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October 13, 2016

Wood River Community Advisory Committee Members

Subject: Wood River Valley Transmission Line Update

Dear Advisory Committee Member:

Update on Recent Activities

Idaho Power began the construction phase to replace the King to Wood River 138-kilovolt (kV) transmission line this summer. This project is one of the two near-term priority projects identified in the 2007 Community Advisory Committee (CAC) process. The construction activity is going well and the replacement is scheduled to be complete next year. This replacement line, in combination with the prior modifications to the Midpoint to Wood River 138 kV line, will provide increased capacity and reliability to the Wood River substation in Hailey.

You may have noticed the increased Hailey to Ketchum redundant transmission line coverage in the Mountain Express recently. Idaho Power has been actively engaged with the local jurisdictions this past summer. The Blaine County Planning and Zoning Commission hearing on transmission line will take place today. Later this month, Idaho Power will file an application for a Certificate of Public Convenience and Necessity with the Idaho Public Utilities Commission to construct the Hailey to Ketchum 138 kV redundant transmission line.

Another area of activity has centered on local backup generation. Individuals in the Wood River Valley have asked whether local electric generation resources combined with the distribution grid (i.e., a microgrid) would be a cost-effective solution to increasing the reliability of service to the northern portion of the Wood River Valley. This prompted a CAC member to ask for updated local backup generation information. The attached report provides a summary of Idaho Power's recent work in this area and an updated analysis of microgrid requirements and capability. Idaho Power's preliminary and conceptual investigation reveals that the cost to provide a 65-megawatt (MW) microgrid with backup generation for a 24-hour period ranges from approximately $57 million (diesel engine system) to $955 million (photovoltaic [PV] plus battery system).

Alternate Generation Background

Idaho Power has been engaged with alternate energy resources for many years. During the 1990s, Idaho Power developed a tariff for the installation and maintenance of solar PV and battery systems for remote electrical energy requirements. Idaho Power contracted for the first utility-scale wind project to interconnect to our system near North Powder, Oregon. This was

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followed by agreements to purchase geothermal generation from facilities located south of Malta, Idaho, and west of Vale, Oregon. Alternate energy resources are evaluated along with traditional resources during the development of the biennial Integrated Resource Plan (IRP).

During the 2007 Community Advisory Committee process, Idaho Power shared information about alternative energy generating technologies. The discussion included wind, solar, geothermal, fuel cells, and combustion turbine technologies. At that time, Idaho Power identified that small-scale solar could provide energy to the region but would not act as a true backup source because of its intermittent qualities. Idaho Power also identified a suitable geothermal electric generating resource in the Moonstone area but noted that "it would still require electrical transmission to deliver the energy to Valley residents."

Since 2014, Idaho Power has taken part in three primary activities to explore alternative energy generating technologies in relation to the Wood River Valley. First, Idaho Power brought together the Wood River Renewable Energy Working Group to better understand the desire for renewable resources and work collaboratively with Wood River Valley residents to explore the feasibility of creating one or more new energy products to help serve the valley. The group explored the following electric generation resources: solar, wind, geothermal, hydro, fuel cells, batteries, biomass, and bio digesters. The group also developed revisions to Idaho Power's Green Power Program to enable customers to offset a portion or all of their energy use with renewable energy through the purchase of renewable energy credits, or green tags.

Second, during this process, backup power questions were raised, and Idaho Power provided some high-level conceptual cost estimates for a storage and diesel project. These estimates revealed that the cost of such options—particularly storage—far exceeded the estimates of the installation of a redundant transmission line.

Third, in 2015, two Idaho Power employees attended the Rocky Mountain Institute eLab Accelerator workshop. This workshop was focused on collaborative innovation to address technical barriers to the economic deployment of distributed resources, with representatives from the City of Ketchum, Sun Valley Company, and NRG. Idaho Power provided load data and ideas at the workshop and developed the two report appendices following the workshop in continued support of the collaborative effort. To my knowledge, these two reports and a confidential presentation from NRG are the only items that were shared with the eLab team since the workshop.

Idaho Power's engineers spent notable time working on Rocky Mountain Institute's eLab Accelerator project. Indeed, representatives from the City of Ketchum openly applauded Idaho Power's participation, stating, "eLab Accelerator was extremely important to help us get started, to get to know the other stakeholders, to hear from national experts, and to grow trust. *Bringing the utility together with the community was key* [emphasis added]." For more information on Idaho Power's efforts, please see http://blog.rmi.org/blog_2015_09_08_elab_accelerator_explores_resilience_options_in_sun_valley.

Alternate Generation Analysis

The attached report summarizes Idaho Power's recent analysis of resources to provide service to the northern portion of the Wood River Valley during an outage of the existing 138-kilovolt (kV) Hailey to Ketchum transmission line. This report was produced by Idaho Power staff with some independent technical review and feedback from the Idaho National Laboratory (INL). Idaho Power has an internal team focused on 1) seeking opportunities for funding sources for piloting alternative technologies and 2) evaluating non-traditional approaches to resolve distribution voltage and equipment overload issues. This team of engineers has been evaluating potential applications of PV generation and battery storage technology the last few years. Employees on this team simulated and contracted for the installation of 18 kilowatt (kW) of PV to mitigate a system voltage issue, participated in the solicitation process for 500 kW of PV, and solicited budgetary quotes for a 500 kilowatt-hours (kWh) energy storage system in response to an Oregon grant opportunity.

Over the past decade, these employees have developed a relationship with energy system researchers from the INL. The INL researchers are leaders in implementing reliable energy systems, with more than 1,000 MW of hybrid power, solar, and wind energy systems deployed at Department of Defense and industry/utility sites around the world. Based on this existing relationship, Idaho Power was able to solicit some assistance on the analysis and report from an INL researcher.

The costs provided in the report have been largely obtained from third-party resources. The report contains references to these third parties throughout the document. Although the attached report contains helpful information related to renewable technologies, it is still conceptual in nature. Idaho Power would need to take part in extensive design and engineering work to provide more detailed estimates.

Idaho Power Electric Energy

Idaho Power's renewable portfolio is significant. In addition to our 1,660 MW nameplate hydroelectric fleet, Idaho Power has about 727 MW of wind, 35 MW of geothermal, 29 MW of biomass, and 290 MW of utility-scale solar installed or planned to be installed through the end of 2017. To put this additional 1,081 MW of renewable resources into perspective, Idaho Power's average load is approximately 1,800 MW.

In addition, Idaho Power continues to produce electricity while reducing carbon emissions. Since 2015, Idaho Power has reduced carbon emissions by over 20 percent. Idaho Power is ranked as the 41st-lowest carbon dioxide emitter among the nation's 100 largest electricity producers. These reductions are present during the winter months where greater than 60 percent of the fuel mix during the 2015 to 2016 winter months was sourced from hydro and renewable sources.[1]

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[1] Because Idaho Power sells (or does not own) the renewable energy certificates or "green tags" associated with certain projects in its resource portfolio, and uses the proceeds to benefit customers, Idaho Power is not permitted to state that renewable energy from those projects is delivered to customers.

Summary

Since 2007, Idaho Power has been engaged in meetings with various members of the Wood River Valley and held numerous discussions on reliability and renewable energy issues. The attached report provides a high-level summary our assessment of local backup generation options. All these options include higher initial and ongoing maintenance costs compared to a transmission line alternative.

Thank you for your continued interest and participation in our community advisory process.

Sincerely,

David M Angell

Manager, Customer Operations Planning

enclosure: Northern Wood River Valley—Local Backup Electrical Supply Report

Northern Wood River Valley—Local Backup Electrical Supply Report

Customer Operations Planning

October 2016

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LIST OF ACRONYMS

BESS—Battery Energy Storage System

CT—Natural Gas Combustion Turbine Generation

DRE—Diesel Reciprocating Engine Generation

F—Fahrenheit

HOMER—Hybrid Optimization of Multiple Energy Resources

INL—Idaho National Laboratory

kV—Kilovolt

kW—Kilowatt

m^2—Square Meter

MW—Megawatt

MWh—Megawatt-Hour

NREL—National Renewable Energy Laboratory

O&M—Operation and Maintenance

PV—Photovoltaic

EXECUTIVE SUMMARY

This document presents the results of a preliminary study to provide the northern Wood River Valley customers served by the Ketchum and Elkhorn substations with backup electrical supply from locally sited generation. The resources considered in the study are diesel reciprocating engine (DRE), natural gas combustion turbines (CT), photovoltaic (PV) plus battery energy storage system (BESS), geothermal generation, and biomass generation.

The analysis was performed using industry-standard energy resource simulation software, HOMER®, which was developed by the National Renewable Energy Laboratory (NREL). The capital, operations and maintenance (O&M), and fuel cost estimates for the resources identified above were obtained from *Lazard's Levelized Cost of Energy Analysis—Version 9.0* (Lazard 2015a). Idaho Power also compared the Lazard estimated with pre-engineering budgetary quotes from several vendors. Additionally, the Idaho National Laboratory (INL), with more than 1,000 megawatts (MW) of hybrid power, solar, and wind energy systems deployed at Department of Defense and industry/utility sites around the world, provided independent technical review and feedback on the analysis and report.

Table 1 summarizes the estimated equipment, installation, O&M, and fuel cost of each resource. The following assumptions were made: 1) the area served requires 60 MW of peak power based on an Idaho Power study of the requirements to maintain residential and commercial building at 55 degrees Fahrenheit (F) (see Appendix A); 2) the total energy consumed during the 24-hour period would be 1,150 megawatt-hours (MWh); and 3) the PV peak output of the area would be 21 MW based on Idaho Power's *Solar Availability in Ketchum* study (see Appendix B). The diesel generator and battery equipment costs were compared against budgetary quotes received during the last year. This study and the estimates provided are preliminary and conceptual in nature. Therefore, Idaho Power cannot guarantee any cost estimates based on this preliminary analysis.

Table 1. Resource cost summary

Resource	Manufacturer Equipment Cost	Total Installation Cost	O&M Annual Cost	24-Hour Fuel Cost
Diesel Engine	$800/kW	$57,000,000	$1,000,000	$197,000
Gas Turbine	$1500/kW	$101,000,000	$455,000	$41,000
PV plus Battery Storage	$800/kWh	$924,000,000	$3,450,000	$46,000

The analysis demonstrates that the most economical way to provide backup electrical supply from local generation (i.e., a microgrid) is by either diesel engines or gas turbines. With respect to the other resources considered, the study area does not have a geothermal resource suitable for electrical generation, and biomass generation costs are significantly higher and the startup time would be substantially longer than for diesel engines or gas turbines. Additionally, the biomass generation would require more investigation into the availability of and cost to extract the local biomass material. Finally, the large winter energy requirement results in a cost-prohibitive battery system at this time.

The study does not address, among other things, the ability to site, permit, or determine the operational limitations that might be imposed on the electrical generation resources. Idaho Power contacted Intermountain Gas to verify the ability to supply natural gas to fuel the generators. However, a response was not provided by the time of report distribution.

Scope

The intent of this study is to provide a preliminary examination of the resource capital (including equipment procurement, installation, land, and grid integration costs); operation and maintenance (O&M); and fuel costs of local generation resources that may be used to supply backup electrical energy for the customers served by the Ketchum and Elkhorn substations. The assessment of the capital and O&M costs are based on the pre-engineering estimates of the performance and cost of commercial or near-commercial technology available at the time of this study.

Local permitting requirements, environmental mitigation, and noise levels for diesel and gas turbine plants were not considered in this study.

Study

This study considered a scenario in which the 138-kilovolt (kV) Hailey to Ketchum transmission line is out of service for a 24-hour period during the winter. The present winter peak load in the area is 60 megawatts (MW) and is projected to reach 65 MW by 2025. The model simulated a single year in 1-hour intervals using each resource and a combination of them. A previous study shows that winter load cannot be substantially reduced by rotating outages but could be reduced by 11 percent if thermostats could be automatically set to 55 degrees during an outage, resulting in a reduction of the forecasted 2025 recent peak loads (see Appendix A). A load profile, shown in Figure 1, modified to reflect reduced Bald and Dollar Mountain operations for December 31, 2015, is used to simulate the total energy consumed during the 24-hour period of 1,150 megawatt-hours (MWh). Idaho Power recognizes that a transmission structure failure during the winter may require several days to repair. The 24-hour period is used merely to determine a base cost. This cost could be multiplied by the desired days of backup service to establish the total cost of a local backup resource option.

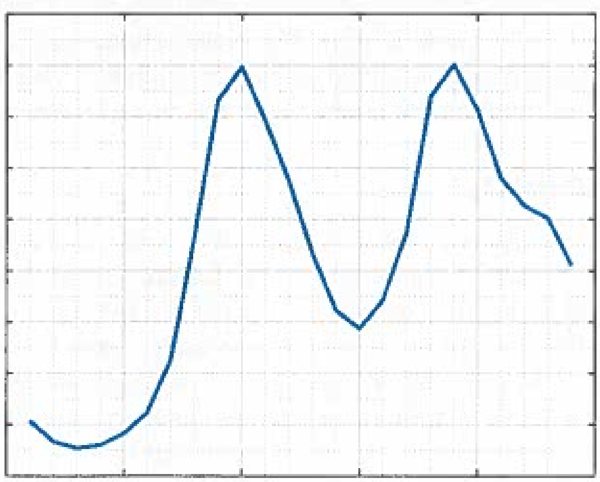

Figure 1. December 31, 2015, load profile

With the transmission line out of service, the customers served by both Ketchum and Elkhorn substations need to be served by the evaluated alternative resource. The study assumes Ketchum and Elkhorn substations respectively supply 46 and 14 MW of the 60 MW peak load.

The generator sizes have been selected based on commercially available units that can manage load restoration and provide reactive power requirements of the loads. These selections result in a total generation capacity of about 110% of the peak load.

LAND AND INTERCONNECTION REQUIREMENTS

Over one acre of land would be required for the diesel reciprocating or combustion turbine generators. It is likely that additional land would be required to site the battery system. The interconnection cost estimates include the transformer, protection, and control systems to interface with the existing substations. The estimated land and interconnection costs are shown in Table 2.

Table 2. Land and interconnection costs

Substation Site	Land Cost	Interconnection Cost	Total
Ketchum	$1,306,800	$862,000	$2,168,800
Elkhorn	$871,200	$558,000	$1,429,200
Total	$2,178,000	$1,420,000	$3,598,000

RESOURCES CONSIDERED

The resources analyzed in the study are diesel reciprocating engine generation (DRE), natural gas combustion turbines (CT), photovoltaic (PV) plus battery energy storage system (BESS), geothermal generation, and biomass. The costs for each resource were obtained from *Lazard's Levelized Cost of Energy Analysis—Version 9.0* (Lazard 2015a). The diesel engine and battery storage costs were compared against budgetary quotes received during the last year. The Idaho National Laboratory (INL) provided feedback on their experience with the cost of the resources.

Diesel Reciprocating Generators

DRE remains the most common choice for emergency power systems worldwide. It is a mature resource that has provided backup power for decades. According to the Lazard (2015a) report, the capital cost for installing DRE can range from $500 per kilowatt (kW) to $1,000 per kW. This price does not include the cost of land or the cost to interconnect to the system. The price of diesel fuel is assumed to be $2.50 per gallon, and the O&M costs for a diesel generator are $15 per kW per year and $15 per MWh (Lazard 2015a). These reciprocating generators could be fueled by natural gas with the fuel pricing shown in the following Natural Gas Combustion Turbine section.

A quote from a vendor during the third quarter of 2016 shows the price of diesel generators is close to the upper end of the range discussed in the Lazard report.

Natural Gas Combustion Turbines

The use of gas turbine technology, while not as common as diesel generation, has increased in recent years as an alternative to providing backup power. According to the Lazard (2015a) report, the capital cost for installing CT can range from $2,500 per kW to $2,700 per kW. However, the INL provided information that shows the cost of CT as being as low as $1,500 per kW. The price does not include the cost of land or the cost to interconnect to the system. The fuel price for natural gas is $0.124 per cubic meter ($m^3$) and the O&M costs associated with CT are $6.85 to $9.12 per kW per year and $7.0 to $10.9 per MWh.

Battery Energy Storage System

One of the emerging technologies used for providing backup power is the BESS. Even though batteries do not generate electricity, they can be charged from the grid and can provide backup power when the grid is off-line. Because of the size and application of the project, a flow battery was chosen for the study with a price of $800 per kWh (Lazard 2015b).

Solar Photovoltaic

The solar capability of the Ketchum area was determined by approximating the amount of residential and commercial roof area suitable for PV installation and following National Renewable Energy Laboratory (NREL) guidelines. The results show that an estimated roof area of 112,578 square meters (m^2) is suitable for roof-mounted PV installation. See Appendix B for the complete study.

Based on the calculated roof area available to install solar PV, the total amount of PV that could be installed in the Ketchum area is 21.4 MW_{dc}. The solar irradiance was obtained for the Ketchum area using NREL's PVWatts calculator. This level of PV penetration may take many years to achieve but is included in the study to represent a potentially reduced level of energy storage requirements in the future.

Geothermal

The geothermal resource was reviewed through the NREL Geothermal Prospector tool (NREL 2016) and is supported by an Idaho Department of Water Resources 1990 report (ID DWR) reference by INL during a Wood River Renewable Working Group presentation on geothermal. The NREL tool indicates the Ketchum area has class 2 and class 3 geothermal resources. Both geothermal classes could support residential or commercial heating but would be inadequate for power generation. The INL researcher, during his presentation, identified only the Magic Hot Springs thermal resource as suitable for electrical generation.

Biomass

According to the Lazard (2015a) report, the capital cost of installing biomass ranges from $3,000 per kW to $4,000 per kW. The installation cost for 60 MW of biomass generation would likely exceed $200,000,000. The biomass option has not been fully evaluated based on the comparably higher capital cost; large land requirements; and uncertainty of fuel capacity, expense and emission requirements.

Results

The analysis evaluated each resource total cost (capital, O&M) and the HOMER simulation results. Additional simulation results are provided in Appendix C.

Total Installed Costs

The locations of the proposed diesel generators, gas turbines, and battery systems were split onto the 2 main sites—50 MW of generation were added to the Ketchum Substation and 15 MW at the Elkhorn Substation. The capital costs for each resource are shown in Table 3. The resources for the capital costs are based on the following: 1) the diesel generation price is based on the Lazard (2015a) report and verified with a Wartsila Company budgetary level quote, 2) the gas combustion turbine price is based on $1,500 per kW which is situated between the microturbine price and the gas peaker plant in the Lazard (2015a) report, and 3) the battery price is based on $800 per kWh for the battery system and assumes 21 MW of local PV installed by others. The size of the battery was calculated based on the energy needs for a one-day outage. The capital cost of the battery will increase if the backup power is needed for more than a single day.

Table 3. Capital costs

Resource	Capital cost
Diesel Generation	$57,000,000
Gas Turbine	$101,000,000
PV plus Battery System	$924,000,000

O&M Cost

There are two components to the O&M cost. The first is a fixed annual cost based on the size of the generator and the routine start-up and operation of the generator, typically 4 hours per month. The second component is directly proportional to the operation time of the generators during an outage of the existing transmission line. Table 4 shows the fixed annual cost for fuel and O&M.

Table 4. O&M costs

Resource	Fixed O&M (per year)
Diesel Generation	$1,000,000
Gas Turbine	$455,000
PV plus Battery System	$3,450,000

The study assumed the existing Hailey to Ketchum 138-kV transmission line was out of service for 1 day. Table 5 shows the fuel cost when operating the diesel generators and gas turbines, and the electricity cost (energy delivered to the battery with associated transmission and substation costs) for charging the battery.

Table 5. Fuel costs for a 1-day transmission outage

Resource	Variable Fuel
Diesel Generation	$197,000
Gas Turbine	$41,000
PV plus Battery System	$46,000

CONCLUSIONS

A study to provide backup power to the Ketchum and Elkhorn area using local generation was performed. The study demonstrates that the use of DRE is the more cost-effective of the local resources considered. A local geothermal generation resource is not available. Biomass generation will require a significantly higher capital cost and require much more resource investigation. Finally, a battery system is cost-prohibitive at this time.

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Appendix A

Power usage distribution

Power Usage Distribution

For Use with the Ketchum Energy Resilience Team

August 2015
Idaho Power
Mike Beacham

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POWER USAGE DISTRIBUTION

Background

A multi-stakeholder team, including the City of Ketchum, Sun Valley Company, Idaho Power, and NRG, attended the Rocky Mountain Institute's Electricity Innovation Lab (e-Lab) during March of 2015. The team is exploring the feasibility of reducing demand during an emergency event (e.g. loss of transmission) and supplying the demand with local generation. To that end, this report breaks down the electricity demand during extreme winter conditions (peak demand energy) into usage categories. With that breakdown, the benefit of various demand response programs can be estimated.

There are different ways to look at electricity usage: energy (the amount of electricity consumed over time) and demand (the amount of electricity being used at a given time). This study focuses on annual energy and peak demand. Annual energy is the total energy used over the period of one year, and does not include data on the distribution of the energy usage throughout the year. Peak demand is based on the time when electricity usage is at its highest value.

Calculations

This study is focused on obtaining a breakdown of how electricity is used during the peak. Three independent methods were used. Method 1 uses annual energy and temperature data to obtain peak demand. Methods 2 and 3 analyze daily data and determine the usage distribution at peak demand from the results.

Method 1: Temperature Based Energy Usage

The first method for determining system loading utilizes statistics to determine peak demand from annual energy usage and temperature data. According to the US Energy Information Administration, annual energy usage in the Mountain North region of the United States (which includes Idaho) can be broken down as follows:

- 50% heating
- 29% appliances
- 19% water heating
- 2% air conditioning (AC)

The breakdown of loads during the winter peak can be estimated using temperature data.

Daily Heating Calculation

Daily temperature values were used to calculate the number of Heating Degree Days (HDD) or Cooling Degree Days (CDD). One HDD (or CDD) represents a need to raise (or lower) the inside temperature one degree on that day. Days with a small HDD (under 20) were not considered to have a significant portion of energy dedicated to heating. This resulted in a total of 161 days where heating was considered to be a significant portion of energy usage. Assigning all of the heating energy to those 161 days yields cold weather energy ratios.

Variable Name	Meaning
HDD	Heating degree days
SWR	Seasonal water heater energy usage ratio
SAR	Seasonal appliances energy usage ratio
YWR	Yearly water heater energy usage ratio
YAR	Yearly appliance energy usage ratio
NWP	New water heating energy usage percentage ratio
NAP	New appliance energy usage percentage ratio
STR	Scaling factor to have 100% total for all percentages after new ratios
HR	Heating Energy Ratio
NHR	New adjusted heat energy ratio

Table 1: Acronyms used in Temperature Based Energy Usage: Daily Heating Calculations

The base household load (water heaters, appliances, etc.) are considered to be consistent from season to season. Based on the percentages above, the amount of energy used by hot water heaters during the cold weather period considered was calculated.

$$SWR = YWR * \frac{HDD}{365\ days}$$

$$SWR = 19\% * \frac{161}{365} = 8.53\%$$

The amount of energy used by appliances and lighting was also calculated.

$$SAR = YAR * \frac{HDD}{365\ days}$$

$$SAR = 29\% * \frac{161}{365} = 13.02\%$$

A percentage of energy used during the cold weather period was calculated.

$$STR = SWR + SAR + HR$$

$$STR = 8.53\% + 13.02\% + 50\% = 72.63\% = .72.63$$

$$NWP = \frac{SWR}{STR}$$

$$NWP = 8.53\% * \frac{1}{.7263} = 11.8\%$$

$$NAP = \frac{SAR}{STR}$$

$$NAP = 13.02\% * \frac{1}{.7263} = 18.0\%$$

$$NHR = \frac{HR}{STR}$$

$$NHR = 50\% \frac{1}{.7263} = 70.3\%$$

With this method, winter loading was estimated to be 70.3% heating, 18.0% appliances, and 11.8% water usage.

Method 2: Population and Occupancy Based Energy Usage

The second method is based upon average hourly customer energy consumption and area population. One consideration to take into account is the large number of cabins and non-permanent residences. In order to more accurately determine the division of energy usage, the area occupancy must first be determined.

Occupancy Calculation

The ratio of population in Ketchum and Sun Valley, relative to all cities and towns within Blaine County is 27.4%. Assuming a proportional amount of people reside near towns, but not within city limits, the total permanent residences within the service area can be calculated.

Variable Name	Meaning
PPT	Percentage of population in Ketchum and Sun Valley
KCHM	The population of the town Ketchum
SV	The population of the town of Sun Valley
Towns	The population of all towns in Blaine County
NPT	Total population near, but not in, Ketchum or Sun Valley
TR	Temporary residences (I.E. Rentals, vacation homes)

PRP	Permanent resident population in or near Ketchum or Sun Valley
IPC	Idaho Power customer points
NPOR	Number of permanently occupied residences
CRO	Current residences occupied
MOR	Monthly Occupancy Rate
VH	Vacant homes or residences
EPVH	Number of vacant homes at energy peak
EPOR	Energy peak occupancy rate
ERKWH	Extreme year residential Kilowatt hours (kWh)
ESCKWH	Extreme year small commercial customer kWh
ELCKWH	Extreme year large commercial customer kWh
EVH	Energy use in vacant homes (not appliances, lighting or AC)

Table 2: Acronyms used for Occupancy Calculations

$$PPT = \frac{KCHM + SV}{\sum Towns}$$

$$PPT = \frac{2706 + 1408}{15019} = 27.4\%$$

$$NPT = (PPT) * (Blaine\ Co\ Pop - \sum Towns)$$

$$NPT = (27\%) * (21376 - 15019) = 1741$$

In Ketchum, the average household size is 1.88, in Sun Valley, 1.95, and in Blaine Co. as a whole, 2.40.

$$NPOR = {}^{NPT}/_{2.40} + {}^{KCHM}/_{1.88} + {}^{SV}/_{1.95} = 2887$$

Comparing the number of permanent residences to number of IPC meters in the same area, the number of vacation homes can be determined.

$$TR = IPC - NPOR = 7575 - 2887 = 4688$$

The occupancy rate of vacation homes is assumed to be the same as the occupancy rate of hotel rooms and cabins from rental agencies. Adding the number of permanent residents to the number of temporary residents gives an approximation of the occupancy for any given month.

$$CRO = NPOR + (MOR * TR)$$

$$CRO(January\ 2014) = 2887 + (42\% * 4688) = 4856$$

The vacant homes are assumed to have base loads of heating and water heating, but no appliance or AC usage. The number of vacant homes is the difference between number of residential IPC customers and the number of occupied homes in the area.

$$VH = IPC - CRO = 7575 - 4856 = 2719$$

Loading Calculations Based on Occupancy

Along with the number of occupants present, the extreme day kWh usage data can then be used to calculate the amount of load for different times of the year. Comparing the peak day kWh average to a typical summer day, an approximation for heat loading can be made by assuming that loading (other than heat) is the same for both days. For the peak day, the calculation is as follows:

$$Peak\ Load = ERKWH * [EPOR + EVH\% * EPVH] + ESCKWH * (\#Small\ Customers) + ELCKWH * (Large\ Customers)$$

$$Peak\ Load = (3.92kWh) * [5372 + 83\% * 2203] + (1.99kWh * 767) + (13.67kWh * 838) = Peak\ Load = 39824$$

On a normal summer day, where there would be no heating or AC load, the calculation is:

$$Loading = ERKWH * \left[\frac{CRO}{(CRO/EPOR)} + (EVH\ \%) * \left(\frac{VH}{VH/EPVH}\right)\right] + ESCKWH * (\#\ Small\ Customers) + ELCKWH * (\#Large\ Customers)$$

$$Loading = (.91\ kWh) * \left[\frac{4856}{4856/5372} + \left(38\% * \frac{2719}{2719/2203}\right)\right] + 0.65 * 767 + 7.75 * 838 = 12671\ kWh$$

The difference between the two energy usages is the amount of heat energy being used, which can be used to find the percentage of energy used for heating:

$$Heat\ energy = \frac{Peak\ Usage\ Day - Similar\ Day}{Peak\ Usage\ Day}$$

$$\text{Heat Energy Percentage} = \frac{39824 - 12671}{39824} = 68.18\%$$

Based on occupancy data, and 2014 power usage statistics, the percentage of demand at peak that is due to heat load is 68.18%

Method 3: Energy Usage Based Calculations

Seasonal variations in energy usage and knowledge of the area can give some measure of how energy is used. The area of study is a winter peaking area, with much larger load demand in the colder months. A load duration curve is shown in Figure 1. The Ketchum and Elkhorn energy usage is measured hourly, and then sorted from highest (winter peak load) to lowest. Using the calculations in Method 1, 161 days of the year (44.11%) are considered cold weather, which leaves 55.89% of days as non-heating days. Therefore, the points between 0% and 44.11% are considered to have occurred during heating periods, and any between 44.11% and 100% occurred during non-heating periods.

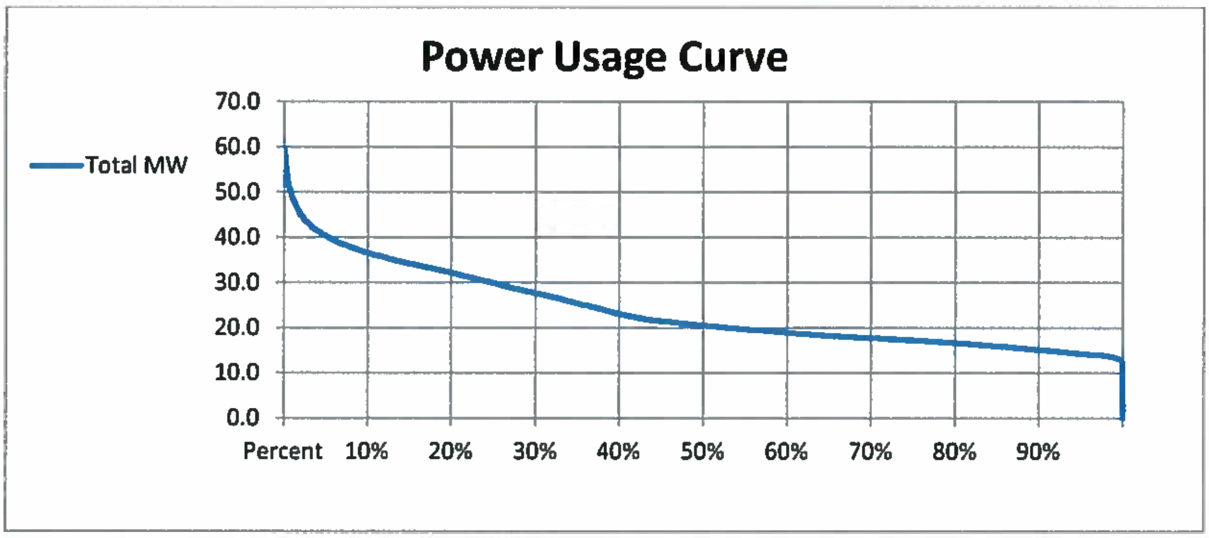

Figure 1: Hourly Energy Consumption.

The energy usage per hour for a non-heating day was averaged to represent a typical hourly load (17.5 MWh). This was then considered to be normal usage for all non-heating loads year round. To calculate the amount of heating load, the average energy usage was subtracted from the total demand during the chosen heating period, and then a percentage was taken based on that amount.

$$\text{Heating Load Percentage} = \frac{\text{Total Energy during Heating} - (\text{Avg. Usage} * \text{Hours heating})}{\text{Total Energy during Heating}}$$

$$\text{Cold weather period heating load} = \frac{116760 - (17.7 * 3592\ hrs)}{116760} = 48.9\%$$

$$\text{Peak Demand heating contribution} = \frac{1360 - (17.7 * 24)}{1360} = 69.2\%$$

During the periods heating is used, 48.9% of the total energy is used to heat buildings. The heating load is 69.2% of the peak demand.

Results

For the Ketchum and Sun Valley area, heating load for homes is between 50 and 60% of total load during the majority of the winter peak with extreme days reaching near 70%.

APPLICATION: HEAT LOAD REDUCTION

Using the results

A method for determining the heat load of a home based on indoor and outdoor temperature was determined in the report "Property Protection Analysis Report" (PPAR). This method can be used to determine the percentage of heating load that can be reduced by lowering thermostats from a comfortable setting to an emergency setting.

Calculations

On an extreme winter day, the PPAR determined that it takes 20.32 kWh to heat an average home to 70 degrees, compared to the 16.97 kWh required to heat the same home to 55 degrees. There is a 16.5% reduction in heat load usage.

$$\text{Reduction} = \frac{20.32\ kWh - 16.97\ kWh}{20.32\ kwH} = 16.5\%$$

Taking the peak demand in the Ketchum/Sun Valley area, less the average summer usage (defined as non-heating load above), we can then calculate the reduced heating load. Using that value, the energy savings, or net reduction can be calculated as well.

$$\text{Heat Load} = \text{Peak Load} * \text{Heating Percentage}$$

$$\text{Heat Load} = 59.6\ MW * 69.2\% = 41.2\ MW$$

$$\text{Other Loads} = \text{Peak Load} - \text{Heat Load}$$

$$\text{Other Loads} = 59.6\ MW - 41.2\ MW = 18.4\ MW$$

$$\text{Reduced Heat Load} = \text{Heat Load} * (1 - \text{Reduction})$$

$$\text{Reduced Heat Load} = 41.2 * (1 - 16.5\%) = 41.2 * (83.5\%) = 34.6\ MW$$

$$Reduced\ Peak\ Load = Reduced\ Heat\ Load + Other\ Loads = 34.6\ MW + 18.4\ MW = 52.8\ MW$$

$$Load\ Reduction = Heat\ Load * Reduction = 41.2\ MW * 16.5\% = 6.6\ MW$$

$$Total\ Peak\ Load\ Reduction\ Percentage = \frac{Reduced\ Total\ Load}{Peak\ Load} = \frac{53.0\ MW}{59.6\ MW} = 11.07\%$$

Conclusions

It is possible to reduce the demand in the area by a maximum of 11.07% with a reduction in thermostat settings on an extreme winter day.

The peak demand breakdown by percentage contribution before and after energy reduction has been determined:

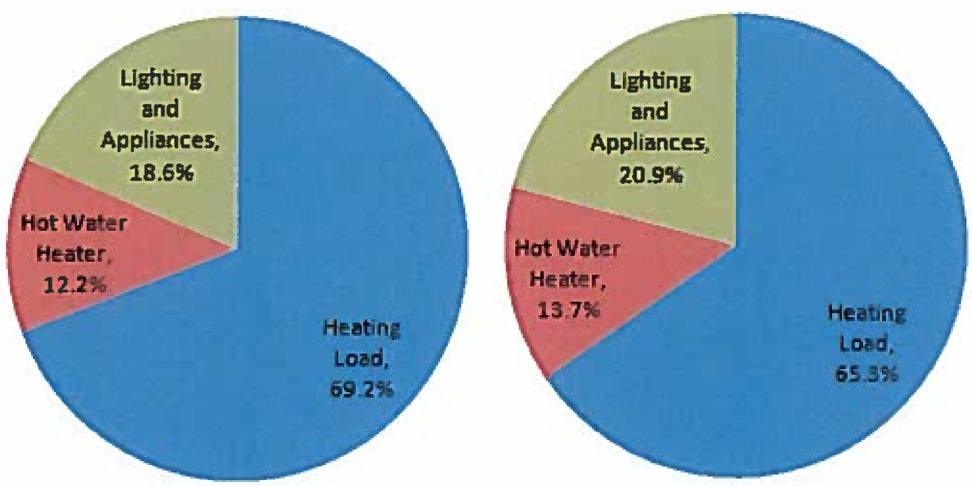

Figure 2: Energy usage by percentage before and after load reduction takes place.

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Appendix B

City of Ketchum Solar Generation Assessment

Via email

August 11, 2015

Ketchum e-Lab Team Members

Subject: City of Ketchum Solar Generation Assessment
Dear e-Lab Team Member:

I directed members of the Idaho Power Customer Operations Planning staff to undertake a high-level assessment of the photovoltaic resource within the city limits of Ketchum, Idaho. In order to estimate this solar photovoltaic (PV) resource capacity, Idaho Power developed a sampling technique to approximate the amount of residential and commercial roof area suitable for photovoltaic installation. This sampling is based on the existing land use which is comprised of 52.87% residential, 7.85% commercial and 39.28% undeveloped area. A sample area of 0.28 square miles, which matched the city land use, was selected as shown in Figure 1. The roof area within the area was computed.

Figure 1: Sample Area

This available area was reduced by roof geometry, near shading, orientation, and other considerations following guidelines outlined by the National Renewable Energy Laboratory (NREL) (http://www.nrel.gov/docs/fy14osti/60593.pdf) to determine the roof area suitable for PV installation. This NREL document identifies 25% of residential and 60% of commercial roof area is suitable for PV installation. The area was further reduced by 50% to match the average net-metering installation in the area. This resultant roof area was scaled to the area of the Ketchum City limits and produced 112,578 m² of PV suitable roof area.

An estimate of the daily energy produced by the suitable roof area was calculated using the solar intensity data from the NREL PVWatts program (http://pvwatts.nrel.gov/). Standard efficiencies for the PV panels and inverter were applied, 16% and 95.6% respectively.

During December and January, there are only eight hours of sun light in the Ketchum area which produces an average daily solar radiation of 2.54 kWh/m² and 1.64 kWh/m², respectively, as reported in the typical meteorological year (TMY3) data from NREL for the Hailey, ID area. This solar irradiance, estimated roof area and the efficiencies result in December and January daily generation ranging from10-30 MWh. The city's daily load during this time period ranges from 300-790 MWh.

Figure 2 provides a winter example of the PVWatts data for December 23. The average solar irradiance for that day is 1.27 kWh/m². This irradiance coupled with estimated roof PV coverage would produce 21.64 MWh of PV Generation. In comparison, the December 23, 2014 Ketchum city customer consumption was 519.75 MWh.

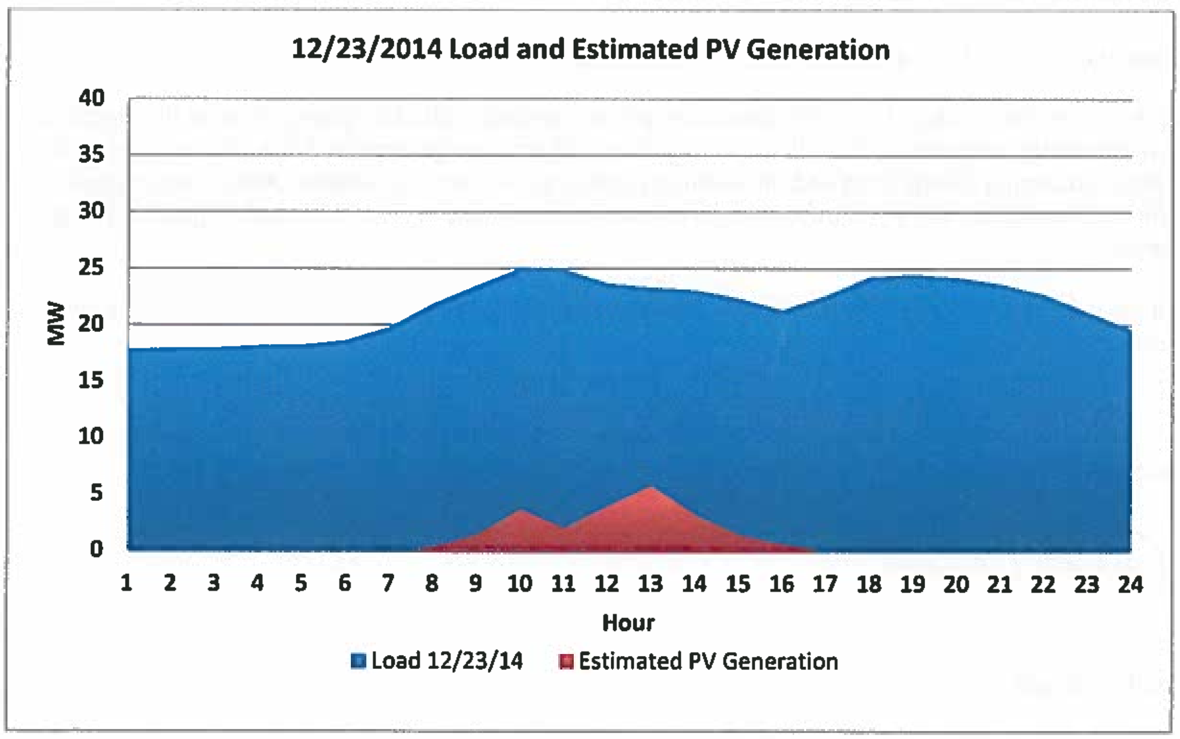

Figure 2: Load and Estimated PV Generation

Figure 3 provides a summer example of the PVWatts data for June 21st. The average solar irradiance for that day is 7.71 kWh/m². This irradiance coupled with estimated roof PV coverage would produce 131.23 MWh of PV Generation. On this day in 2014, the Ketchum city customer consumption was 187.35 MWh.

1221 W. Idaho St. (83702)
P.O. Box 70
Boise, ID 83707

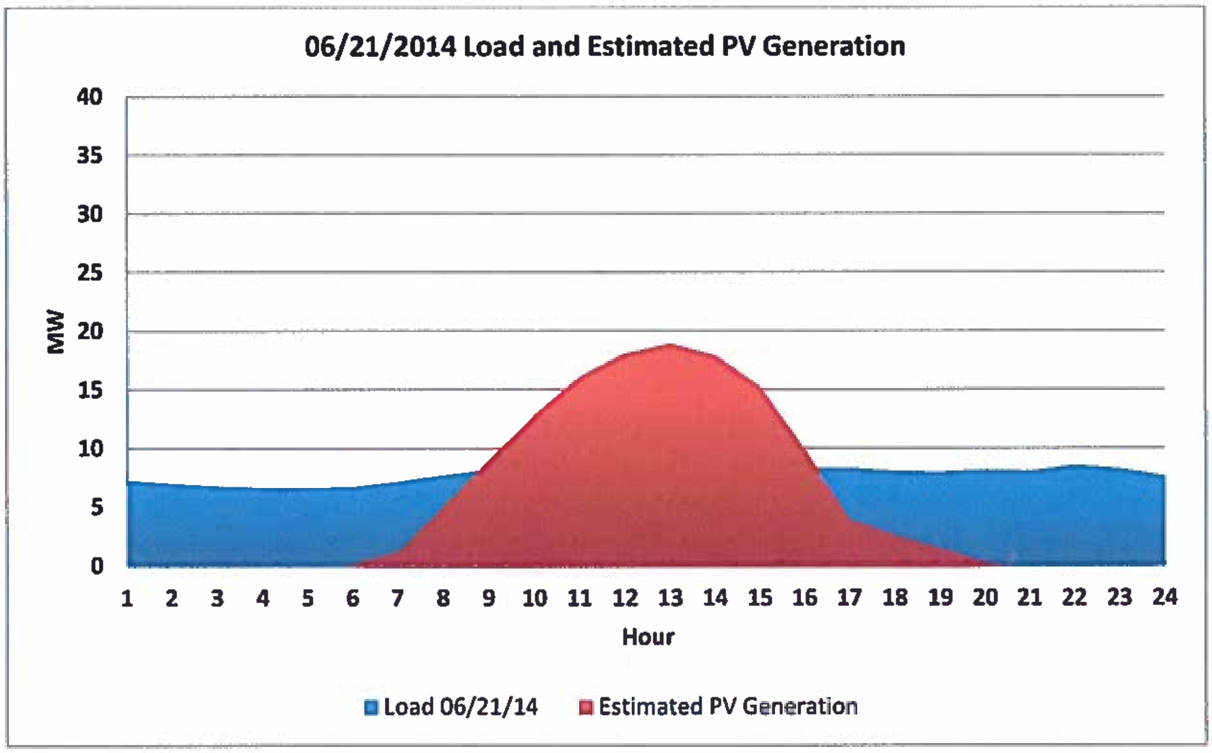

Figure 3: 6/21/2014 Load and Estimated PV Generation

In conclusion, the estimated roof PV generation will not produce sufficient energy to meet the electrical consumption by customers within the city of Ketchum. The winter generation is not able to support the property protection energy level and the summer output cannot meet the summer energy requirement. Additional resources will be required to meet the service levels above critical life safety (police, fire and hospital).

You are welcome to contact me at 208-388-2701 or dangell@idahopower if you have questions or wish to discuss this analysis.

Sincerely,

David M Angell

Manager, Customer Operations Planning

Appendix C

Microgrid Study Results

Diesel Generator results

The results for a one-day transmission line outage with diesel engine generators providing backup power are shown in Tables 1 through 5.

Table 1 Energy Provided

Component	*Production (kWh/yr)*	*Fraction (%)*
Generator	1,150,000	1
Grid Purchases	223,611,531	99
Total	224,761,540	100

Table 2 Diesel Generator Parameters

Quantity	*Value*	*Units*
Hours of operation	24	Hrs/yr
Number of starts	1	Starts/yr
Fixed generation cost	4,677	$/hr
Marginal generation cost	0.13	$/kWh
Electrical production	1,150,000	kWh/yr
Mean electrical output	51,095	kW
Min. electrical output	43,938	kW
Max electrical output	58,506	kW
Fuel consumption	302,597	L/yr
Specific fuel consumption	0.26	L/kWh
Fuel energy input	2,977,557	kWh/yr
Mean electrical efficiency	39	%

Table 3 Diesel Generator Emissions

Pollutant	*Emissions*	*Units*
Carbon dioxide	142,119,326	Kg/yr
Carbon monoxide	1,967	Kg/yr
Unburned hydrocarbons	218	Kg/yr
Particulate matter	148	Kg/yr
Sulfur dioxide	614,296	Kg/yr
Nitrogen oxides	317,190	Kg/yr

Table 4 Diesel Generator Capital cost sensitivity analysis

Capital Cost ($/kW)	*Total Capital Cost (Millions of dollars)*
$500	$33,400,000
$750	$50,100,000
$1,000	$66,800,000
$1,250	$83,500,000
$1,500	$100,200,000

Table 5 Diesel Fuel Cost Sensitivity Analysis

Fuel price ($/gal)	*Total fuel cost*
$2.00	$159,800
$2.25	$179,700
$2.50	$199,700
$2.75	$219,700
$3.00	$239,600

Table 5 was computed with a 1-day outage during the peak months.

Gas Turbine Results

The results for a one-day transmission line outage with gas combustion turbines providing backup power are shown in tables 6 to 10.

Table 6 Energy Provided by Gas Turbine

Component	*Production (kWh/yr)*	*Fraction (%)*
Generator	1,150,000	1
Grid Purchases	223,611,531	99
Total	224,761,540	100

Table 7 Gas Turbine Parameters

Quantity	*Value*	*Units*
Hours of operation	24	Hrs/yr
Number of starts	1	Starts/yr
Fixed generation cost	2,802	$/hr
Marginal generation cost	0.02	$/kWh
Electrical production	1,150,000	kWh/yr
Mean electrical output	51,095	kW
Min. electrical output	43,938	kW
Max electrical output	58,506	kW
Fuel consumption	333,503	m^3/yr
Specific fuel consumption	0.29	m^3/kWh
Fuel energy input	3,293,338	kWh/yr
Mean electrical efficiency	35	%

Table 8 Gas Turbine Emissions

Pollutant	*Emissions*	*Units*
Carbon dioxide	141,968,690	Kg/yr
Carbon monoxide	667	Kg/yr
Unburned hydrocarbons	0	Kg/yr
Particulate matter	0	Kg/yr
Sulfur dioxide	614,434	Kg/yr
Nitrogen oxides	300,056	Kg/yr

Table 9 Gas Turbine Capital Cost Sensitivity Analysis

Capital Cost ($/kW)	*Total Capital Cost*
$750	$48,800,000
$1,125	$73,100,000
$1,500	$97,500,000
$1,875	$121,900,000
$2,250	$146,300,000

Table 10 Natural Gas Cost Sensitivity Analysis

Fuel price ($/m^3)	*Total fuel cost*
$0.075	$25,000
$0.10	$33,400
$0.124	$41,400
$0.15	$50,000
$0.175	$58,400

Battery System Results

The sensitivity analysis to the price of the battery for a one-day transmission line outage with the use of PV plus battery to provide backup power is shown in table 11.

Table 11 Battery Cost Sensitivity Analysis

Battery Price ($/kWh)	*Total Cost*
$372	$45,600,000
$486	$595,000,000
$516	$632,000,000
$636	$779,000,000
$1,115	$1,367,000,000
$1,236	$1,515,000,000

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