Nancy Cooley

From:	Michele Johnson on behalf of Tom Bergin
Sent:	Wednesday, November 09, 2016 10:32 AM
To:	Nancy Cooley
Subject:	FW: [EXTERNAL] Update on the WREP proposed redundant transmission line project
Attachments:	WDRI Local Gen Followup Letter CAC 11 8 16.pdf; Wood River Local Backup Generation Report 11 7 16.pdf; Property Protection Analysis Report Rev 2.pdf; Power Usage Distribution Rev 2.pdf

For the record.

RECEIVED
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BLAINE COUNTY
LAND USE & BUILDING SERVICES

Michele Johnson
Blaine County, Idaho
Land Use / Grant Manager
(208) 788-5570 ext 1179

From: Angell, Dave [mailto:DAngell@idahopower.com]
Sent: Tuesday, November 08, 2016 1:43 PM
To: 'Mike Pepper' <kmpplanning@gmail.com>; Hobson, Bryan <BHobson@idahopower.com>; Rod Kegley <rkegley53@gmail.com>; Barber, Tom <TBarber@idahopower.com>; Rob Struthers <email@robstruthers.com>; Dean Holter <dean@christensenglobal.com>; Rick Baird <Rick@flyfma.com>; Noll, Tom <TNoll@idahopower.com>; Craig Eckles <ceckles@bellevueidaho.us>; Chuck Turner <cturner@co.blaine.id.us>; Schultz, Trevor <TSchultz2@idahopower.com>; Mariel Platt <Mariel.platt@haileycityhall.org>; Kerrin McCall <kerrinmac@gmail.com>; Nils Ribi <nils@nilsribi.com>; Len Harlig <lenharlig@cox.net>; Kurt Nelson <kjnelson@fs.fed.us>; Jim Bell <JBell@idahopower.com>; Harrington, Pat <PHarrington@idahopower.com>; Porter, Vern <VPorter@idahopower.com>; Holly Crawford <hcrawford@blm.gov>; Rick LeFaivre <rlefaivre@gmail.com>; Dennis Harper <dharper@sunvalley.com>; Standley, Lynette <LStandley@idahopower.com>; Tom Bergin <tbergin@co.blaine.id.us>; Tom Hanson <thanson@powereng.com>; Kasey C. Prestwich <kprestwich@blm.gov>; Dave Jensen <dave.jensen@itd.idaho.gov>; Nick Purdy <npurdy@earthlink.net>; Olmstead, Dan <DOlmstead@idahopower.com>; Kasey Prestwich <kprestwich@blm.gov>; Jim Keating <jkeating@bcrd.org>; Lloyd Betts <lloydlarue@yahoo.com>; Richins, Adam <ARichins@idahopower.com>
Subject: RE: [EXTERNAL] Update on the WREP proposed redundant transmission line project

CAC members

I have attached a second letter that provides responses to questions about the Local Backup Generation report that I provided on October 13th. Additionally, I am providing a revised report on local backup generation options. The attached copy includes modified appendices. The first revision is a new Appendix A that addresses the electrical power required to keep homes and businesses warm enough to avoid freezing water in pipes, known as "Property Protection." This Property Protection concept was identified by the team who attended the Rocky Mountain Institute eLab workshop. The Property Protection analysis discussion with some of the eLab team generated the question "how much electrical load could be reduced by setting thermostats down to 55 degrees." The Power Usage Distribution report, Appendix B, provides several analysis methods to determine the potential load reduction of lower thermostat settings. It has been revised with the calculations moved into appendices to improve the readability. I have also provided the two appendices as separate attachments.

I hope you are enjoying the fall weather, Dave

Dave Angell
MANAGER
Idaho Power | Customer Operations Planning
PO Box 70 | Boise, ID | 83707

(208) 388-2701 office

Safety4Life

From: Mike Pepper [mailto:kmpplanning@gmail.com]
Sent: Thursday, October 13, 2016 1:06 PM
To: Hobson, Bryan; Mike Pepper; Rod Kegley; Barber, Tom; Rob Struthers; Dean Holter; Rick Baird; Noll, Tom; Craig Eckles; Chuck Turner; Schultz, Trevor; Mariel Platt; Kerrin McCall; Nils Ribi; Len Harlig; Kurt Nelson; Jim Bell; Harrington, Pat; Porter, Vern; Holly Crawford; Rick LeFaivre; Dennis Harper; Standley, Lynette; Tom Bergin; Tom Hanson; Kasey C. Prestwich; Dave Jensen; Nick Purdy; Olmstead, Dan; Angell, Dave; Kasey Prestwich; Jim Keating; Lloyd Betts; Richins, Adam
Subject: [EXTERNAL] Update on the WREP proposed redundant transmission line project

Greetings CAC

FYI, see attached letter and supporting report from Dave Angell regarding the status of the redundant transmission line project.

thanks for your continued interest in this important project.

Mike

KMP Planning
2530 Canyon Gate Pl.
Twin Falls, ID 83301

(208) 316-5817
kmpplanning@gmail.com

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November 8, 2016

CAC Members

Subject: Answers to Additional Questions Regarding Alternatives to the Proposed Line

Dear CAC Members:

Below are answers to the questions that were raised concerning the Northern Wood River Valley – Local Backup Electrical Supply Report.

1. Real Bid - As to NRG's indicative pricing, it appears to assume siting the generation at the Ketchum substation. In contrast, Idaho Power's report provides cost estimates for generation located at both Ketchum and Elkhorn substations. These estimates include two fuel storage tanks and the land and interconnection costs. Finally, the NRG email states that the maintenance cost would be low. The following industry practices are recommended for backup generation: weekly inspection, monthly operation under load for 30 minutes, and annual preventative maintenance. The annual diesel fuel cost alone amounts to $50,000.00.

2. Heating Load – The first method, Temperature Based Energy Usage, calculates the heating portion of residential electrical load. It is not an estimate of how much heating is electrical versus natural gas or other resource. The analysis is not dependent on the percent of units heated by electricity. Also, three separate methods were used to determine how much winter electrical load is heating related. Each of the methods identifies between 60 and 70 percent of winter load is related to heating. The percentage of load related to heating is then used to determine how much load could be reduced by a change in thermostat setting to 55 degrees.

   As stated in the Local Backup Electrical Supply Report, the Bald and Dollar mountain loads were reduced. The attached Power Usage Distribution report was updated to reflect the same reductions which changed the maximum potential reduction from 11 to 10 percent. There are factors (e.g. participation level and communications failures) that will further reduce the actual achievable load reduction from automatic reduced thermostat set points.

   For reference, the city-data.com website does provide data on home and apartment heating sources for Blaine County, Ketchum and Sun Valley. It presents home electric heating ranging from 26% to 36% and apartment electric heating ranging from 58% to 63%. Natural gas heated homes and businesses have fan loads that will be operating while heating. This, coupled with the use of electric heating in motels, does result in a significant winter electric load related to heating in the northern portion of the Wood River Valley.

3. Intermountain Gas - The statement regarding Intermountain Gas was related to the ability for them to supply gas for either the reciprocating or combustion turbine generators included in the report. A representative from Intermountain Gas indicated that facility upgrades would be

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

required. They would need additional time to study the requirements to determine whether the improvements would be limited to facilities north of Hailey or extend all the way to Jerome. Regardless the improvements will be very costly, potentially doubling the cost of each option, and eliminate the consideration of natural gas supply.

4. Salmon - Since 1980, the Salmon area, with 30 MW of peak load, has been supplied by two transmission lines. The existing diesel generators were used to supply load when the primary source was out of service. Idaho Power recently constructed a new substation and reconfigured the transmission line connects to improve the service reliability. This new substation and line reconfiguration allows for the planned removal of diesel generators.

5. Peak Load – Idaho Power builds transmission and distribution facilities to meet peak loading conditions. Idaho Power cannot predict the day or time when a winter caused outage will occur. Therefore, the study assumes that the backup local generation will require enough capacity to restore peak load service. The study assumes that non-essential loads could be curtailed following initial system restoration to reduce the 24-hour fuel requirement. Two additional considerations are the ability to support cold load pick up conditions and reactive power requirements.

6. Line Outages - There have been nine unplanned outages on the transmission line between Hailey and Ketchum since 1995. Of those nine outages, three occurred during the winter. Ice build-up and trees contacting power lines are the most common cause of unplanned outages during the winter. This line has not experienced an outage due to avalanche; however, it does traverse steep terrain.

7. Backup Emergency Power – Idaho Power has modified the Midpoint to Wood River transmission line to reduce the susceptibility to outage due to ice build-up and the replacement of the King to Wood River transmission line is scheduled for completion next year. Electrical service provided by Idaho Power is subject to interruption or curtailment as described in the Rule J section of the Idaho Public Utilities Commission approved Idaho Power tariff.

Sincerely,

David M Angell

Manager, Customer Operations Planning

enclosures:

IDAHO POWER
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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 Appendices A and B); 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 C). 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 10 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 Appendices A and B). 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.

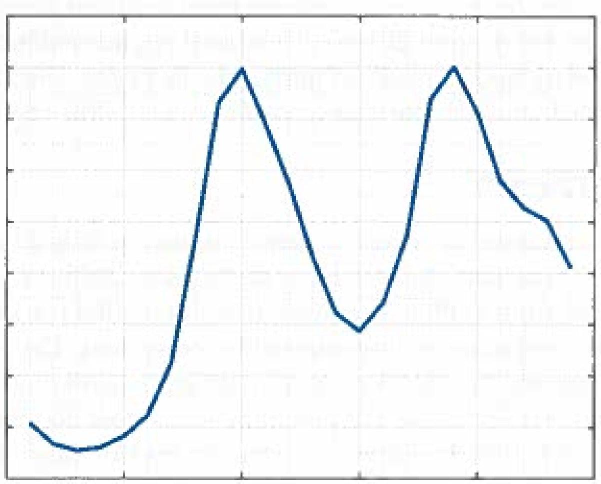

Figure 1. December 31, 2015, load profile

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 C 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 D.

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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IDAHO POWER
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Property Protection Analysis Report

Ketchum Energy Resilience Team

Rev. 2

October 2016

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BACKGROUND

A multi-stakeholder team, including the City of Ketchum, Sun Valley Company, Idaho Power, and NRG, attended the Rocky Mountain Institutes Electricity Innovation Lab (e-Lab) during March of 2015. The team decided that four levels of electrical demand would be evaluated relative to the local renewable resource capability: critical life safety, property protection, summer peak load and winter peak load. This report addresses the property protection demand required to maintain building heat at a level to avoid freezing water pipes during sub-zero temperature conditions.

The report was updated October 2016 to improve readability.

METHODOLOGY

The minimum amount of heat generation necessary to keep water pipes from freezing in homes and businesses with a rotating outage is calculated based on the following elements:

- Minimum indoor temperature
- Heat loss rate
- Heating capacity
- Heating system duty cycle

A formal study can be conducted to determine the heat loss rate for homes in the Ketchum Area and the minimum indoor temperature required to keep the pipes from freezing. If a formal study is desired, it should be conducted during an extreme winter peak.

Minimum Indoor Temperature

The minimum requirement to protect property is based on maintaining a minimum temperature inside homes and businesses. It does not guarantee that pipes will not freeze, as all buildings are not constructed in the same manner. Water pipe placement within exterior walls and along attics will impact the likelihood that property damage occurs. The American Red Cross, Consumer Reports, and State Farm all recommend maintaining an indoor temperature of 55°F to keep pipes from freezing. The report will use 65°F because the buildings will need to be heated above the point at which pipes would freeze, and then be allowed to cool over time in a rotating outage.

Heat Loss Rate

Heat loss determines how quickly indoor temperatures drop and how long the power must be on to prevent damage.

Heat is lost in a variety of ways:

- Walls

- Windows
- Ceiling
- Floor
- Ventilation
- Infiltration

Heat loss for each of these ways can be estimated based upon a set of assumptions and equations. This is done in Appendix A.

Heating Capacity

The heating capacity of a home or business is based on its heat strip size. The recommended heat strip size can be determined based upon the size of the building and the region. An example calculation for the Ketchum area can be found in Appendix B.

Heating System Duty Cycle

The duty cycle of the heating system determines the amount of time that the system can be off compared to how long it must remain on to maintain a set temperature. The equation is located in Appendix B. The calculation results in the heating system must remain on 77% of the time in order to keep the indoor temperature at or above 55°F and avoid frozen water pipes.

Cold Load Pick Up Effect

Under normal conditions in cold weather, the hundreds to thousands of homes and businesses served by an area's substation do not have all of their heating systems, lights, and appliances using power at the same time. The heating and refrigeration loads cycle on and off based on temperature. Due to the temperature cycling effect, a portion of the home and business heating and refrigeration load will be off at a given time. This is known as load diversity.

When a transmission line is out of service, all buildings served from the substation lose power at the same time. When service is restored after some period of time, more heating and refrigeration equipment will be in an on-state at the same time. For greater outage periods prior to restoration, the homes and businesses will require more time to bring the temperature up to thermostat settings. This requires the substation to serve a greater amount of electrical load at the same time. The condition where a substation restores electrical load following an outage is called cold load pick up.

The distribution circuits out of the substation that serve customers in the Ketchum Area have a 12.5MVA loading design limit. Idaho Power does not normally the circuits beyond 10MVA. The additional 20% reserve capacity is used to during situations such as cold load pick up. However, the load on the circuits must be restored in sections resulting in less than 12.5MVA of power. This requires carefully adding the circuit sections over time to allow load diversity to occur within each section. If sections are added prior to the load diversity occurring, an overload will occur, the circuit will be taken out of service, and the restoration process will have to begin again. The customers located in the most remote section will be restored last and are often out of service two to four times as long as the customers located near the substation. A rotating outage backup system would need to protect all of the customers from property damage. More details regarding cold load pick up can be found in Appendix C.

Other Considerations

The time for different houses to drop temperature varies widely based on their thermal mass, square footage, tightness of construction, solar orientation, building use, wind speed and direction, and other factors. Heat loss studies are inherently risky since incorporating all factors is unfeasible and the consequences of a ruptured pipe can be substantial.

Conclusion

This study demonstrates that the heating system must remain on 77% of the time to protect the property. Assuming rotating outages on the distribution circuits, the remote sections will experience a restoration delay exceeding one hour due to cold load pick up effects. Therefore, rotating outages to reduce load during transmission outages cannot prevent property damage for all homes and businesses.

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Chris Pollow, Idaho Power, Senior Engineer (personal communication, May 6, 2015).

Todd Greenwell, Idaho Power, Program Specialist II (personal communication, May 6, 2015).

Appendix A.A

Heat Loss Rate

For the following calculations, these assumptions were made:

- The building size is 2000 sq ft.
- The building is one level with 8 foot ceilings.
- An outside temperature of -21°F was assumed for the extreme peak.

Walls

The average heat loss through a wall can be determined by the following equation:

$$Heat\ loss\ rate\ (walls) = \frac{Q}{t} = \frac{Area \cdot (1 - \frac{Window}{Wall}) \cdot (T_{inside} - T_{outside})}{Thermal\ resistance\ of\ wall}$$

Where:

$$Area = Height_{wall} \cdot Length_{wall} \cdot (Number\ of\ Walls)$$

Additional assumptions are necessary to use the equation:

- The building length is approximately equal to the width.
- The window to wall ratio is 30%.
- The R-Value of the wall is 19.

$$Heat\ loss\ rate\ (walls) = \frac{\left(8 \cdot \sqrt[2]{2{,}000} \cdot 4\ ft^2\right) \cdot (1 - 0.7) \cdot (65 - (-21))}{19 \frac{ft^2 \cdot °F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (walls) = 4{,}535 \frac{BTU}{hr}$$

Windows

Heat loss is greater through windows than through walls. A window-to-wall ratio can be assumed for buildings to help with this calculation. Energy code guidelines typically state a window to wall ratio of 12 to 18%, but the actual ratio can be higher than 30%. 30% was assumed for the calculations. If the window-to-wall ratio is higher than assumed, heat loss will occur more rapidly.

The efficiency of windows is typically measured by a U-factor, which is the reciprocal of an R-value. Most windows have a U-factor value between 0.15 and 1.20. Through a window replacement program, a reasonable assumption for the U-factor is 0.35.

$$Heat\ loss\ rate\ (windows) = \frac{Area \cdot \frac{Window}{Wall} \cdot (T_{inside} - T_{outside})}{Thermal\ resistance\ of\ wall}$$

$$Heat\ loss\ rate\ (windows) = \frac{\left(\sqrt[2]{2{,}000} \cdot .3 \cdot 8 \cdot 4\, ft^2\right) \cdot (65 - (-21))}{\frac{1}{.35} \frac{ft^2 \cdot {}^\circ F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (windows) = 12{,}923\ BTU/hr$$

Ceiling

Attic insulation typically has an R-value of 49-60. Assuming R49:

$$Heat\ loss\ rate\ (ceiling) = \frac{2{,}000 ft^2 \cdot (65 - (-21))}{49 \frac{ft^2 \cdot {}^\circ F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (ceiling) = 3{,}510\ BTU/hr$$

Floor

Heat loss through the floor can be a complicated calculation, but it typically amounts to 20-30% of the total energy loss in a home. 25% will be used in the total heat loss calculation.

Ventilation and Infiltration

Ventilation is heat loss that occurs due to the venting of air from the heating system.

Infiltration heat loss occurs due to leakages in building construction and the opening and closing of windows and doors.

Together they account for approximately 43% of the total heat loss.

Total Heat Loss Rate

The percentage of heat loss through the floor, ventilation, and infiltration total 68% of the total heat loss. The remaining heat loss, 32%, is lost through the walls, windows, and ceiling. The total heat loss can be obtained through the following calculation:

$$\mathit{Heat\ Loss\ Rate}\ (walls) + \mathit{Heat\ Loss\ Rate}(windows) + \mathit{Heat\ Loss\ Rate}(ceiling) = 32\% \cdot \mathit{Total\ Heat\ Loss}$$

$$\mathit{Total\ Heat\ Loss} = \frac{4{,}535 BTU/hr + 12{,}923 BTU/hr + 3{,}510 BTU/hr}{0.32}$$

$$\mathit{Total\ Heat\ Loss} = 65{,}525 BTU/hr$$

Appendix A.B

Heating Capacity and Duty Cycle

The heating capacity of the assumed building size can be found based on the region and heat strip recommendations:

- The Ketchum Area lies in Region 1 and a 2000 sq ft building would require a 25kW heat strip.
- 1 kWh of energy is equivalent to 3,412 BTU.

The heating capacity of the building is:

$$Heating\ Capacity = Heat\ strip\ size \cdot \frac{BTU}{kWh}$$

$$Heating\ Capacity = 25kW \cdot \frac{3{,}412BTU}{kWh}$$

$$Heating\ Capacity = 85{,}300\ BTU/hr$$

The duty cycle can then be determined using previous calculations:

$$Duty\ Cycle_{Heating\ System} = \frac{Total\ Heat\ Loss}{Heating\ Capacity}$$

$$Duty\ Cycle_{Heating\ System} = \frac{65{,}525}{85{,}300}$$

$$Duty\ Cycle_{Heating\ System} = 0.77\ \ (77\%)$$

Appendix A.C

Cold Load Pick Up

Through many years of operational experience, Idaho Power has determined that load increases as indicated in Table 1 where:

- Outage Duration is given in the format Hours:Minutes.
- Percent Normal refers to the percentage of load that can be expected when power is restored compared to the normal load before the outage occurred. As an example, if there is twice as much load when power is restored as there was before the outage occurred, Percent Normal is 200%.

Table 1

Cold load effect on load duration chart

Outage Duration	Percent Normal
0:00	100.0%
0:32	162.0%
1:04	200.0%
1:37	234.0%
2:09	260.0%
2:41	270.0%
3:14	276.0%
3:46	280.0%
4:18	283.0%
4:51	285.0%
5:23	287.0%
5:55	288.0%
6:27	289.0%

Example: If a circuit is loaded to 10MVA normally and a power outage lasts 7 hours (the coincidence factor has saturated), the load will be 28.9MVA when power is restored, exceeding the 12.5MVA circuit rating. In this example, the load must be restored in at least 4 tiers. After each tier is restored, a period of time, typically around 20 minutes, must pass while the coincidence factor decreases and the load diversity normalizes.

Table 2

Load tiers associated with cold load pick up

	Normal Load Restored	Load Added in Previous Tier (Now Normal)	Total Circuit Load with Cold Load Effect	Total Normal Circuit Load Restored
Tier 1	4.33	0.00	12.5	4.33
Tier 2	2.83	4.33	12.5	7.15
Tier 3	1.85	7.15	12.5	9.00

Tier 4	1.00	9.00	11.9	10.00

It would be a minimum of an hour from the time when load was restored to Tier 1 before Tier 4 could be added to the distribution circuit. In that time, the temperature would drop below the minimum temperature threshold of 55°F.

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Property Protection Analysis Report

Ketchum Energy Resilience Team

Rev. 2

October 2016

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BACKGROUND

A multi-stakeholder team, including the City of Ketchum, Sun Valley Company, Idaho Power, and NRG, attended the Rocky Mountain Institutes Electricity Innovation Lab (e-Lab) during March of 2015. The team decided that four levels of electrical demand would be evaluated relative to the local renewable resource capability: critical life safety, property protection, summer peak load and winter peak load. This report addresses the property protection demand required to maintain building heat at a level to avoid freezing water pipes during sub-zero temperature conditions.

The report was updated October 2016 to improve readability.

METHODOLOGY

The minimum amount of heat generation necessary to keep water pipes from freezing in homes and businesses with a rotating outage is calculated based on the following elements:

- Minimum indoor temperature
- Heat loss rate
- Heating capacity
- Heating system duty cycle

A formal study can be conducted to determine the heat loss rate for homes in the Ketchum Area and the minimum indoor temperature required to keep the pipes from freezing. If a formal study is desired, it should be conducted during an extreme winter peak.

Minimum Indoor Temperature

The minimum requirement to protect property is based on maintaining a minimum temperature inside homes and businesses. It does not guarantee that pipes will not freeze, as all buildings are not constructed in the same manner. Water pipe placement within exterior walls and along attics will impact the likelihood that property damage occurs. The American Red Cross, Consumer Reports, and State Farm all recommend maintaining an indoor temperature of 55°F to keep pipes from freezing. The report will use 65°F because the buildings will need to be heated above the point at which pipes would freeze, and then be allowed to cool over time in a rotating outage.

Heat Loss Rate

Heat loss determines how quickly indoor temperatures drop and how long the power must be on to prevent damage.

Heat is lost in a variety of ways:

- Walls
- Windows
- Ceiling
- Floor
- Ventilation
- Infiltration

Heat loss for each of these ways can be estimated based upon a set of assumptions and equations. This is done in Appendix A.

Heating Capacity

The heating capacity of a home or business is based on its heat strip size. The recommended heat strip size can be determined based upon the size of the building and the region. An example calculation for the Ketchum area can be found in Appendix B.

Heating System Duty Cycle

The duty cycle of the heating system determines the amount of time that the system can be off compared to how long it must remain on to maintain a set temperature. The equation is located in Appendix B. The calculation results in the heating system must remain on 77% of the time in order to keep the indoor temperature at or above 55°F and avoid frozen water pipes.

Cold Load Pick Up Effect

Under normal conditions in cold weather, the hundreds to thousands of homes and businesses served by an area's substation do not have all of their heating systems, lights, and appliances using power at the same time. The heating and refrigeration loads cycle on and off based on temperature. Due to the temperature cycling effect, a portion of the home and business heating and refrigeration load will be off at a given time. This is known as load diversity.

When a transmission line is out of service, all buildings served from the substation lose power at the same time. When service is restored after some period of time, more heating and refrigeration equipment will be in an on-state at the same time. For greater outage periods prior to restoration, the homes and businesses will require more time to bring the temperature up to thermostat settings. This requires the substation to serve a greater amount of electrical load at the same time. The condition where a substation restores electrical load following an outage is called cold load pick up.

The distribution circuits out of the substation that serve customers in the Ketchum Area have a 12.5MVA loading design limit. Idaho Power does not normally the circuits beyond 10MVA. The additional 20% reserve capacity is used to during situations such as cold load pick up. However, the load on the circuits must be restored in sections resulting in less than 12.5MVA of power. This requires carefully adding the circuit sections over time to allow load diversity to occur within each section. If sections are added prior to the load diversity occurring, an overload will occur, the circuit will be taken out of service, and the restoration process will have to begin again. The customers located in the most remote section will be restored last and are often out of service two to four times as long as the customers located near the substation. A rotating outage backup system would need to protect all of the customers from property damage. More details regarding cold load pick up can be found in Appendix C.

Other Considerations

The time for different houses to drop temperature varies widely based on their thermal mass, square footage, tightness of construction, solar orientation, building use, wind speed and direction, and other factors. Heat loss studies are inherently risky since incorporating all factors is unfeasible and the consequences of a ruptured pipe can be substantial.

CONCLUSION

This study demonstrates that the heating system must remain on 77% of the time to protect the property. Assuming rotating outages on the distribution circuits, the remote sections will experience a restoration delay exceeding one hour due to cold load pick up effects. Therefore, rotating outages to reduce load during transmission outages cannot prevent property damage for all homes and businesses.

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Chris Pollow, Idaho Power, Senior Engineer (personal communication, May 6, 2015).

Todd Greenwell, Idaho Power, Program Specialist II (personal communication, May 6, 2015).

Appendix A
Heat Loss Rate

For the following calculations, these assumptions were made:

- The building size is 2000 sq ft.
- The building is one level with 8 foot ceilings.
- An outside temperature of -21°F was assumed for the extreme peak.

Walls

The average heat loss through a wall can be determined by the following equation:

$$Heat\ loss\ rate\ (walls) = \frac{Q}{t} = \frac{Area \cdot (1 - \frac{Window}{Wall}) \cdot (T_{inside} - T_{outside})}{Thermal\ resistance\ of\ wall}$$

Where:

$$Area = Height_{wall} \cdot Length_{wall} \cdot (Number\ of\ Walls)$$

Additional assumptions are necessary to use the equation:

- The building length is approximately equal to the width.
- The window to wall ratio is 30%.
- The R-Value of the wall is 19.

$$Heat\ loss\ rate\ (walls) = \frac{\left(8 \cdot \sqrt[2]{2{,}000} \cdot 4\, ft^2\right) \cdot (1 - 0.7) \cdot (65 - (-21))}{19 \frac{ft^2 \cdot {}^\circ F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (walls) = 4{,}535 \frac{BTU}{hr}$$

Windows

Heat loss is greater through windows than through walls. A window-to-wall ratio can be assumed for buildings to help with this calculation. Energy code guidelines typically state a window to wall ratio of 12 to 18%, but the actual ratio can be higher than 30%. 30% was assumed for the calculations. If the window-to-wall ratio is higher than assumed, heat loss will occur more rapidly.

The efficiency of windows is typically measured by a U-factor, which is the reciprocal of an R-value. Most windows have a U-factor value between 0.15 and 1.20. Through a window replacement program, a reasonable assumption for the U-factor is 0.35.

$$Heat\ loss\ rate\ (windows) = \frac{Area \cdot \frac{Window}{Wall} \cdot (T_{inside} - T_{outside})}{Thermal\ resistance\ of\ wall}$$

$$Heat\ loss\ rate\ (windows) = \frac{\left(\sqrt[2]{2{,}000} \cdot .3 \cdot 8 \cdot 4\, ft^2\right) \cdot (65 - (-21))}{\frac{1}{.35} \frac{ft^2 \cdot {}^{\circ}F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (windows) = 12{,}923\ BTU/hr$$

Ceiling

Attic insulation typically has an R-value of 49-60. Assuming R49:

$$Heat\ loss\ rate\ (ceiling) = \frac{2{,}000 ft^2 \cdot (65 - (-21))}{49 \frac{ft^2 \cdot {}^{\circ}F}{BTU/hr}}$$

$$Heat\ loss\ rate\ (ceiling) = 3{,}510\ BTU/hr$$

Floor

Heat loss through the floor can be a complicated calculation, but it typically amounts to 20-30% of the total energy loss in a home. 25% will be used in the total heat loss calculation.

Ventilation and Infiltration

Ventilation is heat loss that occurs due to the venting of air from the heating system.

Infiltration heat loss occurs due to leakages in building construction and the opening and closing of windows and doors.

Together they account for approximately 43% of the total heat loss.

Total Heat Loss Rate

The percentage of heat loss through the floor, ventilation, and infiltration total 68% of the total heat loss. The remaining heat loss, 32%, is lost through the walls, windows, and ceiling. The total heat loss can be obtained through the following calculation:

$$Heat\ Loss\ Rate\ (walls) + Heat\ Loss\ Rate(windows) + Heat\ Loss\ Rate(ceiling) = 32\% \cdot Total\ Heat\ Loss$$

$$Total\ Heat\ Loss = \frac{4{,}535 BTU/hr + 12{,}923 BTU/hr + 3{,}510 BTU/hr}{0.32}$$

$$Total\ Heat\ Loss = 65{,}525 BTU/hr$$

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Appendix B
Heating Capacity and Duty Cycle

The heating capacity of the assumed building size can be found based on the region and heat strip recommendations:

- The Ketchum Area lies in Region 1 and a 2000 sq ft building would require a 25kW heat strip.
- 1 kWh of energy is equivalent to 3,412 BTU.

The heating capacity of the building is:

$$Heating\ Capacity = Heat\ strip\ size \cdot \frac{BTU}{kWh}$$

$$Heating\ Capacity = 25kW \cdot \frac{3{,}412BTU}{kWh}$$

$$Heating\ Capacity = 85{,}300\ BTU/hr$$

The duty cycle can then be determined using previous calculations:

$$Duty\ Cycle_{Heating\ System} = \frac{Total\ Heat\ Loss}{Heating\ Capacity}$$

$$Duty\ Cycle_{Heating\ System} = \frac{65{,}525}{85{,}300}$$

$$Duty\ Cycle_{Heating\ System} = 0.77\ \ (77\%)$$

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Appendix C
Cold Load Pick Up

Through many years of operational experience, Idaho Power has determined that load increases as indicated in Table 1 where:

- Outage Duration is given in the format Hours:Minutes.
- Percent Normal refers to the percentage of load that can be expected when power is restored compared to the normal load before the outage occurred. As an example, if there is twice as much load when power is restored as there was before the outage occurred, Percent Normal is 200%.

Table 1
Cold load effect on load duration chart

Outage Duration	Percent Normal
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3:46	280.0%
4:18	283.0%
4:51	285.0%
5:23	287.0%
5:55	288.0%
6:27	289.0%

Example: If a circuit is loaded to 10MVA normally and a power outage lasts 7 hours (the coincidence factor has saturated), the load will be 28.9MVA when power is restored, exceeding the 12.5MVA circuit rating. In this example, the load must be restored in at least 4 tiers. After each tier is restored, a period of time, typically around 20 minutes, must pass while the coincidence factor decreases and the load diversity normalizes.

Table 2
Load tiers associated with cold load pick up

	Normal Load Restored	Load Added in Previous Tier (Now Normal)	Total Circuit Load with Cold Load Effect	Total Normal Circuit Load Restored
Tier 1	4.33	0.00	12.5	4.33
Tier 2	2.83	4.33	12.5	7.15
Tier 3	1.85	7.15	12.5	9.00
Tier 4	1.00	9.00	11.9	10.00

It would be a minimum of an hour from the time when load was restored to Tier 1 before Tier 4 could be added to the distribution circuit. In that time, the temperature would drop below the minimum temperature threshold of 55°F.

Power Usage Distribution Ketchum, Idaho, Area

Ketchum Energy Resilience Team

Study Report V.2

November 2016

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POWER USAGE DISTRIBUTION

This report describes three independent methods that are used to estimate the heating load percentage of the peak load during the winter peak. The purpose of the study is to estimate the potential electric load reduction associated with heating that can be achieved during the winter peak period.

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 electrical demand during an emergency event (e.g. loss of transmission) and supplying the electrical 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, such as lowering thermostat settings 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 calculations in this study use both annual electrical energy and electrical 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. Electrical peak demand is based on the time when electricity usage is at its highest.

This study is focused on estimating the electricity used to support heating during peak demand. Three independent methods were used to obtain this estimate. Method 1 uses annual energy and temperature data to obtain peak demand and estimates the percent of peak demand used for heating. Method 2 uses average hourly customer energy consumption and area population to estimate the percent of peak demand used for heating. Method 3 analyzes daily data to determine the usage distribution at peak demand and estimates the percent of peak demand used for heating from the results.

Once the percent of peak demand used for heating is known, a method can be determined to estimate the percentage of load that can be reduced by lowering thermostats from a comfortable setting to an emergency setting.

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 (EIA) *Residential Energy Consumption Survey*,[1] annual energy usage in the

[1] *Residential Energy Consumption Survey*, US Energy Information Administration. Retrieved July 13, 2015 from http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/co.pdf.

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 EIA survey is for energy in general. This study focuses on electric energy only.

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

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 during the year 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.

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 for heating, hot water heaters, appliances and lighting during the cold weather period considered can be calculated.

See Appendix A for these calculations.

With this method, winter loading was estimated to be:

- 70.25% heating
- 17.97% appliances
- 11.77% water heating
- 0% air conditioning (AC)

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.

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 study area can be calculated.

The average household size in Ketchum is 1.88 people. In Sun Valley it is 1.95, and in Blaine Co. as a whole it is 2.40. Comparing the number of permanent residences, as determined above, to the number of IPC meters in the same area, the number of vacation homes can be determined.

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.

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. 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. 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.

See Appendix B for these calculations.

Based on occupancy data, and 2014 power usage statistics, the percentage of electrical demand at peak that is due to heat load is approximately 69.32%.

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.

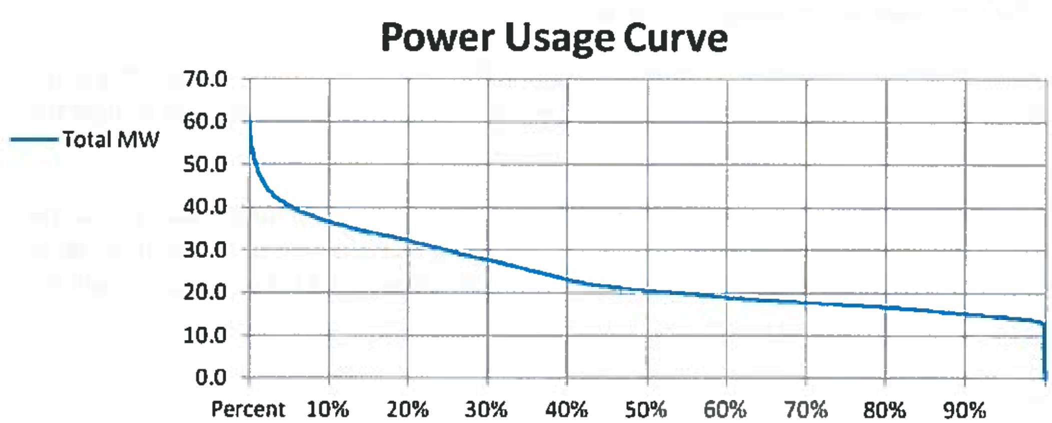

Figure 1
Hourly Energy Consumption

The estimated non-heating load was determined from the load duration curve. This value was summed with other known non-heating loads that occur during winter peak conditions. This totals approximately 23.0 MW. The difference between this sum and the total load was determined to be heating load. A peak demand heating contribution percentage was then calculated.

See Appendix C for these calculations.

During the periods heating is used, 45.0% of the total energy is used to heat buildings. The heating load represents about 61.4% of the total peak electrical demand.

Results from the Three Methods

For the Ketchum and Sun Valley area, heating load for homes is approximately 45% of total load during the majority of the winter peak with the percentage of peak electrical demand for heating being:

Method 1	70.25%
Method 2	69.32%
Method 3	61.4%

All three independently derived methods resulted in similar results. Method 3, which is based on actual measured electrical usage data will be used in the heat load reduction application.

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).[2] 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.

On an extreme winter day, using the assumptions and methodology contained in the PPAR, it takes 20.32 kWh to heat a home to 70 degrees, compared to the 16.97 kWh required to heat the home to 55 degrees. There is a 16.5% reduction in heat load usage.

Taking the peak demand in the Ketchum/Sun Valley area, less the non-heating load, we can then calculate the reduced heating load. Using that value, the energy savings, or net reduction can be calculated as well. Reducing the thermostat setting from 70 degrees to 55 degrees can result in a peak electrical load reduction of 10.1%.

[2] *Property Protection Analysis Report*, Jared Hansen. Idaho Power Company. October 2016.

See Appendix D for these calculations.

Conclusions

It is possible to reduce the demand in the area by a maximum of 10.1% 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:

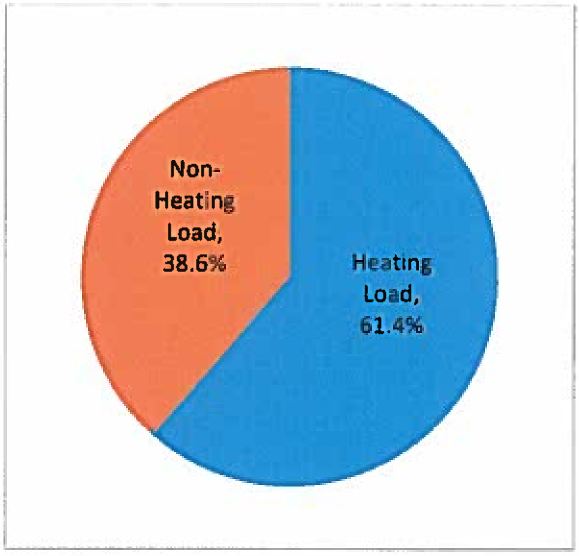

Figure 2
Peak electrical demand before load reduction

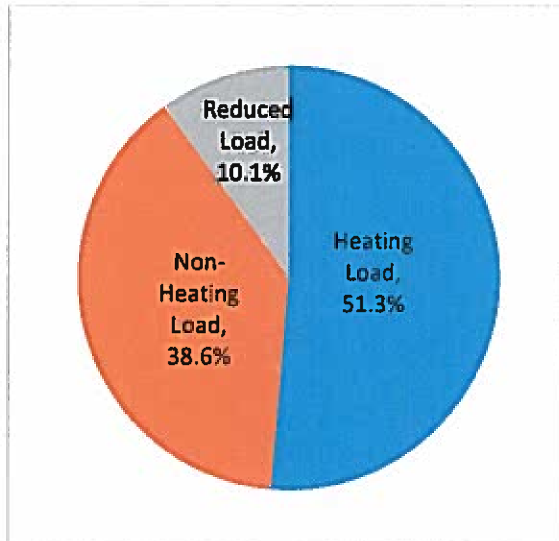

Figure 3
Peak electrical demand after load reduction

References

Visitor and Room Night Estimates March 2015, Visit Sun Valley. Provided by Aly Swindly (Aswindly@visitsunvalley.com) Retrieved May 6, 2015.

Daily Temperature Values, Weather Underground. Retrieved August 13, 2015 from http://www.wunderground.com/history/airport/KSUN/2014/1/1/CustomHistory.html?dayend=31&monthend=12&yearend=2014&req_city=&req_state=&req_statename=&reqdb.zip=&reqdb.magic=&reqdb.wmo=

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Review/Revision History

This document has been approved and revised according to the revision history recorded below.

Review Date	Revisions
08/14/2015	Initial issue.
10/27/2016	Revised for re-issue.
11/02/2016	Add large customer load to non-heating load.

Appendix A
Method 1 calculations

Temperature Based Energy Usage Calculation

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 (EIA) *Residential Energy Consumption Survey*,[3] annual energy usage in the Mountain North region of the United States (which includes Idaho) can be broken down as follows:

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- 2% air conditioning (AC)

The EIA survey is for energy in general. This study focuses on electric energy only.

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Daily temperature values were used to calculate the number of Heating Degree Days (HDD) or Cooling Degree Days (CDD).[4] 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 during the year 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.

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Table 1
Acronyms used in temperature based energy usage: daily heating calculations

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 convert yearly energy usage to cold weather energy usage
HR	Heating Energy Ratio
NHR	New adjusted heat energy ratio

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.

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

$$SWR = 19\% * \frac{161}{365} = 8.38\%$$

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

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

$$SAR = 29\% * \frac{161}{365} = 12.79\%$$

A percentage of energy used during the cold weather period relative to the year was calculated to derive a scaling factor.

$$STR = SWR + SAR + HR$$

$$STR = 8.38\% + 12.79\% + 50\% = 71.17\% = 0.7117$$

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

$$NWP = 8.38\% * \frac{1}{.7117} = 11.77\%$$

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

$$NAP = 12.79\% * \frac{1}{.7117} = 17.97\%$$

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

$$NHR = 50\% \frac{1}{.7117} = 70.25\%$$

With this method, winter loading was estimated to be 70.25% heating, 17.97% appliances, and 11.77% water heating.

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Appendix B
Method 2 calculations

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.

Table 2
Acronyms used for occupancy calculations

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
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PRP	Permanent resident population in or near Ketchum or Sun Valley
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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)

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

$$PPT = \frac{2706 + 1408}{15019} = 27.39\%$$

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

$$NPT = (27.39\%) * (21376 - 15019) = 1741$$

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:

$$\begin{aligned} Peak\ Load = {} & ERKWH * [EPOR + EVH\% * EPVH] \\ & + ESCKWH * (\#Small\ Customers) + ELCKWH * (Large\ Customers) \end{aligned}$$

$$\begin{aligned} Peak\ Load = {} & (3.92kWh) * [5372 + 83\% * 2203] + (1.99kWh * 767) + (13.67kWh * 838) \\ & = Peak\ Load = 41207.71 \end{aligned}$$

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

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

$$Loading = (.91\ kWh) * \left[\frac{4856}{4856/_{5372}} + \left(38\% * \frac{2719}{2719/_{2203}}\right)\right] + 0.65 * 767 + 7.75 * 838$$
$$= 12643.37\ kWh$$

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:

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

$$Heat\ Energy\ Percentage = \frac{41207.71 - 12643.37}{41207.71} = 69.32\%$$

Based on occupancy data, and 2014 power usage statistics, the percentage of demand at peak that is due to heat load is 69.32%.

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Appendix C
Method 3 calculations

Energy Usage Based Calculations

The estimated non-heating load was determined from the load duration curve. This value was summed with other known non-heating loads that occur during winter peak conditions. The difference between this sum and the total load was determined to be heating load. A heating contribution percentage was then calculated.

$$Heating\ Load\ Percentage = \frac{Total\ Energy\ during\ Heating - Total\ Energy\ of\ non\ heating\ loads}{Total\ Energy\ during\ Heating}$$

$$Cold\ weather\ period\ heating\ load = \frac{122850.4 - (67620.0)}{122850.4} = 45.0\%$$

$$Peak\ Demand\ heating\ contribution = \frac{Peak\ Demand\ during\ Heating - (sum\ of\ non\ heating\ loads\ during\ Peak\ Demand)}{Peak\ Demand\ during\ Heating}$$

$$Peak\ Demand\ heating\ contribution = \frac{59.6 - 23.0}{59.6} = 61.4\%$$

During the periods heating is used, approximately 45.0% of the total energy is used to heat buildings. The heating load is 61.4% of the peak demand.

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Appendix D
Application calculations

Heat Load Reduction

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.

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

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

$$Heat\ Load = Peak\ Load * Heating\ Percentage$$

$$Heat\ Load = 59.6\ MW * 61.4\% = 36.6\ MW$$

$$Other\ Loads = Peak\ Load - Heat\ Load$$

$$Other\ Loads = 59.6\ MW - 36.6\ MW = 23.0\ MW$$

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

$$Reduced\ Heat\ Load = 36.6 * (1 - 16.5\%) = 36.6 * (83.5\%) = 30.6\ MW$$

$$Reduced\ Peak\ Load = Reduced\ Heat\ Load + Other\ Loads = 30.6MW + 23.0\ MW = 53.6\ MW$$

$$Load\ Reduction = Heat\ Load * Reduction = 36.6\ MW * 16.5\% = 6.0\ MW$$

$$Total\ Peak\ Load\ Reduction\ Percentage = \frac{Load\ Reduction}{Peak\ Load} = \frac{6.0\ MW}{59.6\ MW} = 10.1\%$$

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IDAHO POWER
An IDACORP Company

Power Usage Distribution Ketchum, Idaho, Area

Ketchum Energy Resilience Team

Study Report V.2

November 2016

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

POWER USAGE DISTRIBUTION

This report describes three independent methods that are used to estimate the heating load percentage of the peak load during the winter peak. The purpose of the study is to estimate the potential electric load reduction associated with heating that can be achieved during the winter peak period.

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 electrical demand during an emergency event (e.g. loss of transmission) and supplying the electrical 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, such as lowering thermostat settings 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 calculations in this study use both annual electrical energy and electrical 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. Electrical peak demand is based on the time when electricity usage is at its highest.

This study is focused on estimating the electricity used to support heating during peak demand. Three independent methods were used to obtain this estimate. Method 1 uses annual energy and temperature data to obtain peak demand and estimates the percent of peak demand used for heating. Method 2 uses average hourly customer energy consumption and area population to estimate the percent of peak demand used for heating. Method 3 analyzes daily data to determine the usage distribution at peak demand and estimates the percent of peak demand used for heating from the results.

Once the percent of peak demand used for heating is known, a method can be determined to estimate the percentage of load that can be reduced by lowering thermostats from a comfortable setting to an emergency setting.

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 (EIA) *Residential Energy Consumption Survey*,[1] annual energy usage in the

[1] *Residential Energy Consumption Survey*, US Energy Information Administration. Retrieved July 13, 2015 from http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/co.pdf.

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 EIA survey is for energy in general. This study focuses on electric energy only.

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

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 during the year 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.

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 for heating, hot water heaters, appliances and lighting during the cold weather period considered can be calculated.

See Appendix A for these calculations.

With this method, winter loading was estimated to be:

- 70.25% heating
- 17.97% appliances
- 11.77% water heating
- 0% air conditioning (AC)

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.

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 study area can be calculated.

The average household size in Ketchum is 1.88 people. In Sun Valley it is 1.95, and in Blaine Co. as a whole it is 2.40. Comparing the number of permanent residences, as determined above, to the number of IPC meters in the same area, the number of vacation homes can be determined.

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.

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. 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. 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.

See Appendix B for these calculations.

Based on occupancy data, and 2014 power usage statistics, the percentage of electrical demand at peak that is due to heat load is approximately 69.32%.

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.

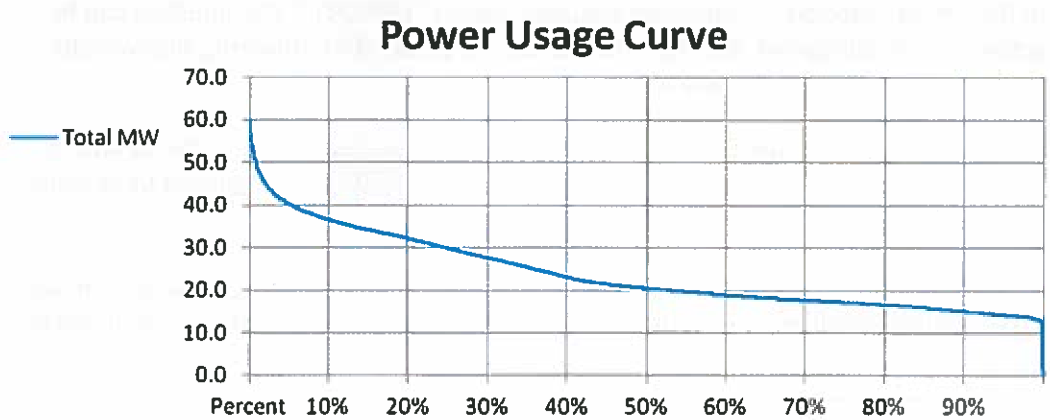

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Figure 1

Hourly Energy Consumption

The estimated non-heating load was determined from the load duration curve. This value was summed with other known non-heating loads that occur during winter peak conditions. This totals approximately 23.0 MW. The difference between this sum and the total load was determined to be heating load. A peak demand heating contribution percentage was then calculated.

See Appendix C for these calculations.

During the periods heating is used, 45.0% of the total energy is used to heat buildings. The heating load represents about 61.4% of the total peak electrical demand.

Results from the Three Methods

For the Ketchum and Sun Valley area, heating load for homes is approximately 45% of total load during the majority of the winter peak with the percentage of peak electrical demand for heating being:

Method 1	70.25%
Method 2	69.32%
Method 3	61.4%

All three independently derived methods resulted in similar results. Method 3, which is based on actual measured electrical usage data will be used in the heat load reduction application.

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).[2] 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.

On an extreme winter day, using the assumptions and methodology contained in the PPAR, it takes 20.32 kWh to heat a home to 70 degrees, compared to the 16.97 kWh required to heat the home to 55 degrees. There is a 16.5% reduction in heat load usage.

Taking the peak demand in the Ketchum/Sun Valley area, less the non-heating load, we can then calculate the reduced heating load. Using that value, the energy savings, or net reduction can be

[2] *Property Protection Analysis Report*, Jared Hansen. Idaho Power Company. October 2016.

calculated as well. Reducing the thermostat setting from 70 degrees to 55 degrees can result in a peak electrical load reduction of 10.1%.

See Appendix D for these calculations.

Conclusions

It is possible to reduce the demand in the area by a maximum of 10.1% 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:

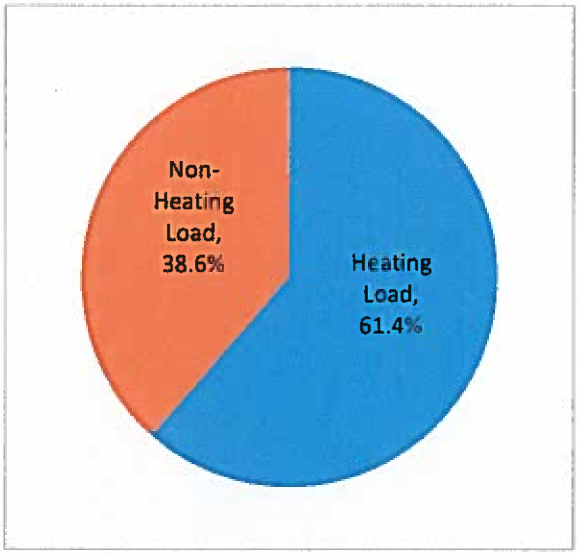

Figure 2

Peak electrical demand before load reduction

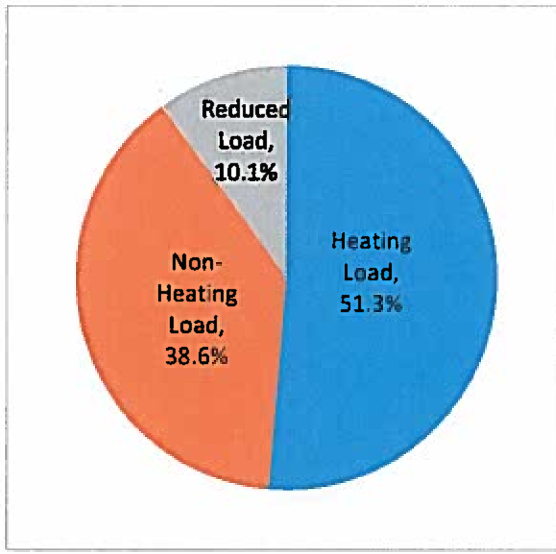

Figure 3

Peak electrical demand after load reduction

References

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Appendix B.B

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

$$Peak\ Load = (3.92kWh) * [5372 + 83\% * 2203] + (1.99kWh * 767) + (13.67kWh * 838) = Peak\ Load = 41207.71$$

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

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

$$Loading = (.91\ kWh) * \left[\frac{4856}{4856/_{5372}} + \left(38\% * \frac{2719}{2719/_{2203}}\right)\right] + 0.65 * 767 + 7.75 * 838 = 12643.37\ kWh$$

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:

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

$$Heat\ Energy\ Percentage = \frac{41207.71 - 12643.37}{41207.71} = 69.32\%$$

Based on occupancy data, and 2014 power usage statistics, the percentage of demand at peak that is due to heat load is 69.32%.

Appendix B.C

Method 3 Calculations

Energy Usage Based Calculations

The estimated non-heating load was determined from the load duration curve. This value was summed with other known non-heating loads that occur during winter peak conditions. The difference between this sum and the total load was determined to be heating load. A heating contribution percentage was then calculated.

$$\mathit{Heating\ Load\ Percentage} = \frac{\mathit{Total\ Energy\ during\ Heating} - \mathit{Total\ Energy\ of\ non\ heating\ loads}}{\mathit{Total\ Energy\ during\ Heating}}$$

$$\mathit{Cold\ weather\ period\ heating\ load} = \frac{122850.4 - (67620.0)}{122850.4} = 45.0\%$$

$$\mathit{Peak\ Demand\ heating\ contribution} = \frac{\mathit{Peak\ Demand\ during\ Heating} - (\mathit{sum\ of\ non\ heating\ loads\ during\ Peak\ Demand})}{\mathit{Peak\ Demand\ during\ Heating}}$$

$$\mathit{Peak\ Demand\ heating\ contribution} = \frac{59.6 - 23.0}{59.6} = 61.4\%$$

During the periods heating is used, approximately 45.0% of the total energy is used to heat buildings. The heating load is 61.4% of the peak demand.

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Appendix B.D

Application Calculations

Heat Load Reduction

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.

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

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

$$Heat\ Load = Peak\ Load * Heating\ Percentage$$

$$Heat\ Load = 59.6\ MW * 61.4\% = 36.6\ MW$$

$$Other\ Loads = Peak\ Load - Heat\ Load$$

$$Other\ Loads = 59.6\ MW - 36.6\ MW = 23.0\ MW$$

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

$$Reduced\ Heat\ Load = 36.6 * (1 - 16.5\%) = 36.6 * (83.5\%) = 30.6\ MW$$

$$Reduced\ Peak\ Load = Reduced\ Heat\ Load + Other\ Loads = 30.6MW + 23.0\ MW = 53.6\ MW$$

$$Load\ Reduction = Heat\ Load * Reduction = 36.6\ MW * 16.5\% = 6.0\ MW$$

$$Total\ Peak\ Load\ Reduction\ Percentage = \frac{Load\ Reduction}{Peak\ Load} = \frac{6.0\ MW}{59.6\ MW} = 10.1\%$$

Appendix C

City of Ketchum Solar Generation Assessment

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.

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.

Figure 1: Sample Area

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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.

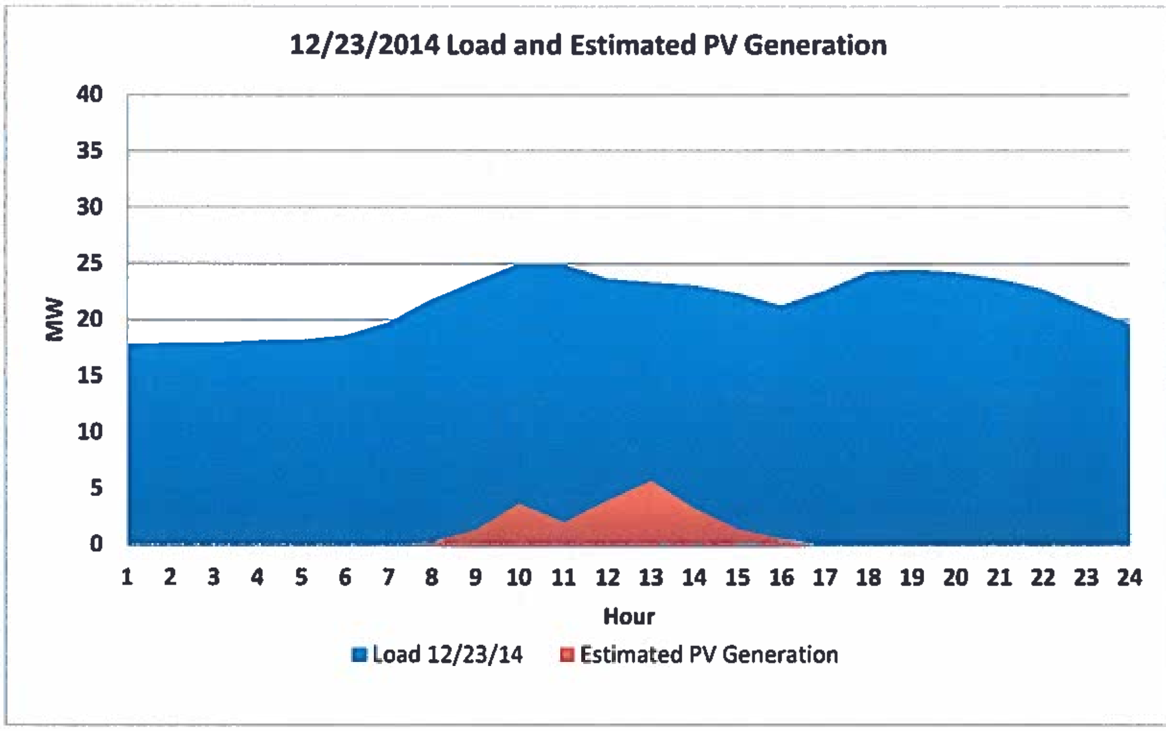

Figure 2: Load and Estimated PV Generation

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.

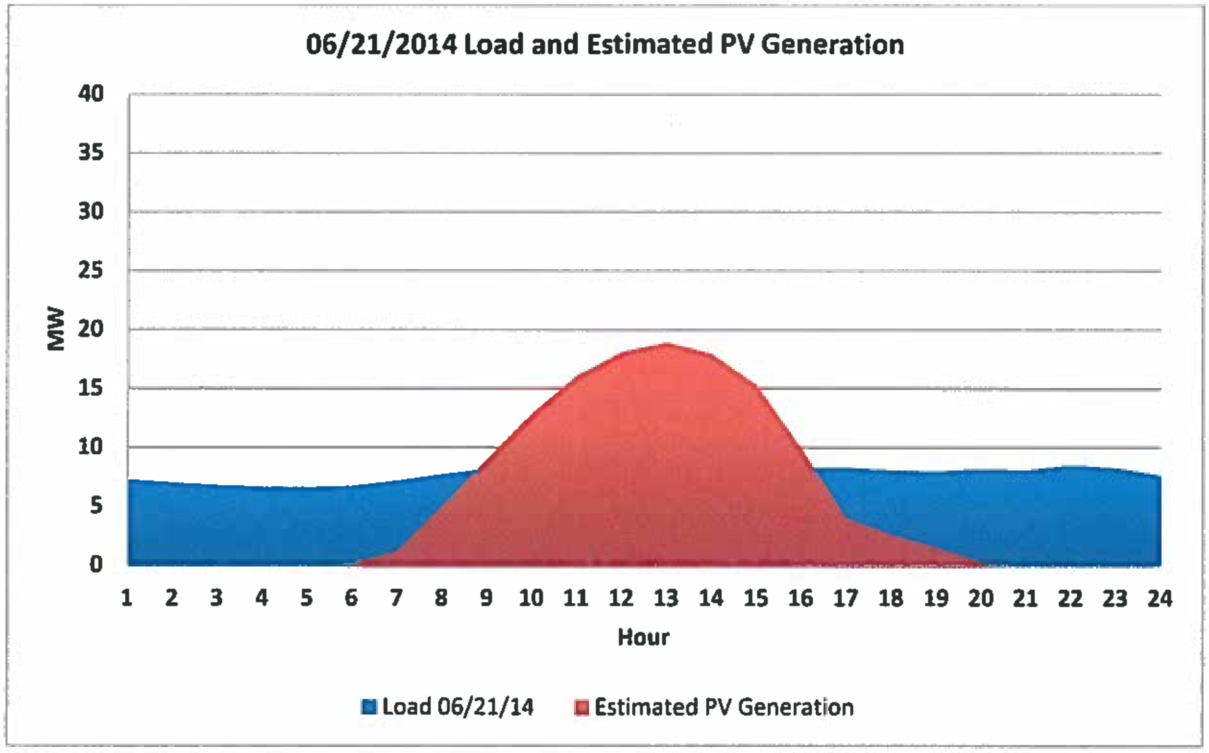

Figure 3: 6/21/2014 Load and Estimated PV Generation

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

David M Angell

Manager, Customer Operations Planning

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

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Appendix D

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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