric loads by *customer type* (i.e., residential, seasonal residential, commercial, irrigation, and industrial customers) and *end use*, which is how customers use the electricity (e.g., water heating, lighting). One could then precisely determine the effect of making new capital investments in the system. Unfortunately, such detailed information does not exist, and we must instead estimate the loads.

Estimated Mazama Loads

We estimated the loads for the Mazama feeder, as it currently exists, as follows:

(1) Obtain measured hourly load data from Bonneville Power Administration for the Winthrop substation (BPA, 1998a).
(2) Convert the data into average hourly loads for each month of the year (12 months times 24 hours per month, for a total of 288 load values) so they can be used with the end-use load data in the next section of the analysis.
(3) Obtain billing data for the Mazama Feeder (Co-op, 1998).
(4) Adjust the magnitude of the Winthrop substation load data to match the annual electricity sales from the August 1997–July 1998 billing data. We estimated that the Mazama Feeder accounts for 15 percent of the load from the Winthrop substation and is 13 percent of the Co-op's total load. Thus, each of the load points from the Winthrop substation was multiplied by 0.15.

Figure 1 shows the effect of converting the data from hourly points for a whole year to 24 average hours for each month of the year. The figure presents the 1997 load duration curve[8] based on hourly load data from BPA (8,760 points), as well as the averaged data for each hour of the month (288 points). For example, the figure shows that demand is

[8] A load duration curve is built by sorting consumption in decreasing order (rather than chronological order) and then plotting the points next to each other. Here is an example of how to build a load duration curve for a 4-hour period. Suppose that demand averaged 3 kWh/hour in the first hour, 5 kWh/hour in the second hour, 6 kWh/hour in the third hour, and 4 kWh/hour in the fourth hour. The hours would be sorted in the order of third hour, second hour, fourth hour, and first hour to put them in a load duration curve order. An annual load duration curve performs this sorting for every point during the year.

greater than 300 kilowatts for 100 percent of the year and that demand is greater than 500 kilowatts for half of the year. The figure suggests that the hourly approximation is accurate except during the top 1 percent of the hours, where the averaging approach underestimates the peak demand.

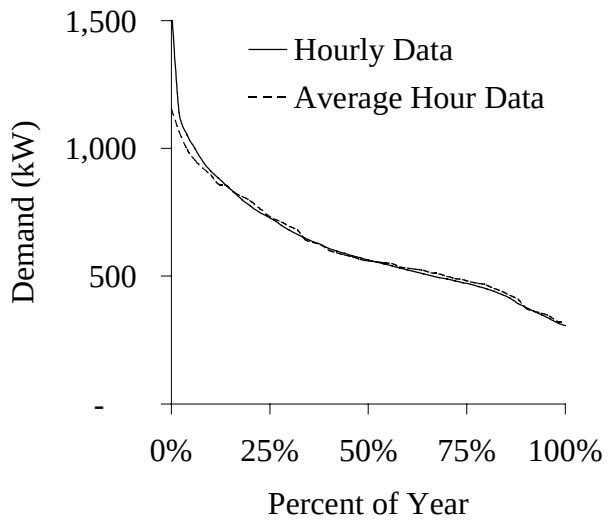

Figure 1. Mazama load (full-year and average-hour data).

Estimated Mazama Loads by End Use

The next step was to look at the shape of the existing electric load and to estimate the components of this load shape by *end use*.

(1) We selected the 120 residential customers who consume the most on the Mazama Feeder (out of a total of 166 residential customers on the feeder). These 120 customers account for 38 percent of the total electricity consumption on the feeder and have an average electricity consumption of 17,900 kilowatt-hours per year. The other 46 residential customers account for 4 percent of the total electricity consumption on the feeder.

(2) A detailed examination of the billing records for each of the 120 customers indicated that two-thirds of these customers use electric heating as their primary heat source. Consequently, electricity consumption shows a large peak during the winter. Although this consumption is higher than the 49-percent average for the entire Co-op, the reason is because we selected the largest 120 residential consumers from the feeder. We assumed that 92 percent of the customers have electric water-heating, based on a Co-op Attitude Survey (NRECA, 1997).

(3) We obtained estimates of hourly electricity consumption by month and by end-use for a typical residential customer (BPA, 1998b). Electrical usage is categorized into these end-uses: water heating, HVAC—or heating, ventilation, and air conditioning (which we assumed to be space-heating totally), clothes dryers, lights and

conveniences, refrigerator, and other. The average consumption per home is about 18,400 kilowatt-hours per year.

(4) We validated these sample data for the Mazama Feeder by comparing the estimated loads for the 120 residential customers with the actual billing data (see Figure 2). The figure suggests that the sample data from BPA does actually represent the consumption on the Mazama Feeder.

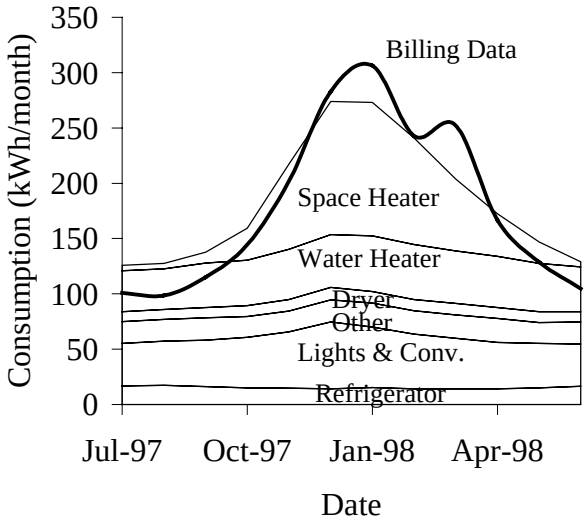

Figure 2. Electricity consumption for 120 residential customers on Mazama Feeder: billing data (heavy line) and estimated end-use data (light lines).

Second, Determine the New Mazama Load

We now have an estimate of the *current* load, as well as the *end-use* loads, on the Mazama Feeder. Let's consider five possible scenarios of the future.

Scenario 1: ***All new homes have same characteristics as existing homes***

The first scenario is that 1,500 new homes are built that have the same characteristics as the 120 residential homes that are currently on the feeder.[9] This means that 92 percent of the homes will have electric water-heating, 66 percent will have electric space-heating, and no special effort will be made to increase the efficiency of the homes' appliances, lighting, etc. Each home consumes 18,500 kilowatt-hours of electricity per year.

[9] The assumption of how much electricity these new homes will use will depend upon whether they are year round residential or seasonal residential customers. This analysis assumes that all new homes are year round residential homes.

Scenario 2: ***Electric heating / no appliance efficiency / 0.5 MW of PV***

The second scenario is identical to the first scenario—but with one difference: 500 of the homes have, on average, a 1-kilowatt PV system (some systems could be smaller, some systems could be larger). These installations mean that there is a total capacity of 0.5 megawatt (or 500 kilowatts) of PV on the feeder, producing 700,000 kilowatt-hours per year. If we spread this consumption out across all 1,500 new homes, this is equivalent to each home producing about 500 kilowatt-hours per year. The overall effect is that the net consumption for the average home decreases from 18,500 down to 18,000 kilowatt-hours per year.

Scenario 3: ***Propane heating / efficient appliances / no PV***

The third scenario is where *all* of the 1,500 new homes use propane for their space- and water-heating needs, and the homes have "moderate" appliance efficiency—defined as lighting and refrigeration needs that are 50 percent less than the existing homes, and gas clothes dryers rather than electric clothes dryers. This scenario results in each new home using slightly more than 5,150 kilowatt-hours per year.

Results for Scenarios 1, 2, and 3

Figure 3 presents the annual "load duration" curves for the first three scenarios. The figure suggests several things: First, the peak electric load on the feeder will greatly increase if 1,500 new homes *that have the same characteristics as the existing homes* are added to the feeder. Second, adding 0.5 megawatt of PV to the feeder without making any other changes in the homes has almost no effect on peak demand (because the peak occurs at 8 a.m. in January, a time when there is almost no sunlight) and the reduction in electricity consumption is minimal. Third, even if all of the electric space and water heaters for the new homes are propane and the new homes have moderate efficiency, the peak load on the feeder will still more than double.

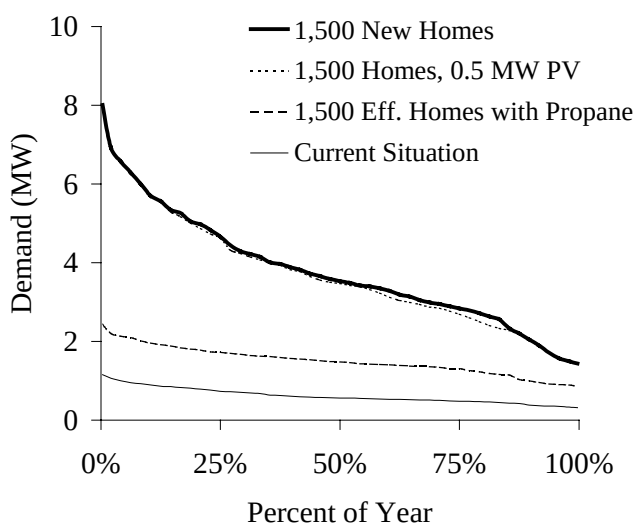

Figure 3. Annual load-duration curve for Scenarios 1, 2, and 3.

Scenario 4: ***Propane heating for 500 homes / cogeneration for 1,000 homes / appliance-efficient homes***

The fourth scenario assumes that cogeneration, using either generator or fuel-cell technologies, can supply the heating needs and part of the electrical needs of 1,000 of the 1,500 new homes. This could be accomplished by using *district heating*[10] at the new housing developments, such as Arrowleaf, and in portions of Lost River and Edelweiss. We assumed that the cogeneration units have an *electrical* efficiency of 25 percent and a *thermal* efficiency of 65 percent.[11] The electric capacity of the cogeneration is 2 megawatts, and the thermal capacity is 5.2 megawatts. This means that, for every hour the cogeneration is operated at full capacity, it will produce 2,000 kWh of electricity and 5,200 kWh of heat.

The remaining 500 new homes would have propane water and space heating, but no cogeneration. All of the homes are built to have moderately efficient appliances, as defined in Scenario 3. The average electricity consumption for the 1,500 new homes is 5,150 kilowatt-hours per year. The cogeneration will produce 4,700,000 kilowatt-hours of electricity per year[12]—or 3,150 kilowatt-hours per new home. Thus, the net electricity demand for the new homes is 2,000 kilowatt-hours per year.

Scenario 5: ***Propane heating for 500 homes / cogeneration for 1,000 homes / appliance-efficient homes / 0.5 MW of PV***

Scenario 5 is the same as Scenario 4, except that 0.5 megawatt of PV would be installed. This scenario could occur if one out of every three homes put in a 1-kilowatt PV system.[13] One-half a megawatt of PV will produce 700,000 kilowatt-hours per year—or an average of about 500 kilowatt-hours per home. The net demand for each of the 1,500 new homes is 1,500 kilowatt-hours per year.

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[10] With district heating, one generator produces both electricity and heat and the heat is transported using underground pipes to nearby houses. An alternative to district heating would be a single, small unit for each house. This will become more technically feasible as fuel cells continue to develop.

[11] The average daily water and space heating load during the worst month is 2.7 kW. Since the cogeneration has a 5.2 $MW_{thermal}$ rating, the cogeneration is capable of meeting twice the average load during the worst month. The average water and space heating load throughout the year is 1.4 kW.

[12] The cogeneration will produce 4,700,000 kWh of electricity and 12,200,000 kWh of heat per year (this is based on a 27 percent annual capacity factor for 2 MW_{elec}/5.2 $MW_{thermal}$ of cogeneration). Since heat production is typically reported in therms (1 therm equals 100,000 Btu,s), 12,200,000 kWh of heat converts to about 42,000 therms of heat.

[13] A 1-kW PV system includes about 100 square feet of PV panels and a sine wave DC to AC inverter. Customers could add storage batteries to their systems to have added reliability.

Results for Scenarios 4 and 5

Figure 4 presents the annual load duration curves for Scenarios 4 and 5. As in Figure 3, the "Current Situation" is included for reference purposes. Note that the scale of the figure is not the same as in the previous figure.

This figure suggests several things:

- First , the cogeneration (for 1,000 homes) and the propane space and water heating (for the other 500 homes) substantially reduce the peak load on the feeder. This action, together with the efficient appliances, turns the Mazama Feeder from one that has peak loads in the winter to one that peaks in the summer instead.
- Second, it is at this point—of shifting to a summer peak—that adding the 0.5 megawatts of PV addresses the summer peaking problem and brings the feeder's peak to within the current level.

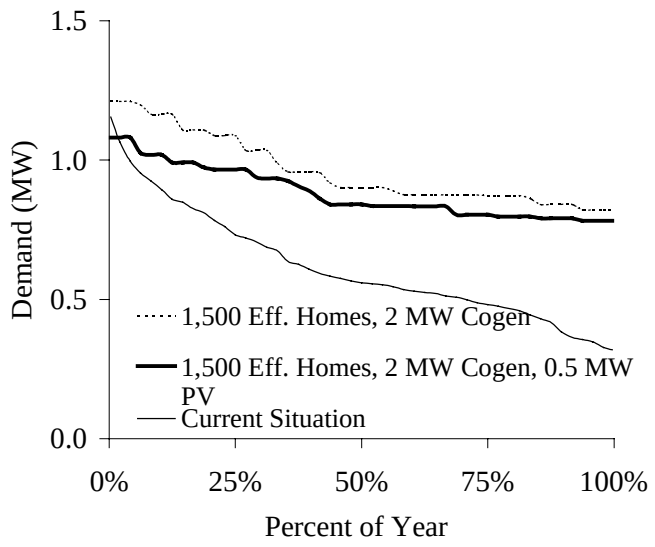

Figure 4. Annual load-duration curves for Scenarios 4 and 5.

Figure 5 shows that combining cogeneration and PV satisfies peak demand during January (the *old* peak month) and August (the *new* peak month). Photovoltaic systems produce more electricity during the *summer* than during the winter because there is more sunlight in the summer. And cogeneration produces more electricity during the *winter* than during the summer because there are both space-heating and water-heating demands in the winter, whereas there are only water-heating demands in the summer. The combined effect is shown in the figure for a typical day in January (winter) and a typical day in August (summer).

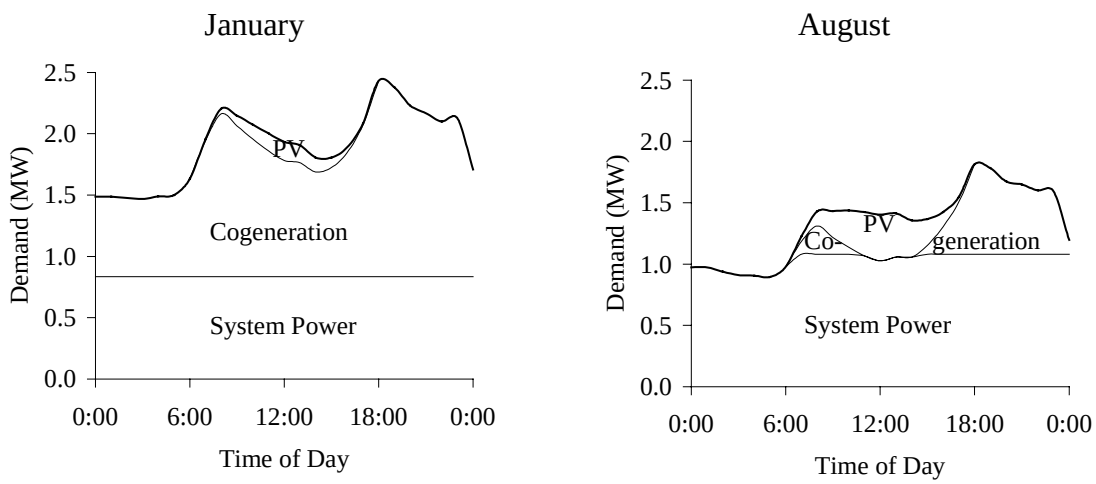

Figure 5. Supply and demand during January and August with 1,500 efficient new homes, 2 megawatts of cogeneration, and 0.5 megawatt of PV.

The Bottomline Economics—Comparing Upgrading with the Distributed Resource Alternative

Here, we summarize the economic results of the analysis for Scenario 5. The Appendix contains the assumptions and spreadsheets used in the economic analysis.

Our key assumptions are:

- 1,500 homes are built over a period of 10 years
- Cogeneration and PV are installed incrementally as the homes are built (annual investments of 200 kilowatts of electricity from cogeneration and 50 kilowatts from PV).
- Cogeneration costs $1,000 per kilowatt of electricity, and 2 megawatts of electricity from cogeneration are eventually installed for a total cost of $2 million.
- The service access fee is $1,000 per new home
- The service access fee is waived for customers who put in a 1-kilowatt PV system (thus, the Co-op is effectively subsidizing PV at a cost of $1,000 per kilowatt)
- 500 customers will put in a 1-kilowatt PV system
- The feeder upgrade costs $2.3 million, and the cost is incurred immediately.

Our economic analysis suggests that:

- The feeder upgrade has a net present value (NPV) of negative $1.2 million. The feeder upgrade is negative because the cost of the feeder is $2.3 million but the service access fees collected from the 1,500 homes over 10 years has a present value of only $1.1 million.
- The distributed-resource alternative has a NPV of positive $0.2 million (the Appendix shows the details of these calculations).
- It appears that the Co-op can save $1.4 million using the distributed resources alternative.[14]

Conclusions and Next Steps—Seriously Consider the Alternative

These results suggest that the Co-op should give serious consideration to exploring the use of distributed resources to satisfy increased demand on the Mazama feeder rather than upgrading the feeder to a transmission line. These are the specific steps that the Co-op could take with new customers on the Mazama feeder.[15]

1. ***Efficiency*** – Encourage/require all new homes to have a reasonable level of energy efficiency (e.g., tightly sealed, well insulated building envelope, use of fluorescent lighting where feasible, high efficiency refrigerators, and propane clothes dryers)
2. ***Cogeneration*** - Work with the Arrowleaf and other new housing developers and Lost River and Edelweiss home owners associations to install district heating rather than electric or propane heating; the Co-op would operate the cogeneration units and sell the heat to the consumers at a rate that is 20% below the cost of customers buying the heat using electricity; this could be the Co-op's first step into the propane business
3. ***Propane Space and Water Heating*** – Encourage all other new homes that go in on the Mazama feeder to use propane for their space and water heating needs; the Co-op could either supply the propane or arrange bulk buying for customers in order to lower the cost of propane.
4. ***Photovoltaics*** – Waive the system access fee (approximately $1,000 per home) for any customer that puts in a 1-kW PV system or greater; work with housing developers and architects to help them offer this to their customers as an optional feature on the new homes

It is recommended that the Co-op obtain the services of a qualified engineering firm to validate the findings in this preliminary report before any investments are made.

[14] In our economic analysis the feeder upgrade has a negative NPV of $1,195,987 while the distributed resource alternative has a positive NPV of $223,527 for a savings of $1,419,514.

[15] While our analysis focused on new homes, retrofits of existing homes, where feasible, could also be part of a distributed resource plan to meet increasing customer demand for electrical power.

Appendix

Table 2. Scenario 5 Inputs.

PV Investment (kW)	500
Cogen Size (kW_{elec}/cust)	2
New Homes	1,500
Cogen Efficiency (Elec)	25%
Cogen Efficiency (Thermal)	65%
Propane Cost ($/gal)	$0.60
Thermal Rate ($/kWh)	$0.042
Electricity cost savings ($/kWh)	$0.030
Cogen O&M Cost ($/$kWh_{elec}$)	$0.02
Cogen Cost ($/kW)	$1,000
PV Incentive ($/kW)	$1,000
Cogen Life (years)	15
Discount Rate	6%
Years to Install All New Homes	10
System Access Fees ($/house)	$1,000
Feeder Upgrade Cost ($)	$2,300,000

Water and Space Heating By Source (cogen must be both water and space heating where used)

	Water Heating			Space Heating		
	Electric	Gas	Cogen	Electric	Gas	Cogen
Current	92%	8%	0%	66%	34%	0%
Retrofit	92%	8%	0%	66%	34%	0%
New Homes	0%	33%	67%	0%	33%	67%

Electricity Consumption as percent of base case

	Lights	Refrigerator	Dryer	Other
Current	100%	100%	100%	100%
Retrofit	100%	100%	100%	100%
New Homes	50%	50%	10%	100%

Table 3. Results.

Year	New Homes	Total New Homes	New PV (kW)	Total PV (kW)	New Cogen (kW)	Total Cogen (kW)	Cogen Elec. Production (MWh/y)	Cogen Thermal Production (MWh/y)	Propane Consump. (gals)
1	150	150	50	50	200	200	470	1,222	68,107
2	150	300	50	100	200	400	940	2,444	136,214
3	150	450	50	150	200	600	1,410	3,666	204,321
4	150	600	50	200	200	800	1,880	4,887	272,427
5	150	750	50	250	200	1,000	2,350	6,109	340,534
6	150	900	50	300	200	1,200	2,820	7,331	408,641
7	150	1,050	50	350	200	1,400	3,290	8,553	476,748
8	150	1,200	50	400	200	1,600	3,759	9,775	544,855
9	150	1,350	50	450	200	1,800	4,229	10,997	612,962
10	150	1,500	50	500	200	2,000	4,699	12,218	681,069
11	0	1,500	0	500	0	2,000	4,699	12,218	681,069
12	0	1,500	0	500	0	2,000	4,699	12,218	681,069
13	0	1,500	0	500	0	2,000	4,699	12,218	681,069
14	0	1,500	0	500	0	2,000	4,699	12,218	681,069
15	0	1,500	0	500	0	2,000	4,699	12,218	681,069
16	0	1,500	0	500	0	2,000	4,699	12,218	681,069
17	0	1,500	0	500	0	2,000	4,699	12,218	681,069
18	0	1,500	0	500	0	2,000	4,699	12,218	681,069
19	0	1,500	0	500	0	2,000	4,699	12,218	681,069
20	0	1,500	0	500	0	2,000	4,699	12,218	681,069
21	0	1,500	0	500	0	2,000	4,699	12,218	681,069
22	0	1,500	0	500	0	2,000	4,699	12,218	681,069
23	0	1,500	0	500	0	2,000	4,699	12,218	681,069
24	0	1,500	0	500	0	2,000	4,699	12,218	681,069
25	0	1,500	0	500	0	2,000	4,699	12,218	681,069
26	0	1,500	0	500	0	2,000	4,699	12,218	681,069
27	0	1,500	0	500	0	2,000	4,699	12,218	681,069
28	0	1,500	0	500	0	2,000	4,699	12,218	681,069
29	0	1,500	0	500	0	2,000	4,699	12,218	681,069
30	0	1,500	0	500	0	2,000	4,699	12,218	681,069

Table 4 presents the Co-op's annual cash flows for the distributed resources alternative. Column 1 is the year. Columns 2 through 4 are the positive cash flows (the revenues and electricity cost savings). Columns 5 through 8 are the negative cash flows (finance charges on the cogeneration and other expenses). Column 9 is the net revenue (positive cash flows minus the negative cash flows). Column 10 is the discounted net revenue for each year. The bottom of Column 10 shows that the discounted net revenue, i.e., the net present value, equals $223,527.

Table 4. Economic Results

1	2	3	4	5	6	7	8	9	10
Year	System Access Fee Revenue ($)	Cogen Thermal Revenue ($)	Cogen Electricity Cost Savings ($)	Annual Cogen Capital Cost	Propane Expense ($)	Cogen O&M Expense ($)	PV Incentive Cost	Net Revenue	Discounted Net Revenue
1	$ 150,000	$ 51,684	$ 14,098	$ (20,593)	$ (40,864)	$ (9,399)	$ (50,000)	$94,926	$89,553
2	$ 150,000	$ 103,367	$ 28,196	$ (41,185)	$ (81,728)	$ (18,797)	$ (50,000)	$89,853	$79,969
3	$ 150,000	$ 155,051	$ 42,294	$ (61,778)	$ (122,592)	$ (28,196)	$ (50,000)	$84,779	$71,182
4	$ 150,000	$ 206,735	$ 56,392	$ (82,370)	$ (163,456)	$ (37,595)	$ (50,000)	$79,706	$63,134
5	$ 150,000	$ 258,419	$ 70,491	$ (102,963)	$ (204,321)	$ (46,994)	$ (50,000)	$74,632	$55,769
6	$ 150,000	$ 310,102	$ 84,589	$ (123,555)	$ (245,185)	$ (56,392)	$ (50,000)	$69,558	$49,036
7	$ 150,000	$ 361,786	$ 98,687	$ (144,148)	$ (286,049)	$ (65,791)	$ (50,000)	$64,485	$42,886
8	$ 150,000	$ 413,470	$ 112,785	$ (164,740)	$ (326,913)	$ (75,190)	$ (50,000)	$59,411	$37,275
9	$ 150,000	$ 465,153	$ 126,883	$ (185,333)	$ (367,777)	$ (84,589)	$ (50,000)	$54,338	$32,162
10	$ 150,000	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ (50,000)	$49,264	$27,509
11	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$26,727
12	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$25,214
13	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$23,787
14	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$22,441
15	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$21,170
16	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$19,972
17	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$18,841
18	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$17,775
19	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$16,769
20	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$15,820
21	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$14,924
22	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$14,079
23	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$13,283
24	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$12,531
25	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$11,821
26	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$11,152
27	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$10,521
28	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$9,925
29	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$9,364
30	$ -	$ 516,837	$ 140,981	$ (205,926)	$ (408,641)	$ (93,987)	$ -	-$50,736	-$8,834
								NPV	$223,527

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Further Reading

Papers that describe several of the concepts referred to in this report in more detail can be obtained from the Internet site: **www.clean–power.com**.