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State of Maine
Department of Education
School Energy System Study
Augusta, ME
PROJECT #13786

October 27, 2014

FINAL REPORT

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TABLE OF CONTENTS

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STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

EXECUTIVE SUMMARY

Harriman was contracted to study the operational costs associated with geothermal and biomass heating systems, along with a comparison of those systems to traditional oil heat. These analyzed costs include first costs along with long-term maintenance and operational costs. For the purposes of this study, we included Gorham Middle School as a compartmentalized geothermal system and Durham Elementary School as a centralized geothermal system. The Ridge View Community School in Dexter was used as an example of a wood chip heating system, and the Mallett School in Farmington is used as an example of a wood pellet fired heating system.

The report is broken down into the following sections of detailed analysis:

- **COMPARISON OF GEOTHERMAL SYSTEMS**
  Analysis of a compartmentalized geothermal system compared to a more centralized geothermal system, including initial costs along with long term maintenance and operational costs. In this analysis we compare Gorham Middle School to Durham Elementary School and investigate not only the economic impacts but also the pros and cons of both systems.

- **COMPARISON OF WOOD HEATING SYSTEMS**
  Comparison of operational and projected maintenance costs between wood chip heating systems and wood pellet heating systems. In this analysis we compare the Ridge View Community School to the Mallet School. As part of the analysis we discuss the differences between wood chip fuel and wood pellet fuel as well as the required fuel storage and handling systems for each fuel type.

- **LIFE CYCLE COSTING FOR GEOTHERMAL SYSTEMS**
  Life cycle costing for geothermal systems in general to include information based upon past experiences with other types of systems. In this analysis we evaluate the steps required to develop an energy model for a building, as well as benchmark the performance of Durham Elementary School.

- **COMPARISON OF ELECTRICAL COST IMPACTS**
  Electrical cost impact of geothermal systems compared to wood chip heating, wood pellet heating and traditional #2 oil heating. In this analysis we discuss in depth the operation of geothermal, wood chip and wood pellet systems relative to electrical power requirements for each system.

- **ANALYSIS OF HEAT DISTRIBUTION SYSTEMS**
  Analysis of heat distribution systems to compare compartmentalized heating systems to more centralized heating systems. In this analysis we provide an in-depth evaluation of all types of compartmentalized and centralized heating systems including a discussion of which application is a better fit for each system.

- **STANDARDIZED PROCESS FOR COMPARISON**
  Development of a standardized and consistent process for comparing system options to include consistency in baseline comparison, assumptions, incentives and escalation of fuel costs. In this analysis, we explore the evaluation process that was very recently used at Kennebunk High School to determine the fuel source for that prospective project.

STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

COMPARISON OF GEOTHERMAL SYSTEMS

Compartmentalized: The Gorham Middle School is heated and cooled by a geothermal system that consists of more than 100 water source heat pumps distributed throughout the 135,914 square foot building. The heat pumps are coupled to a closed loop heat sink consisting of 130 wells each of which is approximately 450 feet deep. It is understood that natural gas fired boilers are only used to provide domestic hot water for the school, and do not contribute to building heating.

Centralized: Conditioned air is distributed to the 87,521 square foot Durham Elementary School by nine modular air handlers located throughout the building. Heating hot water and chilled water for cooling is distributed to the air handlers from the central mechanical plant within the school. The central mechanical plant consists of 10 water source heat pumps coupled to a closed loop heat sink that consists of 66 wells. As a supplement to the heating system, the piping loop is coupled to fully redundant propane fired boilers each with a net output rating of 2,175 MBH.

In order to compare operational costs, we first need to identify annual fuel consumption and fuel costs for each school. This data is presented in the following tables:

BUILDING INFORMATION			ANNUAL FUEL CONSUMPTION		
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY (KWH)	PROPANE (GALLONS)	NATURAL GAS (CCF)
GORHAM MIDDLE SCHOOL	135,914	2009 - 2010	1,146,480	--	312,060
		2010 - 2011	1,275,600	--	291,390
		2011 - 2012	1,278,720	--	245,260
		2012 - 2013	1,351,440	--	246,670
DURHAM ELEMENTARY SCHOOL	87,521	2010 - 2011	857,471	3,332	--
		2011 - 2012	869,760	--	--
		2012 - 2013	896,880	--	--

BUILDING INFORMATION			ANNUAL FUEL COSTS		
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY	PROPANE	NATURAL GAS
GORHAM MIDDLE SCHOOL	135,914	2009 - 2010	$178,341	--	$2,918
		2010 - 2011	$166,682	--	$2,745
		2011 - 2012	$149,348	--	$2,799
		2012 - 2013	$143,595	--	$2,856
DURHAM ELEMENTARY SCHOOL	87,521	2010 - 2011	$99,401	$7,974	--
		2011 - 2012	$97,549	--	--
		2012 - 2013	$98,549	--	--

As you can see in the previous tables, the Durham Elementary School has not operated the backup propane boilers since the 2010 – 2011 heating season. They have been able to maintain the building by exclusively using the heat pump system. It is also understood that the natural gas consumption for Gorham Middle School is only for domestic hot water production. Therefore, we can perform an equal comparison between the schools by comparing their electrical data.

Following is a table that identifies fuel usage per square foot of building, which is a direct comparison of each building's performance:

BUILDING INFORMATION			CONSUMPTION PER SQUARE FOOT		
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY (KWH/SF)	PROPANE (GAL/SF)	NATURAL GAS (CCF/SF)
GORHAM MIDDLE SCHOOL	135,914	2009 - 2010	8.44	--	2.30
		2010 - 2011	9.39	--	2.14
		2011 - 2012	9.41	--	1.80
		2012 - 2013	9.94	--	1.81
DURHAM ELEMENTARY SCHOOL	87,521	2010 - 2011	9.80	0.04	--
		2011 - 2012	9.94	--	--
		2012 - 2013	10.25	--	--

As you will notice on a year-by-year basis, the performance of each building is very similar with the Durham Elementary School consuming slightly more energy per square foot than the Gorham Middle School. Since the heat pumps are not separately metered for either building, it is difficult to discern whether the additional electrical consumption in Durham Elementary School is attributed to thermal loads or non-HVAC related equipment within the building. Regardless of whether the difference in electrical consumption is related to HVAC equipment or not, it is reasonable to discern that operational costs of compartmentalized and centralized geothermal water source heat pump systems are very similar.

Comparing the initial costs of compartmentalized and centralized systems, in general the compartmentalized systems will have a lower first cost than the centralized systems. From our experience with both types of systems, the mechanical construction costs for compartmentalized geothermal systems typically are approximately $36 per square foot, while centralized geothermal systems are typically approximately $39 per square foot. As stated previously, there are more heat pumps in a compartmentalized system but they are smaller in size than they would be for a centralized system. Additionally, with a centralized system it is required to provide additional air handling equipment instead of allowing the heat pumps to condition the space. Lastly, a compartmentalized system requires small diameter condenser piping run throughout the building as opposed to large diameter hot water and chilled water piping with a centralized system.

Lastly, there are significant differences when comparing the maintenance costs between the two systems. The compartmentalized system has more equipment to service than a centralized system. The main reason for this is attributed to zoning of spaces. Only certain spaces can be grouped together in a common zone. For instance, a conference room would not be zoned with office spaces since the occupancy schedule of those spaces is completely different. Also, rooms with different outside wall exposures would not be grouped together in the same zone because the heating and cooling requirements of those spaces would be different. Therefore in general, with a compartmentalized system, a large number of smaller capacity heat pumps would be used to serve the building. A centralized system would include a much smaller number of high capacity heat pumps located at one location within the building. Zoning of spaces is accomplished through providing a small number of air handling units to split the building up into smaller portions. Individual space zoning at each air handler is provided through either reheat coils or Variable Air Volume (VAV) terminals with reheat coils which require very little maintenance.

Additionally, with a compartmentalized system the maintenance staff needs to service heat pumps all over the building instead of servicing all of the heat pumps at one location isolated from the occupied spaces. Traditionally, equipment located in spaces that are not easy to access like above ceilings for instance, is less likely to get serviced than easily accessible equipment within mechanical spaces. Taking all of this into consideration, it is expected that maintenance costs associated with compartmentalized systems are higher than they are for centralized systems. We have researched maintenance costs for both types of systems, and determined that on average $0.25 per square foot covers maintenance costs for a centralized system. This includes one worker at $100 per hour providing four visits per year at one week per visit. This cost also includes an allowance for filters, belts, rags, grease, etc. For a compartmentalized system, the maintenance cost increases to $0.50 per square foot. This increase is attributed to the fact that equipment is spread out across the entire building which makes the maintenance more labor intensive.

We have developed a cost benefit analysis to compare the difference between a compartmentalized and a centralized and geothermal system. As noted in the tables above, Gorham Middle School is a 135,914 square foot building and they paid $143,595 for electricity during the 2012-2013 fiscal year. This calculates out to $1.06 per square foot electrical cost with typical maintenance costs of $0.50 per square foot, which results in a total operating cost of $1.56 per square foot for a compartmentalized geothermal system. Also noted in the tables above, Durham Elementary School is an 87,521 square foot building and they paid $98,549 for electricity during the 2012-2013 fiscal year. This calculates out to $1.13 per square foot electrical cost with typical maintenance costs of $0.25 per square foot which results in a total operating cost of $1.38 per square foot for a centralized geothermal system. Therefore, on average the overall operating cost of a centralized geothermal system is $0.18 per square foot less expensive than a compartmentalized geothermal system.

As a result of the analysis, we discovered that even though the compartmentalized geothermal system has a lower electrical operating cost, the total operating cost is higher than a centralized geothermal system when you take into account the higher maintenance costs associated with a compartmentalized geothermal system.

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STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

COMPARISON OF WOOD HEATING SYSTEMS

The Ridge View Community School in Dexter is a 125,000 square foot building which incorporates a wood chip heating system. The boiler plant for the school includes a backup boiler fired with #2 heating oil; however, according to fuel usage data that boiler has not been in operation since the 2011-2012 heating season. Additionally, the school uses propane but it is understood that this is only used for non-heating purposes.

The Mallet School in Farmington is a 52,000 square foot building which incorporates a wood pellet heating system. The boiler plant for the school includes a backup boiler fired with #2 heating oil; however, according to fuel usage data that boiler has not been in operation since the 2012-2013 heating season.

In order to compare operational costs, we first need to identify annual fuel consumption and fuel costs for each school. This data is presented in the following tables:

BUILDING INFORMATION			ANNUAL FUEL CONSUMPTION				
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY (KWH)	#2 OIL (GALS)	PROPANE (GALS)	WOOD PELLETS (TONS)	WOOD CHIPS (TONS)
RIDGE VIEW COMMUNITY SCHOOL	125,000	2011 - 12	533,400	1,990	1,804	--	296
		2012 - 13	586,400	--	2,254	--	337
		2013 - 14	588,960	--	1,713	--	368
MALLETT SCHOOL	52,000	2011 - 12	197,657	1,700	--	--	--
		2012 - 13	251,200	1,007	--	77	--
		2013 - 14	224,429	--	--	102	--

BUILDING INFORMATION			ANNUAL FUEL COSTS				
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY	#2 OIL	PROPANE	WOOD PELLETS	WOOD CHIPS
RIDGE VIEW COMMUNITY SCHOOL	125,000	2011 - 12	$59,080	$5,292	$5,446	--	
		2012 - 13	$65,948	--	$4,610	--	$20,232
		2013 - 14	$81,889	--	$3,606	--	$22,094
MALLETT SCHOOL	52,000	2011 - 12	$30,076	$5,132	--	--	--
		2012 - 13	$26,646	$2,982	--	$13,580	--
		2013 - 14	$28,361	--	--	$17,766	--

In the previous tables, you will notice that the Ridge View Community School has not used their #2 oil backup boilers since the 2011 – 2012 heating season and has been heating the building exclusively with wood chips since that time. There is also propane consumption on an annual basis; however, it is understood that the propane consumption is attributed to non-heating usage.

The Mallet School was heated exclusively with #2 oil during the 2011 – 2012 heating season. During the 2012 – 2013 heating season, the school was finishing construction of the wood pellet fired heating plant and so the school was heated with both #2 oil and wood pellets during that year. However, during the 2013 – 2014 heating season the building was heated exclusively with wood pellets.

In order to compare the two schools, we will look at all three heating seasons, but we will focus on the 2013 – 2014 heating season. Following is a table that identifies fuel usage per square foot of building, which is a direct comparison of each building's performance:

BUILDING INFORMATION			CONSUMPTION PER SQUARE FOOT				
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY (KWH/SF)	#2 OIL (GAL/SF)	PROPANE (GAL/SF)	WOOD PELLETS (TON/SF)	WOOD CHIPS (TON/SF)
RIDGE VIEW COMMUNITY SCHOOL	125,000	2011 - 12	4.27	0.0159	0.01	--	0.0024
		2012 - 13	4.69	--	0.02	--	0.0030
		2013 - 14	4.71	--	0.01	--	0.0029
MALLETT SCHOOL	52,000	2011 - 12	3.80	0.0327	--	--	--
		2012 - 13	4.83	0.0194	--	0.0015	--
		2013 - 14	4.32	--	--	0.0020	--

As indicated in the fuel consumption data above, the wood chip fired plant consumes more fuel per square foot than the wood pellet fired plant. In fact, when you compare the 2013 – 2014 heating season at the Mallet School to the 2012 – 2013 and 2013 – 2014 heating seasons at the Ridgeview Community School; the wood chip fired plant consumes one and a half times as much fuel per square foot as the wood pellet fired plant. This difference can be attributed to the difference in moisture content between wood chips and wood pellets.

Since wood chips are not a processed fuel, the moisture content of the fuel can vary significantly from one load of fuel to another which affects the heat output of the fuel. Essentially, the same amount of input energy is provided to consume wood chips and wood pellets. However, since wood chips have higher moisture content than wood pellets, a significant amount of the input energy is lost as latent heat of vaporization to vaporize the moisture within the fuel. Therefore on average, the heat output from wood chip fuel is 4,500 Btu/pound or 9,000,000 Btu/ton.

STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

In comparison, wood pellets are a processed fuel and as such there is very little variation in moisture content or fuel quality between loads of fuel. Since wood pellet fuel has much less moisture content than wood chip fuel, less of the input energy is lost as latent heat of vaporization. Therefore on average, the heat output from wood pellet fuel is 8,000 Btu/pound or 16,000,000 Btu/ton.

As indicated above, it is necessary to consume more wood chip fuel per square foot than wood pellet fuel in order to achieve the same heat output. However, to fully compare the fuel types, we need to investigate the fuel costs on a square foot basis. Below is a table that identifies fuel costs per square foot of building:

BUILDING INFORMATION			COST PER SQUARE FOOT				
SCHOOL NAME	SQUARE FOOTAGE (SF)	SCHOOL YEAR	ELECTRICITY ($/SF)	#2 OIL ($/SF)	PROPANE ($/SF)	WOOD PELLETS ($/SF)	WOOD CHIPS ($/SF)
RIDGE VIEW COMMUNITY SCHOOL	125,000	2011 - 12	$0.47	$0.04	$0.04	--	$0.14
		2012 - 13	$0.53	--	$0.04	--	$0.16
		2013 - 14	$0.66	--	$0.03	--	$0.18
MALLETT SCHOOL	52,000	2011 - 12	$0.58	$0.10	--	--	--
		2012 - 13	$0.51	$0.06	--	$0.26	--
		2013 - 14	$0.55	--	--	$0.34	--

As noted within the previous table, the cost per square foot of wood pellet fuel is significantly higher than the cost per square foot for wood chip fuel. Comparing the 2013 – 2014 heating season, the cost per square foot of wood pellet fuel is nearly twice as much as wood chip fuel. However, it is important to note that wood chip fired boiler plants typically incur higher electrical operating costs than wood pellet fired boiler plants due to larger horsepower motors associated with the fuel handling system.

Wood chip fuel is typically stored inside of a building that tractor trailers can back into and deposit fuel on to a walking floor. Hydraulic rams powered by large motors are used to transfer fuel from the walking floor to a conveyer system, where it is screened to prevent excessively large or irregular shaped chip fuel from being distributed to the boiler(s). Following the screening process, the conveyer system transfers the wood chip fuel to the boiler(s) where it is consumed.

In contrast, wood pellet fuel is typically stored within traditional grain silos and transferred from the silo(s) to the boiler(s) using augers powered by small horsepower motors. Since wood pellet fuel is processed, there is no need for screening since the fuel is very uniform in size and shape.

Within the table above, it is noted that for the 2013 – 2014 heating season the electrical cost per square foot for the Ridgeview Community School is $0.11 higher than it is for the Mallett School. It is difficult to determine what percentage of the increased electrical cost is attributed to the wood chip fuel storage and handling system; however, it does indicate that there are additional operating costs for these systems which need to be considered as part of the comparison.

It is not uncommon for walking floor fuel storage systems to fail, due to the fact that the hydraulic rams are very powerful and they will attempt to move the floor sections even if there is a blockage with the wood chip fuel. When this type of failure happens, the entire wood chip boiler plant is shut down for a significant amount of time. In order to assess the extent of failure, the wood chip fuel needs to be manually unloaded from the fuel storage building typically with a front end loader and a dump truck. Depending upon the extent of failure, it could take hours or days to repair the walking floor system during which time the building would be heated by higher cost fossil fuels.

Wood pellet fuel from grain silos is augured from the bottom of the silo to the boiler, and so there is a possibility that the auger could jam or fail. In order to avoid a complete system failure, redundant grain silos and augers can be provided that feed into a common “day bin” prior to being augured to the boiler(s). Compared to a wood chip storage building with a walking floor, grain silos are a fraction of the initial cost. Additionally, grain silos have the capability of storing weeks of pelletized fuel within the same footprint as a wood chip storage building that can only store days of chip fuel. From our experience, we have noticed that mechanical construction costs for a wood chip fired boiler plant are typically in the range of $260 per square foot, whereas mechanical construction costs for a wood pellet fired boiler plant are typically in the range of $100 per square foot. This cost difference is primarily attributed to the fact that construction of a building is required for wood chip storage which is much more expensive than grain silos for wood pellet storage.

With a wood chip fuel storage and handling system, it is not uncommon for there to be minor disruptions to the fuel feed system which need to be addressed. These minor disruptions typically are sporadic and only last a few minutes once they are addressed by personnel. According to our research, we have determined that on average $0.05 per square foot covers additional regular maintenance costs associated with a wood chip fired boiler plant. This includes one worker at $100 per hour to provide one hour per week for ash removal. In contrast, we have determined that on average $0.02 per square foot covers additional regular maintenance costs associated with a wood pellet fired boiler plant. This includes two workers at $100 per hour for one 8 hour day to provide one additional boiler cleaning per year.

We have developed a cost benefit analysis to compare the difference between a wood chip fired boiler plant and a wood pellet fired boiler plant. As noted in the tables above, the Ridge View Community School is a 125,914 square foot building and they paid $0.18 per square foot for wood chips along with $0.66 per square foot for electrical consumption during the 2013-2014 fiscal year. It is important to include the electrical consumption along with the wood fuel consumption since there is a significant difference between electrical loads for both types of wood fuel systems. Overall, the fuel consumption cost for the Ridge View Community School with a wood chip fired boiler plant equals $0.84 per square foot. When you combine the overall fuel consumption cost with the typical maintenance cost of $0.05 per square foot, this results in a total operating cost of $0.89 per square foot for a building with a wood chip fired boiler plant. Also noted in the tables above, the Mallett School is a 52,000 square foot building and they paid $0.34 per square foot for wood pellets and $0.55 per square foot for electrical consumption during the 2013-2014 fiscal year. Overall, the fuel consumption cost for the Mallet School with a wood pellet fired boiler plant equals $0.89 per square foot. When you combine the overall fuel consumption cost with the typical maintenance cost of $0.02 per square foot, this results in a total operating cost of $0.91 per square foot for a building with a wood pellet fired boiler plant.

As a result of the analysis, we discovered that there is a financial advantage with using a wood chip fired boiler plant; however, the overall operating costs are very close to a wood pellet fired boiler plant. It is important to look at the electrical consumption and maintenance costs to form a clear understanding of how these systems perform.

In summary, even though wood chip fired boiler plants provide a slight financial advantage compared to wood pellet fired boiler plants; there are other matters to consider beyond the economic impact. Typically wood fired systems are installed in remote areas of the state where it is advantageous to store large amounts of fuel onsite in the event of a major snow storm. Due to the nature of the fuel storage systems, it is much more cost effective to store large amounts of wood pellet fuel than it is to store a comparable amount of wood chip fuel. Additionally, most school districts have a shortage of maintenance staff and in those situations it is advantageous to have a low maintenance boiler plant. Additional regular maintenance for a wood chip fired boiler plant can be handled by a smaller maintenance staff; however, it can become overwhelming for a smaller maintenance staff when significant system failures occur.

Therefore, prior to making a decision regarding the type of wood fired system for a proposed building, the potential client needs to be made aware of the pros and cons of each system and the decision needs to be evaluated on a case-by-case basis to determine whether wood pellets or wood chips are the best fit for their facility.

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STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

LIFE CYCLE COSTING FOR GEOTHERMAL SYSTEMS

A Life Cycle Costing Analysis (LCCA) is a tool that is used to determine the cost effectiveness of a proposed building design, and compares projected operating and maintenance costs over a 20 year period against initial construction costs. A 20 year period is used for the LCCA since it is expected that the mechanical equipment will last 20 years on average. All of the costs are discounted by a 3.0% rate in accordance with the United States Department of Energy requirements for federal life cycle costing analyses.

In order to develop an LCCA, the first step is to develop a detailed energy model of the proposed building design to determine the building energy consumption. In developing an energy model, it is important to be as accurate as possible since the results are only as good as the input data. Development of the energy model begins with establishing operating schedules for the building associated with occupancy, ventilation, lighting and equipment use. Since there are many different types of spaces within a school, operating schedules need to be customized for each type of space. For example, a typical occupancy schedule for a private office could be one person working from 8 AM until noon, taking an hour for lunch and then working from 1 PM until 5 PM. In contrast, a typical occupancy schedule for a classroom could be 25 students and 1 teacher arriving at 7 AM to start their day. The morning would include four 50 minute classes followed by a 10 minute break to allow students to get to their next class. The classroom would be empty during the lunch period followed by two more afternoon classes with the school day ending at 2:00 PM. These are only a few examples; however, there is clearly a significant difference in occupancy schedules which needs to be taken into account in order to develop an accurate energy model.

Once the operating schedules have been established, the spaces within the building need to be entered into the energy model. In order to accomplish this task, it is necessary to know the orientation of the building, U-Factor of walls and roofs, lighting levels in all spaces, glazing characteristics, color and type of roofs, along with basement and/or floor slab U-Factor. Lastly, modeling of the mechanical systems needs to match the designed systems as closely as possible.

Once all of the data is entered into the energy model, the model is run and the results are reviewed by the designer. The designer compares the results to models and real world energy consumption data from similar buildings to verify accuracy of the energy model. Often times, the model will need to be adjusted in order to accurately reflect the projected energy consumption of the proposed building.

When the energy model is for a new building that has not been constructed, the energy model would be considered as accurate as possible at this point and the energy usage data would be used in the next step of the LCCA. However, when real world energy consumption data exists for a building, the energy model can be calibrated to reflect the actual energy consumption of that particular building. Calibrating an energy model involves several iterations of adjusting and running the energy model until the proposed energy consumption matches the real world data. This is often a time consuming process; however, once the model is calibrated it is an extremely accurate representation of the energy usage at that particular building.

STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

For the purposes of this study, we have developed a detailed energy model of Durham Elementary School with a centralized geothermal plant. Since real world energy consumption data exists for this school, we used this data to calibrate the energy model and provide a very accurate representation of this building's energy usage. For comparative purposes, we also modeled a Maine Benchmark building to determine if Durham Elementary School actually uses less energy than the Maine Benchmark building and if so, by how much.

At the time when Durham Elementary School was constructed, the Maine Benchmark building raised the bar for energy efficiency by defining the minimum level of acceptable performance at 20% better than ASHRAE 90.1-2001. The Durham Elementary School project received State of Maine capitol construction funding assistance, and therefore was required to comply with the requirements set forth by the Maine Benchmark. In order for a building to meet the Maine Benchmark it must meet the following criteria:

- Basic Criteria that is necessary for all buildings constructed or renovated, which is similar to the prerequisites for LEED-NC:
  - Documented Design Certification
  - Documented Construction Certification
  - Documented Operations Certification
  - Documented Energy Code Compliance
  - Envelope Air Barrier Performance
  - Envelope Window, Skylight and Door Certification
  - Building Controls for Monitoring and Trend Logging for Buildings over 25,000 sf
  - Electrical Transformers Meeting NEMA TP 1-2002 or Energy Star
  - Lighting Controls for Interior and Exterior Lighting
  - Indoor Air Quality to Meet or Exceed ASHRAE Standard 62-2001
  - Refrigeration and Icemaker Minimum Efficiency Requirements
  - Networked Computer Monitor Controls

- Follow a prescriptive approach to meet certain statutory requirements:
  - Documented Opaque Envelope Performance
  - Utilize High-Performance Glazing Systems
  - Mechanical Design to Improve System Performance and Meet ASHRAE Std. 55
  - Mechanical Equipment to Meet Minimum Efficiency Requirements
  - Utilize Variable Speed Drives on Pump and Fan Motors 10 HP or Larger
  - Reduced Lighting Power Density
  - Utilize Daylighting Responsive Lighting Controls for Schools

- Additional recommended credits can be achieved to meet additional program goals:
  - Documented Pre-Design Certification
  - Documented Additional Building Commissioning
  - Documented Continuous Recommissioning
  - Documented Performance Certification
  - Utilize Technology to Reduce Electrical Demand or Replace Electrical Supply
  - Provide On-Site Supply of Renewable Energy

As noted in the attached Energy Cost Budget/PRM Summary, the maximum allowable energy consumption in order to meet the Maine Benchmark building is 4,287,000,000 Btu/yr. According to the calibrated energy model for Durham Elementary School, the actual annual energy consumption is 2,997,900,000 Btu/yr which represents a 30% improvement over the Maine Benchmark Building.

More recently, energy performance of Maine Schools is being benchmarked using the Maine Annual Energy Use Index (EUI). The EUI offers an indication of where a building falls on a spectrum in comparison to other similar buildings in Maine. The EUI is calculated based upon the annual energy consumed per square foot, adjusted for the regional climate (BTU/ft^2/HDD). In the case of Durham Elementary School, the EUI is calculated as (2,997,900,000/87,521)/7,318 which equals 4.68. This is considered a low energy use ranking compared to over 100 Maine school buildings that have been benchmarked.

The next step in developing an LCCA is to develop an opinion of probable cost estimate for construction of the proposed building. Since Durham Elementary School is already built, we used the actual mechanical construction cost of $3,425,000. Based upon the total building area of 87,521 square feet, this calculates out to $39 per square foot. From our past experience with fully air conditioned buildings using conventional mechanical systems, we have assigned $32 per square foot as the mechanical construction cost for the Maine Benchmark Building.

Additionally, it is necessary to identify current utility rate(s) to be used in the LCCA calculations. Lastly, it is necessary to estimate regularly scheduled maintenance costs for both the proposed building and the alternative. This is somewhat subjective since each building is different however in general service contracts include a minimum of four visits per year. The amount of time spent at each visit depends upon the amount of equipment to be serviced, whether the equipment is centralized or compartmentalized and if the equipment is easily serviceable or not. For Durham Elementary School, we used $0.25 per square foot for maintenance costs which covers one worker at $100 per hour to provide four visits per year at one week per visit. This cost also includes an allowance for filters, belts, rags, grease, etc. which are all part of the regularly scheduled maintenance cost. We carried the same maintenance cost for the Maine Benchmark Building since the equipment maintenance would be similar to Durham Elementary School.

After entering all of the above mentioned data into the LCCA, Durham Elementary School has an annual savings of $37,406 compared to the Maine Benchmark Building. Durham Elementary School has a simple payback of 16.7 years and an internal rate of return of 4.5% compared to the Maine Benchmark Building.

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STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

COMPARISON OF ELECTRICAL COST IMPACTS

In comparing the electrical cost impacts of geothermal systems against biomass and conventional #2 oil fired systems, it is important to explore each type of system individually and identify any similarities or differences between the systems.

Geothermal Systems

Geothermal systems just by their nature consume electricity as their primary fuel source; however, the backbone of any geothermal system is the ground source connection. Regardless of whether it is an open well or closed well geothermal system, electrically powered pumps are required to circulate water and transfer heat between the ground and the HVAC equipment. In an open well system, each well is equipped with a submerged pump to circulate ground water as the heat transfer medium. Since each well has a dedicated pump, the motor horsepower for each pump is small; however, there are several of these small motors within the system. Capacity of an open well system is controlled by enabling and disabling well pumps as necessary to match the HVAC load of the equipment. Under normal operation, it is common that multiple well pumps will be operating at the same time.

In a closed well system, there is a redundant pair of pumps located within a mechanical space that circulate water within a closed loop through the ground. Instead of using ground water as the heat transfer medium, the closed loop system uses the ground as a large heat sink to transfer energy. Since the closed loop system pumps serve the entire ground source loop instead of each well individually, the motor horsepower for each pump is large. However, only one pump is operating at any given time with the speed of the pump motor adjusted through a Variable Frequency Drive (VFD) to match the HVAC load of the equipment.

The second most important component of a geothermal system is the water source heat pump itself. Each water source heat pump includes an electrically powered compressor(s) which is sized for the HVAC load of the spaces that it serves. As discussed previously, in a compartmentalized system there are several water source heat pumps located within the building each of which serves either a single space or a small number of spaces. On a year round basis, in order to meet the HVAC loads of the building there are multiple small capacity heat pumps operating all at the same time.

Conversely, in a centralized system there is a small number of large capacity heat pumps located within a mechanical space to serve the HVAC requirements of the entire building. As the HVAC loads of the building fluctuate, the building control system stages heat pumps on and off to meet the building load. At any given time, it is common to have multiple heat pumps operating; however, the difference is that there would be a small number of large capacity heat pumps versus a large number of small capacity heat pumps.

Lastly, the system pumps and associated piping system tie the ground source connection and heat pumps together to complete the geothermal HVAC system. In order to understand this connection, it is important to understand how heat pumps interact with a ground source loop as well as the remainder of the building HVAC equipment. Water source heat pumps serve as an interface between the building and the ground source system water. If the building requires cooling, the heat pump uses the compressor(s) through the refrigerant cycle to cool either warm water or warm air on the building side. Now that the heat pump has drawn heat from the building, it needs to reject that heat to the ground source system water. Conversely, in heating mode the water source heat pump draws heat from the ground source side and rejects that heat to the building.

As discussed previously, there are both open-well and closed-well geothermal systems that can be implemented. In an open well system, the actual ground water is pumped into the building where it can either be pumped through a water-to-water heat exchanger to separate the ground water from the building water or through the heat pumps themselves. Due to potential corrosion issues from the ground water, open well systems are not recommended; however, that system option has been discussed for completeness. Since the Gorham Middle School and Durham Elementary School both utilize closed well geothermal systems, the remainder of the discussion will focus on closed well systems.

In a closed well system, it is typical to pump the water from the ground source side directly through the heat pumps since there are no issues with contamination. In a compartmentalized system, one set of condenser water lines is run around the building to serve all of the heat pumps. The heat pumps in this system are console type and they are directly used to heat and cool the building. In a centralized system, the water from the ground source side pumps directly through a small group of heat pumps within a mechanical space. The heat pumps in this system are water-to-water type and they are used to condition water on the building side which in turn provides heating and cooling for the building. In this system, a secondary piping loop is required with an additional set of pumps to circulate the conditioned water to remote air handlers throughout the building.

Wood Pellet Heating Systems

Wood pellet heating systems are similar to conventional #2 oil fired systems in that they are both heating only and they utilize a redundant set of pumps to circulate conditioned water to remote air handlers and other heating elements throughout the building. The main difference with a wood pellet heating system is that augers are used to transfer wood pellets from fuel storage container(s) to the wood pellet fired boiler(s). Auger motors are typically 2 HP or less with a quantity of motors that varies from project to project depending upon the field conditions. Wood pellet fuel is processed within a manufacturing facility to achieve very consistent fuel quality, size and shape. One of the most important features of the consistent fuel quality is that the moisture content associated with wood pellet fuel is typically around 6-7%. Due to the fact that the wood pellet fuel is processed, there is very little variance between deliveries. The density of wood pellet fuel is approximately 40 lb/ft3 which is very similar to the density of grain. Since the size and shape of wood pellet fuel is also very similar to grain, it is possible to deliver, store and handle wood pellet fuel with the same equipment that is used for grain.

Heating output of wood pellet fired boilers is controlled by the feed rate of the wood pellet fuel, as well as the quantity of combustion air fed into the boiler. There are two separate strategies associated with capacity control of wood pellet fired boilers, each of which operates differently from an electrical standpoint. On a call for heat with constant speed capacity control, the boiler control panel starts constant speed augers to feed wood pellet fuel from the fuel storage grain silo to the stoker mounted to the boiler itself. Integral to the stoker is a small temporary bin. A level sensor at the top of the temporary bin turns off the auger motors once the temporary bin is full. At that point, a constant speed combustion air fan starts on the boiler and the constant speed stoker feeds all of the fuel from the temporary bin into the combustion chamber. Once the minimum internal temperature of the combustion chamber is achieved, a second set of constant speed combustion air fans start and the boiler is now operating at high fire. The entire process repeats each time that there is a call for heat from the boiler.

On a call for heat with variable speed capacity control, the boiler control panel starts variable speed augers to feed wood pellet fuel from the fuel storage grain silo to the variable speed stoker mounted to the boiler itself. When the boiler is ready to fire, a variable speed combustion fan starts on the boiler and the variable speed stoker begins to feed fuel into the combustion chamber. In order to control capacity, the variable speed augers and stoker modulate in conjunction with the variable speed combustion air fans to closely match the system heating requirements. If the boiler needs to go to high fire to match the heating load, the wood pellet fuel feed rate is increased, the variable speed combustion fan introduces more air and a second set of variable speed combustion air fans start. In this control strategy, the auger motors are always operating; however, they spend most of their time operating at a reduced speed which allows for some energy savings. Additionally, it is understood that every time a motor starts an inrush or current is required to overcome the locked rotor amps of the motor. Using variable speed drives on all of the motors avoids that situation with a soft start and it keeps the motors running continuously instead of continuously starting and stopping the motors.

Wood Chip Heating Systems

Wood chip heating systems are similar to conventional #2 oil fired systems and wood pellet fired heating systems in that they are both heating only and they utilize a redundant set of pumps to circulate conditioned water to remote air handlers and other heating elements throughout the building. The main difference between wood pellet heating systems and wood chip heating systems is that the fuel handling system for wood chips is more robust due to the nature of the fuel itself. Wood chip fuel is not processed within a manufacturing facility like wood pellet fuel is processed. The size and shape of wood chip fuel varies significantly as well of the quality of fuel itself. The lowest quality of wood chip fuel is referred to as “hog fuel” which can include tree tops and bark. Not all wood chip boilers can burn hog fuel, and so if a client intends to burn that type of fuel it needs to be discussed up front to insure that the equipment is properly selected. A more common grade of wood chip fuel does not include tree tops or bark and the moisture content of the fuel is approximately 36%. Since the wood chip fuel is not processed like wood pellets, the moisture content of the fuel can and will vary between deliveries and needs to be verified for acceptance by the building owner prior to each fuel delivery.

Wood chip fuel is typically unloaded from a tractor trailer to a building with a walking floor. The purpose of the walking floor is to move the fuel pile towards a conveyer belt along the side of the storage fuel storage bin. The walking floor is moved by hydraulic rams powered by typically 7.5 to 10 HP motors. The walking floor and fuel conveyer systems are operational any time the wood chip boiler calls for fuel. The motors associated with the conveyer belt fuel handling system are typically 2 HP or less. Similar to wood pellet boilers, wood chip boilers incorporate both constant speed and variable speed capacity control strategies.

Conventional #2 Oil Fired Systems

The main difference between conventional #2 oil fired heating systems and geothermal systems is that #2 oil fired systems are heating only and do not incorporate cooling as geothermal systems do. As expected, the primary fuel source for this type of system is #2 heating oil with electricity as their secondary fuel source. A conventional oil fired boiler includes a burner mounted to the boiler with an integral electrically operated fuel oil pump. The burner mounted fuel oil pumps require a minimal amount of electricity to operate and are typically powered from the burner control circuit which is typically a 120 volt, 20 amp circuit. Larger #2 oil systems include underground fuel storage tanks which require an additional fuel oil transfer pump to draw fuel from the tank into the building so that the burner mounted fuel oil pumps can draw the fuel that they need. Even though a fuel oil transfer pump would be needed, the pump would typically require a motor that is 2hp or less.

A conventional #2 oil fired system uses a redundant set of pumps to circulate conditioned water to remote air handlers and other heating elements throughout the building. This is no different than wood pellet and wood chip fired heating systems and the horsepower of the pump motors varies greatly depending upon the size of the building that is being conditioned.

Summary

In summary, following is a list of each system type along with the typical electrical impact associated with each system:

- Closed Well Geothermal Compartmentalized System:
    - Redundant pair of large horsepower variable speed well pumps
    - Large number of small horsepower water source heat pumps
    - Building air conditioning included in addition to building heating
- Closed Well Geothermal Central System:
    - Redundant pair of large horsepower variable speed well pumps
    - Redundant pair of large horsepower variable speed heating/cooling pumps
    - Small number of large horsepower water source heat pumps
    - Building air conditioning included in addition to building heating
    - Remote air handling equipment to condition building
- Wood Pellet Heating System (Constant Speed Capacity Control):
    - Small horsepower constant speed on/off auger motors (typically 2-3 total)
    - Small horsepower constant speed on/off combustion air fans (typically 3)
    - Redundant pair of large horsepower variable speed heating pumps
    - Remote air handling equipment to condition building

- Wood Pellet Heating System (Variable Speed Capacity Control):
  - Small horsepower variable speed auger motors (typically 2-3 total)
  - Small horsepower variable speed combustion air fans (typically 3)
  - Redundant pair of large horsepower variable speed heating pumps
  - Remote air handling equipment to condition building
- Wood Chip Heating System (Constant Speed Capacity Control):
  - Small horsepower constant speed on/off conveyer motors (typically 2-3 total)
  - Small horsepower constant speed on/off combustion air fans (typically 3)
  - Large horsepower hydraulic ram motors (typically 4)
  - Redundant pair of large horsepower variable speed heating pumps
  - Remote air handling equipment to condition building
- Wood Chip Heating System (Variable Speed Capacity Control):
  - Small horsepower variable speed conveyer motors (typically 2-3 total)
  - Small horsepower variable speed combustion air fans (typically 3)
  - Large horsepower hydraulic ram motors (typically 4)
  - Redundant pair of large horsepower variable speed heating pumps
  - Remote air handling equipment to condition building
- Conventional #2 Oil Fired System:
  - Typically 120 volt, 20 amp circuit per boiler
  - Small horsepower constant speed oil pump motor on large systems
  - Redundant pair of large horsepower variable speed heating pumps
  - Remote air handling equipment to condition building

BUILDING INFORMATION			
SCHOOL NAME	**SQUARE FOOTAGE (SF)**	**SCHOOL YEAR**	**ELECTRICITY ($/SQFT)**
GORHAM MIDDLE SCHOOL Compartmentalized Geo-Thermal	135,914	2009 - 2010	$1.31
		2010 - 2011	$1.23
		2011 - 2012	$1.10
		2012 - 2013	$1.06
DURHAM ELEMENTARY SCHOOL Centralized Geo-Thermal	87,521	2010 - 2011	$1.14
		2011 - 2012	$1.11
		2012 - 2013	$1.13
RIDGE VIEW COMMUNITY SCHOOL Bio-Mass - Chips	125,000	2011 - 2012	$0.47
		2012 - 2013	$0.53
		2013 - 2014	$0.66
MALLETT SCHOOL Bio-Mass - Pellets	52,000	2011 - 2012	$0.58
		2012 - 2013	$0.51
		2013 - 2014	$0.55

In reviewing the information stated above, it is understood that following schools incorporate the following systems:

- Gorham Middle School – Compartmentalized geothermal heating/cooling system
- Durham Elementary School – Centralized geothermal heating/cooling system
- Ridgeview Community School – Wood chip heating system
- Mallet School – Wood pellet heating system

Even though a conventional #2 oil fired system is not included in the table, it is understood that the electrical costs associated with this system type would have the lowest electrical operating cost per square foot numbers since these systems are heating only and the costs associated with fuel handling would be far less than for a wood pellet heating system.

In comparing the two geothermal systems to each other, the electrical costs per square foot are very similar between the compartmentalized system and the central system. Overall, the geothermal systems have a much higher electrical cost per square foot than the heating only systems due to operating costs associated with air conditioning.

In comparing the wood pellet and wood chip heating systems, the electrical cost per square foot associated with the wood pellet system is slightly less than with the wood chip system. This is expected due to the larger horsepower motors required to handle the wood chip fuel.

The table does not differentiate between constant speed or variable speed control of biomass boilers; however, in general energy savings can be achieved by reducing the speed of motors instead of operating them at full motor horsepower.

STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

ANALYSIS OF HEAT DISTRIBUTION SYSTEMS

This analysis is focused on comparing compartmentalized heating distribution systems to centralized heating distribution systems. This analysis includes geothermal systems as well as conventional hot water distribution systems.

Compartmentalized Geothermal System

A compartmentalized geothermal system consists of several small tonnage console type and/or ducted water source heat pumps distributed throughout the building to provide both heating and cooling to individual spaces. Console type heat pumps are typically floor mounted within the space they serve. The heating/cooling capacity of the console units range from 0.5 tons to 1.5 tons, they include a fan to draw room air across their evaporator coil and can include either stand-alone controls or they can be controlled through a central building management system. Since these console units include a compressor, they tend to be rather noisy therefore they are not recommended for sound sensitive spaces.

Another option is ducted water source heat pumps which are typically located above ceiling cavities or within small mechanical spaces adjacent to the room that they serve. Depending upon the model selected, ducted heat pumps can range in capacity from 0.5 tons to as much as 25 tons. The large capacity ducted units would typically be used for large spaces like an auditorium or cafeteria. The important thing to keep in mind with a compartmentalized system is that each heat pump is a zone of heating and cooling. It would not be desirable to include dis-similar spaces on the same heat pump because it would be very difficult to keep everyone comfortable. For instance, it would not be a good decision to zone a private office on an outside wall with an open office space that is completely interior to the building. Both of these spaces will perform completely differently when it comes to heating and cooling loads and none of the occupants will be comfortable. For instance in cooling mode with the temperature sensor located in the open office, the heat pump will satisfy that space but the private office will be much too cold. However, with the temperature sensor is located inside the private office, the heat pump will satisfy that space but the open office will be too warm. It would be a far better decision to use one heat pump for the open office space and a separate heat pump for the private office.

The ultimate level of comfort for any building would be for every space to be zoned independently; however, this method is cost prohibitive. Therefore it is important to explore zoning similar spaces together in order to keep the project within a reasonable budget. For instance, a group of four private offices all along the same outside wall with only one wall of exposure could be zoned together. As far as heating and cooling loads are concerned, all four offices will perform the same. However, if one of those offices was a corner office it would be a better decision to place that office on a separate zone from the other three offices. Additionally, in an open concept office it would be a good decision to zone the portion of the office along the exterior wall separately from the interior portion of the open office. This applies primarily to a very large open office that is deeper than 15 feet from the outside wall. The reason being that even though this is one large open space the exterior portion will still perform differently than the portion that is completely interior. Lastly, it is important to zone only similar types of spaces together. For instance it would not be a good decision to zone a private office with a conference room even if both are completely interior to the building. Even though these spaces have the same exposure they will perform very differently from each other and neither space will be comfortable. Offices have rather constant loads including 1-2 people with a computer and consistent day-long schedule. On the other hand, conference rooms are used intermittently and when they are used it is typically a large group of people for a short period of time. For instance, if the temperature sensor is located inside the private office, the heat pump will keep that space satisfied but the conference room will always overheat. Conversely, if the temperature sensor is located in the conference room, the private office will always be too warm except for when the conference room is occupied when it will be too cold. Again it would be a better decision to zone the private office and conference room separately.

In a compartmentalized heat pump system a single set of condenser water piping is run around the building to each heat pump. This condenser water piping is typically smaller in diameter than system heating or cooling piping and the temperature of the fluid within the piping is near room temperature which means that the piping does not need to be insulated.

Centralized Geothermal Heat Pump System

A centralized geothermal heat pump system consists of a small number of large water-to-water heat pumps located within a mechanical space. The centralized water source heat pumps range in size from 3 tons to 35 tons each and combined serve as a central heating/cooling plant for the entire building. In this scenario, the heat pumps are not serving individual spaces and so they stage on and off as necessary to match the heating and cooling requirements of the entire building. From the central plant of heat pumps, hot water heating and/or cooling distribution piping mains are run around the building to serve individual heating/cooling elements and remote air handlers serving individual spaces. These piping systems would typically be larger than a condenser water loop and the temperature of the fluid inside the piping is significantly different than the room air temperature which means that the piping needs to be insulated.

All of the same rules apply to zoning spaces together, except with this system it is the individual heating/cooling elements and the remote air handlers that are used for zoning instead of the heat pumps. With this type of system at a school for instance, it would be a good decision to designate a central air handler to a school wing with ducted distribution to each classroom. If this were a heating only system, the air handler could be constant air volume and each classroom could be zoned individually with a hot water heating coil. However, with a heating/cooling system the classrooms would need to be zoned individually with variable air volume (VAV) terminals.

Heating Hot Water Distribution Systems

There are several types of heating hot water distribution systems that are used in central heating systems, each of which has benefits and drawbacks.

In a residential application, a common piping system is a series loop heating system. This can also include a zoned series loop heating system if for instance the first and second floors were zoned separately. In this type of system the first heating element served by the boiler supply piping sees the highest temperature water in the system. As the water moves along from one heating element to another the temperature of the water continues to drop until the last heating element sees the coolest water in the heating system. After the water passes through the last heating element, it returns to the boiler to be re-heated. For this type of system to work effectively, the length of each section of baseboard needs to be selected based upon the incoming temperature of water that it will see. Essentially, the length of finned element will increase as the incoming water temperature decreases in order to maintain a constant heat output. This type of system is inexpensive and can be effective in a residential application, but not practical in a commercial application.

The most common hot water piping system is a two-pipe reversed return. In this system each heating element in the building sees the highest temperature incoming supply water from the boiler. Granted in a large system there may be a temperature loss of a few degrees through the piping at the furthest elements but pipe insulation keeps the loss at a minimum. With this system the supply main piping at the first heating element is at the full system size. As the supply main continues serving heating elements, the size of the piping decreases until it ends at the last heating element. Conversely, the return piping main begins at the first heating element and increases from the element branch size to the full system size by the time it finishes with the last heating element.

In addition to the two-pipe reversed return, it is common to incorporate primary/secondary piping loops into the overall system. In this scenario, the 2-pipe reversed return piping main within the boiler room would run past the heating boilers instead of running through the boilers. In the event that the primary building loop supply water temperature starts to drop below setpoint, the building management system would start the boiler(s) pump in the secondary loop to inject heat into the primary loop. The secondary loop would interface with the primary loop using two closely spaced tees within the primary system piping. This way, both loops are completely independent hydraulically and the boilers can cycle on and off as necessary to provide significant fuel savings.

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STANDARDIZED PROCESS FOR COMPARISON

In order to directly compare fuel sources, the data needs to be normalized to a standard annual heating consumption. As noted in the following table, we have assumed an annual heating consumption of 16,000 Dekatherms. For reference, one dekatherm is equal to 1,000,000 BTUs. As you will see in the following table, each fuel type has a different heat output per fuel unit. Additionally, each fuel source has a different maximum efficiency which all factors into how many units of fuel are consumed in order to achieve an equivalent annual heating output. With that information, current utility rates are included in the table to present a cost per Dekatherm for each fuel source which can be used as a direct comparison. As noted in the following table, #2 Fuel Oil has the highest cost per Dekatherm at $31.64 with wood chips having the lowest cost per Dekatherm at $9.63. It is important to note; however, that even though geothermal is not the lowest cost, it is very close to wood chips and roughly two thirds the cost of wood pellets.

FUEL SOURCE ANALYSIS						
Fuel Source	BTUs/unit	Equipment Type	16,000 Dekatherm Annual Heating (12 Dekatherm/hr Peak Heating)			
			Equipment Efficiency	Fuel Consumption	Fuel Unit Costs	$/DTherm
No 2 Oil	139,000 Gallon	Boiler	83%	138,684 Gallon	$ 3.65 /Gallon	$ 31.64
Natural Gas	100,000 CCF	Boiler	94%	170,213 CCF	$ 1.06 /CCF	$ 11.28
Propane	91,600 Gallon	Boiler	94%	185,822 Gallon	$ 1.70 /Gallon	$ 19.74
Geothermal	3,413 kWh	WSHP	3.80 COP	1,234,035 kWh	$ 0.137 /kWh	$ 10.57
Wood Chips	4,500 Pound	Boiler	75%	2,370 Ton	$ 65 /Ton	$ 9.63
Wood Pellets	8,000 Pound	Boiler	83%	1,205 Ton	$ 200 /Ton	$ 15.06
Compressed Natural Gas	100,000 CCF	Boiler	94%	170,213 CCF	$ 1.20 /CCF	$ 12.77
Liquified Natural Gas	100,000 CCF	Boiler	94%	170,213 CCF	$ 1.70 /CCF	$ 18.09

As a first step in the comparison of system options for a specific building, an energy model of the proposed building needs to be developed in order to determine the annual heating consumption. A detailed explanation of how to develop an accurate energy model is included in the Life Cycle Costing for Geothermal Systems section of the report.

Once the energy model has been developed, it is important to normalize the fuel sources based upon the calculated annual heating load from the energy model. In the following table, we used Kennebunk High School as an example with an annual heating consumption of 7,900 Dekatherms.

Using data from the table above, we compared all fuel sources to #2 Fuel Oil to determine the most cost effective fuel source for the proposed building. As expected, both wood chips and geothermal are at the top of the list, followed by natural gas and wood pellets. In order to keep the analysis up to date and relevant, the fuel unit costs need to continuously be updated. This table is useful in that it can help select the top fuel source choices for further evaluation.

Dekatherms	7,900				
KENNEBUNK HIGH SCHOOL SCHEME A1					
	Fuel Unit Costs		Equip Eff	Fuel Cost per Year	Cost Savings vs Oil
No 2 Oil	$ 3.65	/Gal	83%	$ 248,603.35	$ -
Natural Gas	$ 1.06	/CCF	94%	$ 88,610.46	$ 159,992.88
Propane	$ 1.70	/Gal	94%	$ 155,143.15	$ 93,460.20
Geothermal	$ 0.14	/kWh	3.80	$ 83,474.73	$ 165,128.61
Wood Chips	$ 65	/ton	75%	$ 75,668.75	$ 172,934.59
Wood Pellets	$ 200	/ton	83%	$ 118,342.00	$ 130,261.34
Compressed Natural Gas	$ 1.20	/CCF	94%	$ 100,313.73	$ 148,289.61
Liquified Natural Gas	$ 1.70	/CCF	94%	$ 142,111.12	$ 106,492.23

The next step is to further evaluate the top fuel source choices against the projected utility costs of the building being evaluated. As you will see in the following table, the base electricity load is projected at $317,000 as a two year total. This total is then added to the projected two year total of all the explored fuel sources with the totals noted in the summary section. It is important to note that at Kennebunk High School both wood chips and natural gas had a lower two year projected utility cost than geothermal since geothermal included full air conditioning verses partial air conditioning for the remaining options. Therefore, it is very important to evaluate each building individually to determine the lowest cost option for that particular building.

TWO YEAR PROJECTED UTILITY COST					
	Unit Cost		Year 1	Year 2	Total
Electricity					
Lights, plugs, misc	$ 0.14	/kWh	$ 154,000	$ 155,000	$ 309,000
DX Cooling	$ 0.14	/kWh	$ 4,000	$ 4,000	$ 8,000
Subtotal			*$ 158,000*	*$ 159,000*	**$ 317,000**
Heating Plant Option 1					
Oil	$ 3.65	/Gal	$ 249,000	$ 256,000	**$ 505,000**
Heating Plant Option 2					
Propane	$ 1.70	/Gal	$ 23,250	$ 24,000	$ 47,250
Wood Chips	$ 65	/ton	$ 64,600	$ 67,000	$ 131,600
Subtotal			*$ 87,850*	*$ 91,000*	**$ 178,850**
Heating Plant Option 3					
Propane	$ 1.70	/Gal	$ 23,250	$ 24,000	$ 47,250
Wood Pellets	$ 200	/ton	$ 100,300	$ 103,000	$ 203,300
Subtotal			*$ 123,550*	*$ 127,000*	**$ 250,550**
Heating Plant Option 4					
Propane	$ 1.70	/Gal	$ 23,250	$ 24,000	$ 47,250
Geothermal	*$ 0.14*	*/kWh*	*$ 69,000*	*$ 69,000*	$ 138,000
Subtotal			*$ 92,250*	*$ 93,000*	**$ 185,250**
Heating Plant Option 5					
Natural Gas	$ -	$ -	$ 88,600	$ 91,000	**$ 179,600**
Summary					
Option 1 Partial AC	Electricity + Heating Oil				**$ 822,000**
Option 2 Partial AC	Electricity + Propane + Wood Chips				**$ 495,850**
Option 3 Partial AC	Electricity + Propane + Wood Pellets				**$ 567,550**
Option 4 Full AC	Electricity + Propane + Geothermal				**$ 502,250**
Option 5 Partial AC	Electricity + Propane + Natural Gas				**$ 496,600**

At this point in the evaluation process, the top two remaining choices for fuel sources are wood chips and natural gas. Since natural gas was available as an option at Kennebunk High School, the decision was to go with natural gas instead of wood chips even though the projected utility cost for wood chips was the lowest option. In evaluating options it is important to evaluate more than just the economic impact. Often times, the Owner will have a preference for one fuel source instead of another. It is understood that a wood chip fired heating plant will require more maintenance than a natural gas fired heating plant. Also, using wood chips as a heating source will require fuel delivery trucks to arrive at the school on a regular basis, whereas delivery trucks are not required for natural gas. In this particular situation, if natural gas had not been available then serious consideration would have been given to either wood chips or geothermal as a fuel source.

STATE OF MAINE DEPARTMENT OF EDUCATION SCHOOL ENERGY SYSTEM STUDY

The following table is a facility utility cost comparison for Kennebunk High School using natural gas as the selected fuel source. This information provides the Owner with a very good understanding of how the proposed building will perform, which can be used for preliminary cost budgeting purposes.

FACILITY UTILITY COST COMPARISON

KENNEBUNK HIGH SCHOOL SCHEME A1

EXISTING	ACTUAL		PROJECTED[4]			
156,500 SQFT	2012/13	2013/14	2017/18		2018/19	
Electricity	$ 75,486	$ 72,198	$ 76,200	2, 3	$ 76,800	2
Water/Sewer	$ 16,456	$ 18,213	$ 19,500	1, 3	$ 20,100	1
Fossil Fuel[5]	$ 221,775	$ 231,401	$ 255,000	1, 3	$ 262,700	1
Total	**$ 313,717**	**$ 321,812**	**$ 350,700**		**$ 359,600**	

RENOVATED	PROJECTED[4]		PROJECTED[4]			
213,426 SQFT	2013/14		2017/18		2018/19	
Electricity	$ 140,400	6	$ 144,900	2, 6	$ 146,100	2
Water/Sewer	$ 19,200		$ 21,600	1	$ 22,200	1
Natural Gas - heat[7]	$ 88,600		$ 99,700	1	$ 102,700	1
Natural Gas - domestic[7]	$ 2,400		$ 2,700	1	$ 2,800	1
Natural Gas - kitchen equipment[7]	$ 3,800		$ 4,300	1	$ 4,400	1
Fossil Fuel Subtotal	*$ 94,800*		*$ 106,700*		*$ 109,900*	
Total	**$ 254,400**		**$ 273,200**		**$ 278,200**	

1) Assumes 3% annual inflation
2) Assumes 0.8% annual inflation based on 12 year trend of electric rates in Maine.
3) 2018/19 cost based on average of 2012-2014 costs plus inflation
4) Projected costs rounded to nearest 100
5) Fossil fuel includes oil, propane, kerosene
6) Current electric rates assumed to be $0.137/kWh
7) Current natural gas rates assumed to be $1.06/ccf

Actual hours of operation, temperature settings, equipment operation and maintenance, and lighting utilization will impact these numbers. In addition, the unpredictability of the energy market can make it difficult to predict what the energy costs will actually be for more than one budget year. The estimates are for budgeting purposes only.

Other utility and non-utility items to be considered for yearly operational expenses but not included above: Building insurance, building maintenance and supplies, equipment maintenance, landscape maintenance, security and monitoring services, trash removal, telephone service, internet service, cable or satellite TV service.

STATE OF MAINE
PROFESSIONAL SERVICES AGREEMENT

CONSULTING SERVICES

Agreement entered into the ***2nd*** day of ***January***, ***2014*** by and between the ***State of Maine*** through the ***Department of Education*** hereinafter called the ***Owner*** and ***Harriman Associates*** hereinafter called the ***Consultant***.

(The term "Consultant" means the Architect or Engineer firm or other professional consultant acting as the Professional-of-Record.)

The Professional Services Prequalification List was the process used for the selection of the Consultant. An RFQ may be used for any project. The Professional Services Prequalification List protocol requires all Consultant fees for the entire project to not exceed $25,000.

BGS Project No.:_____
Other Project No.:_____

For the following Project: ***School Heating Systems Study.***

Brief Project Description: ***Study of the costs related to geothermal and biomass heating systems in Maine schools***.

Brief Scope of Services: ***Analysis of geothermal heating systems, comparison of maintenance costs, life cycle estimate, electrical costs impact, comments on heat distribution, and development of a process for comparing system options***.

The Owner and Consultant agree as follows:

ARTICLE 1 PAYMENTS AND COMPENSATION TO THE CONSULTANT

The Owner shall compensate the Consultant as follows:

§ 1.1 The Consultant's Compensation shall not exceed ***twenty four thousand nine hundred Dollars ($24,900.00)*** and shall be computed as follows:

.1 Basic Services Fee (***Stipulated Sum***) ***$24,900.00***
Basic Services shall include:
- **.1** All services described in Article 4; and
- **.2** Other: ***none.***

.2 Reimbursable Expenses (Sum of the estimated items below) ***$0.00***

.1	Transportation in connection with the Project, authorized out-of-town travel and subsistence at the prevailing State of Maine rate at the time the expense is incurred	*$0.00*
.2	Fees paid for securing approval of authorities having jurisdiction over the Project	*$0.00*
.3	Reproductions (other than for required State submissions or Consultant's in-house use), postage, handling and delivery of Instruments of Service	*$0.00*
.4	Other: ***none***	*$0.00*

§ 1.2 Reimbursable Expenses are in addition to compensation for the Consultant's services and include actual, reasonable expenses incurred by the Consultant and subconsultants directly related to the Project, not to exceed the amount set forth above without the written approval of the Owner and the Bureau of General Services (BGS). Compensation for Reimbursable Expenses, except travel and subsistence expenses, shall be computed as a multiple of 1.10 times the expenses incurred by the Consultant and subconsultants. Compensation for travel and subsistence expenses shall be computed as a multiple of 1.0 times the actual expenses incurred by the Consultant and subconsultants. The acceptable ***maximum*** per diem may be determined at the State of Maine website: http://www.maine.gov/osc/travel/travelrelatedlinks.htm.

§ 1.3 Payments on account of services properly rendered and for Reimbursable Expenses incurred shall be made monthly within thirty (30) days of receipt of the Consultant's valid statement of services. Consultant's statement of services shall contain sufficient detail and supporting information for Owner and BGS to evaluate the Consultant's entitlement to payment.

.1 Payments are due and payable thirty (30) days from the date of receipt of the Consultant's invoice. Amounts due that are unpaid thirty (30) days after receipt of the invoice shall bear interest at the rate of seven percent (7%) per annum.

§ 1.4 A change in services of the Consultant, including services required of subconsultants, may be accomplished after execution of this Agreement, without invalidating the Agreement, if mutually agreed in writing between Consultant and Owner, and approved by BGS. Compensation for a change in services may be based on the Consultant's Professional Rate Schedule *(See Attachment A – Professional Rate Schedule)*. Compensation for a change in services of subconsultants shall be computed as a multiple of 1.10 times the amounts billed to the Consultant for such services.

ARTICLE 2 SCHEDULE

§ 2.1 The Consultant shall complete all work of this Agreement per the attached Project Schedule (***See Attachment B – Project Schedule)***.

§ 2.2 This schedule includes allowances for periods of time required for the Owner's review, for the performance of the Owner's consultants, and for approval of submissions by authorities having jurisdiction over the Project. Time limits established by this schedule approved by the Owner shall not, except for reasonable cause and the written approval of the other party and the Bureau of General Services, be exceeded by the Consultant or the Owner.

ARTICLE 3 PROJECT TEAM

§ 3.1 The Owner's Designated Representative is:

Scott Brown, Director of School Facilities
Maine Department of Education
23 State House Station
Augusta, ME 04330
207-624-6883 *fax: 207-624-6618* *scott.brown@maine.gov*

§ 3.2 The Consultant's Designated Representative is:

Clifton W. Greim, P.E.
President
Harriman
46 Harriman Drive
Auburn, ME 04210
207-784-5100 *fax: 207-782-3017* *cgreim@harriman.com*

§ 3.2.1 The Consultant agrees that ***NA*** will be available at all public presentations.

§ 3.3 The subconsultants retained at the Consultant's expense are: ***NA***

ARTICLE 4 CONSULTANT'S RESPONSIBILITIES

§ 4.1 The Consultant shall provide appropriate architectural, engineering or other professional consulting services for the Project. The Consultant's services shall be performed expeditiously and consistent with standard professional skill and care and the orderly progress of the Project.

§ 4.2 The Consultant shall review laws, codes, and regulations applicable to the Consultant's services. The Consultant's work product shall reflect all requirements imposed by authorities having jurisdiction over the Project.

§ 4.3 *See Attachment C – Scope of Services.*

ARTICLE 5 OWNER'S RESPONSIBILITIES

§ 5.1 The Owner shall provide full information about the objectives, schedule, constraints and existing conditions of the project, and shall establish a budget with reasonable contingencies that meets the project requirements.

ARTICLE 6 INSTRUMENTS OF SERVICE

§ 6.1 Drawings, specifications and other documents, including those in electronic form, prepared by the Consultant and the Consultant's subconsultants are Instruments of Service for use solely with respect to this Project. The Consultant and the Consultant's subconsultants shall be deemed the authors and owners of their respective Instruments of Service and shall retain all common law, statutory and other reserved rights, including copyrights, except as expressly provided herein.

§ 6.2 Upon execution of this Agreement, the Consultant grants to the Owner a nonexclusive, assignable license to reproduce the Consultant's Instruments of Service solely for purposes of (i) designing, constructing, using and maintaining the Project, provided that the Owner shall comply with all obligations, including prompt payment of all sums when due, under this Agreement; (ii) completion of the Project if Owner has declared Consultant to be in default, including any modified or different project; and (iii) any subsequent addition to or renovation of the Project. The Consultant shall obtain similar nonexclusive licenses from the Consultant's subconsultants consistent with this Agreement. In the event the Owner contracts with a different Consultant for the completion of the design and construction of the Project contemplated by the Consultant's Instruments of Service, such use shall be at Owner's sole risk.

§ 6.3 Submission or distribution of Instruments of Service to meet official regulatory requirements or for similar purposes in connection with the Project is not to be construed as publication in derogation of the reserved rights of the Consultant and the Consultant's subconsultants. Any unauthorized use of the Instruments of Service shall be at the Owner's sole risk and without liability to the Consultant and the Consultant's subconsultants.

§ 6.4 Prior to the Consultant providing to the Owner any Instruments of Service in electronic form or the Owner providing to the Consultant any electronic data for incorporation into the Instruments of Service, the Owner and the Consultant shall by separate written agreement set forth the specific conditions governing the format of such Instruments of Service or electronic data, including any third party special limitations or licenses not otherwise provided in this Agreement.

§ 6.5 The Consultant is prohibited from releasing, publishing or allowing publication of narrative, graphic, photographic or artistic representations of the Project unless expressly allowed in writing by BGS. The Consultant shall not include the Owner's confidential or proprietary information in any project representations if the Owner has previously advised the Consultant in writing of the specific information considered by the Owner to be confidential or proprietary.

ARTICLE 7 TERMINATION

§ 7.1 This Agreement may be terminated at the Owner's convenience and without cause upon not less than seven days written notice to the Consultant.

§ 7.2 The Consultant shall be compensated for services satisfactorily performed prior to termination, with Reimbursable Expenses then due, in the event of termination not the fault of the Consultant.

§ 7.3 The Consultant shall deliver all finished work and all documentation, complete and incomplete, to the Owner in the event of termination. The Consultant shall not be held responsible for modifications to the Consultant's work or work subsequently completed by others beyond the point of termination and their submittal of documents.

§ 7.4 The Consultant shall not be entitled to special or exemplary damages of any kind, including, but not limited to, lost profits, consequential damages, or loss of business in the event of termination for any reason.

§ 7.5 The Owner or the Consultant may terminate this Agreement upon not less than seven days written notice to the other party should such other party fail to perform in accordance with the terms of this Agreement. If the Consultant should fail to submit documents under this agreement at the times specified herein, or violate any of the stipulations herein, causing the Owner to incur expenses above and beyond those funds allocated in the approved budget, without prior written authorization for such from the Owner, the Owner may elect to terminate this Agreement by giving seven days notice to them in writing by registered mail, return receipt requested.

§ 7.6 If the Consultant is unable to continue to the completion of the project without successors or administrators or assigns competent in the Owner's judgment to carry the work to completion, or if the Owner terminates the contract prior to the completion of the Project due to the Consultant's failure to correct a material breach in its performance, the Owner shall have the right and license to use any and all finished and unfinished work product produced for the Project solely for the purpose of continuing the Project, which license and right of use shall in the case of unfinished work product, be at the Owner's sole risk. In such event the Consultant will be entitled to receive just and equitable compensation for services already satisfactorily performed and approved.

ARTICLE 8 MISCELLANEOUS PROVISIONS

§ 8.1 This Agreement shall be governed by the laws of the State of Maine.

§ 8.2 The Owner and Consultant, respectively, bind themselves, their partners, successors, assigns and legal representatives to this Agreement. Neither party to this Agreement shall assign the contract as a whole without written consent of the other, which consent the Owner may withhold without cause.

§ 8.3 Professional Services not covered by this Agreement include, but are not limited to, unanticipated scope of services revisions due to changes in the scope, quality or budget of the Project.

§ 8.4 The Consultant and Consultant's subconsultants shall have no responsibility for the identification, discovery, presence, handling, removal or disposal of, or exposure of persons to, hazardous materials in any form at the project site. The Consultant shall promptly notify the Owner in writing if the Consultant discovers any hazardous materials or toxic substances at the Project site.

ARTICLE 9 INDEMNIFICATION

§ 9.1 The Consultant shall indemnify and hold harmless the Owner and its officers, agents and employees from and against any and all claims, liabilities and costs, including reasonable attorney's fees, for any or all injuries to persons or property, including claims for violation of intellectual property rights, arising from the negligent acts or omissions of the Consultant, its employees, agents, officers or subcontractors in the performance of work under this Agreement. The Consultant shall not be liable for claims arising out of the negligent acts or omissions of the Owner or for actions taken in reasonable reliance on written instructions of the Owner.

The Consultant shall notify the Owner promptly of all claims arising out of the performance of work under this Agreement by the Consultant, its employees or agents, officers or subcontractors.

This indemnity provision shall survive the termination of the Agreement, completion of the project or the expiration of the term of the Agreement.

ARTICLE 10 INSURANCE REQUIREMENTS

§ 10.1 The Consultant shall provide, with each original of this signed Agreement, an insurance certificate or certificates issued by companies acceptable to the Owner and BGS. The certificates shall identify the specific project and shall name the Owner as certificate holder and as additional insured for general liability and automobile liability coverages. The submitted forms shall contain a provision that coverage afforded under the insurance policies will not be canceled or materially changed unless the Owner is given notice in accordance with applicable State law.

§ 10.2 The Owner does not warrant or represent that the insurance required herein constitutes an insurance portfolio which adequately addresses all risks faced by the Consultant. The Consultant is responsible for the existence, extent and adequacy of insurance prior to signing this Agreement.

§ 10.3 The Consultant shall procure and maintain insurance for the duration of the Project and, if written on a claims made basis, shall maintain such insurance for the duration of time that the claims insured against may be brought within the applicable Maine statute of repose. The Consultant shall ensure that all Consultants the Consultant engages or employs carry and maintain similar insurance in form and amount acceptable to the Owner. The insurance shall be of the types and limits set forth herein and such insurance as will protect the Consultant from claims which may result from the Consultant's execution of the Work, whether such execution be by the Consultant or by those employed by the Consultant or by those for whose acts they may be liable. The insurance coverage provided by the Consultant will be primary coverage.

§ 10.4 The Consultant shall have **workers' compensation** insurance for all employees on the Project site in accordance with the statutory workers' compensation law of the State of Maine. Minimum acceptable limits for Employer's Liability are:

Bodily Injury by Accident................................. $500,000
Bodily Injury by Disease.................................. $500,000 Each Employee

Bodily Injury by Disease.................................. $500,000 Policy Limit

§ 10.5 The Consultant shall have **general liability** insurance providing coverage for bodily injury and property damage liability for all hazards of the Project including premise and operations, products and completed operations, contractual, and personal injury liabilities. Minimum acceptable limits are:

General aggregate limit..................................... $2,000,000
Products and completed operations aggregate ... $1,000,000
Each occurrence limit....................................... $1,000,000
Personal injury aggregate.................................. $1,000,000

§ 10.6 The Consultant shall have **automobile liability** insurance against claims for bodily injury, death or property damage resulting from the maintenance, ownership or use of all owned, non-owned and hired automobiles, trucks and trailers. Minimum acceptable limit is:

Any one accident or loss $1,000,000

§ 10.7 The Consultant shall have Consultants **professional liability** insurance against claims arising out of a negligent act, error, mistake or omission of the Consultant in rendering or failing to render professional services related to the Project. If such insurance is on a claims-made basis, the Consultant shall maintain professional liability insurance for four (4) years if such coverage is reasonably available at commercially affordable premiums, and shall submit certificates of insurance to the Owner and Bureau of General Services each year. For the purposes of this Agreement, "reasonably available" and "commercially affordable," shall mean that more than half the design professionals practicing in this state in this discipline are able to obtain such coverage. Minimum acceptable limit is:

Each claim.. $1,000,000

§ 10.8 The Consultant shall assure that professional liability insurance policies with minimum acceptable limits of $500,000 per each claim are in place for civil, structural, and mechanical engineering consultants who work for the Consultant on a project where such services are required by the Project. By entering into this Agreement with the Owner, the Consultant assures that these policies are in place and will continue to be in place as described in §10.7.

ARTICLE 11 EQUAL EMPLOYMENT OPPORTUNITY

§ 11.1 The Consultant shall not discriminate against any employee or applicant for employment relating to this Agreement because of race, color, religious creed, sex, national origin, ancestry, age, physical or mental disability, or sexual orientation, unless related to a bona fide occupational qualification.

The Consultant shall take affirmative action to ensure that applicants are employed and employees are treated during employment, without regard to their race, color, religion, sex, age, national origin, physical or mental disability, or sexual orientation. Such action shall include but not be limited to the following: employment, upgrading, demotions, or transfers; recruitment or recruitment advertising; layoffs or terminations; rates of pay or other forms of compensation; and selection for training including apprenticeship. The Consultant agrees to post in conspicuous places available to employees and applicants for employment notices setting forth the provisions of this nondiscrimination clause.

§ 11.2 The Consultant shall, in all solicitations or advertising for employees placed by or on behalf of the Consultant relating to this Agreement, state that all qualified applicants shall receive consideration for employment without regard to race, color, religious creed, sex, national origin, ancestry, age, physical or mental disability, or sexual orientation.

§ 11.3 The Consultant shall send to each labor union or representative of the workers with which it has a collective bargaining agreement, or other agreement or understanding, whereby it is furnished with labor for the performance of this Agreement a notice to be provided by the contracting agency, advising the said labor union or workers' representative of the Consultant's commitment under this section and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

§ 11.4 The Consultant shall inform the contracting Department's Equal Employment Opportunity Coordinator of any discrimination complaints brought to an external regulatory body (Maine Human Rights Commission, EEOC, Office of Civil Rights) against their agency by any individual as well as any lawsuit regarding alleged discriminatory practice.

§ 11.5 The Consultant shall comply with all aspects of the Americans with Disabilities Act (ADA) in employment and in the provision of service to include accessibility and reasonable accommodations for employees and clients.

§ 11.6 Consultants and consultants with contracts in excess of $50,000 shall also pursue in good faith affirmative action programs.

§ 11.7 The Consultant shall cause the foregoing provisions to be inserted in any subcontract for any work covered by this Agreement so that such provisions shall be binding upon each subcontractor, provided that the foregoing provisions shall not apply to contracts or subcontracts for standard commercial supplies or raw materials.

ARTICLE 12 DISPUTE RESOLUTION

§ 12.1 Mediation

.1 In the event of a dispute between the parties which arises under this Agreement and the dispute cannot be resolved through informal negotiation, the dispute shall be submitted to a neutral mediator jointly selected by the parties.

.2 Either party may file suit before or during mediation if the party in good faith deems it to be necessary to avoid losing the right to sue due to a statute of limitations. If suit is filed before good faith mediation efforts are completed, the party filing suit shall agree to stay all proceedings in the lawsuit pending completion of the mediation process, provided such stay is without prejudice.

§ 12.2 Arbitration

.1 If the dispute is not resolved through mediation, the dispute shall be settled by arbitration. The arbitration shall be conducted before a panel of three (3) arbitrators. Each party shall select one arbitrator; the third arbitrator shall be appointed by the arbitrators selected by the parties. The arbitration shall be conducted in accordance with the Maine Uniform Arbitration Act ("MUAA"), except as otherwise provided in this section.

.2 The decision of the arbitrators shall be final and binding upon all parties. The decision may be entered in court as provided in the MUAA.

.3 The costs of the arbitration, including the arbitrators' fees shall be borne equally by the parties to the arbitration, unless the arbitrator orders otherwise.

.4 In any arbitration between the Owner and the Consultant, the Owner shall have the right to consolidate related claims between Owner and Contractor.

ARTICLE 13 OTHER PROVISIONS

§13.1 American Recovery and Reinvestment Act

.1 For projects funded with American Recovery and Reinvestment Act (ARRA) monies, the parties to this Agreement shall abide by and fulfill the applicable requirements of the ARRA, including, but not limited to, the Buy American criteria, federal wage rates, ARRA specific reporting requirements.

(Insert any additional provisions of this Agreement as approved by BGS.)

§ 13.2 ***There are no other provisions.***

This Agreement entered into as of the day and year first written above.

OWNER	CONSULTANT
1-16-14	
(Signature) (Date)	*(Signature) (Date)*
James E. Rier, Jr., Commissioner	*Clifton W. Greim, P.E., President*

If a corporation, use the corporate seal and write State of Incorporation. If a partnership, all partners should execute this Agreement.

ENCUMBERED
JAN 28 2014
STATE CONTROLLER

BUREAU OF GENERAL SERVICES

Reviewed by:	**Approved by:**
1/21/2014	21 JAN 2014
(Signature) (Date)	*(Signature) (Date)*
OPERATIONS DIRECTOR DAFS/BGS/PURCHASES	*Joseph H. Ostwald*
Project Manager/ Contract Administrator	*Director, Planning, Design & Construction*

PROFESSIONAL RATE SCHEDULE *Attachment A*

Personnel **Rate per hour**

NA..NA

PROJECT SCHEDULE *Attachment B*

Task	**Projected completion date**
Heating systems study report submitted to the Owner	March 1, 2014
Contract termination date	March 31, 2014

The Consultant shall complete a study of the costs related to geothermal and biomass heating systems. The study shall include:

1. Analysis of a geothermal system that is compartmentalized such as Gorham Middle School (systems in a closet in each room) compared to a more centralized system such as Durham Elementary. This will include both initial costs and long-term maintenance and operating costs.

2. Comparison of operating and projected maintenance costs for wood chip heating (Chelsea School) compared to pellet wood heating (Mallett School in Farmington) and geothermal heating (Durham School).

3. Life cycle estimate of geothermal systems in general. This will include information based upon past experiences with other types of systems.

4. Electrical costs impact of geothermal as compared to wood heat and the traditional oil heat.

5. Comments and observations on heat distribution.

6. Develop a standardized and consistent process for comparing system options. Consistency in baseline comparison, assumptions, incentives and escalation of fuel costs. These are all variables which can significantly impact any comparison. We will provide a format for consistency and equitable comparison.

The Consultant shall produce a report of the study results.

HARRASS-01 VPULLING

ACORD

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 12/20/2013

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER Clark Insurance 2385 Congress Street Portland, ME 04104	CONTACT NAME: PHONE (A/C, No, Ext): (207) 774-6267 FAX (A/C, No): (207) 774-2994 E-MAIL ADDRESS:
	INSURER(S) AFFORDING COVERAGE — NAIC #
	INSURER A : XL Specialty Insurance Co
INSURED Harriman Associates 46 Harriman Drive Auburn, ME 04210	INSURER B :
	INSURER C :
	INSURER D :
	INSURER E :
	INSURER F :

COVERAGES CERTIFICATE NUMBER: REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	GENERAL LIABILITY COMMERCIAL GENERAL LIABILITY CLAIMS-MADE OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: POLICY PRO-JECT LOC						EACH OCCURRENCE	$
							DAMAGE TO RENTED PREMISES (Ea occurrence)	$
							MED EXP (Any one person)	$
							PERSONAL & ADV INJURY	$
							GENERAL AGGREGATE	$
							PRODUCTS - COMP/OP AGG	$
								$
	AUTOMOBILE LIABILITY ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS HIRED AUTOS NON-OWNED AUTOS						COMBINED SINGLE LIMIT (Ea accident)	$
							BODILY INJURY (Per person)	$
							BODILY INJURY (Per accident)	$
							PROPERTY DAMAGE (PER ACCIDENT)	$
								$
	UMBRELLA LIAB OCCUR EXCESS LIAB CLAIMS-MADE DED RETENTION $						EACH OCCURRENCE	$
							AGGREGATE	$
								$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A					WC STATU-TORY LIMITS OTH-ER	
							E.L. EACH ACCIDENT	$
							E.L. DISEASE - EA EMPLOYEE	$
							E.L. DISEASE - POLICY LIMIT	$
A	Prof Liability			DPR9712679	12/31/2013	12/31/2014	Each Claim	2,000,000
A	Ded - $100,000			DPR9712679	12/31/2013	12/31/2014	Aggregate	4,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)

CERTIFICATE HOLDER	CANCELLATION
For informational purposes Can be updated with Certificate holder information	SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS. AUTHORIZED REPRESENTATIVE

HARRASS-01 VPULLING

ACORD

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 12/20/2013

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IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER Clark Insurance 2385 Congress Street Portland, ME 04104	CONTACT NAME: PHONE (A/C, No, Ext): (207) 774-6257 FAX (A/C, No): (207) 774-2994 E-MAIL ADDRESS:
	INSURER(S) AFFORDING COVERAGE — NAIC #
	INSURER A : XL Specialty Insurance Co
INSURED Harriman Associates 46 Harriman Drive Auburn, ME 04210	INSURER B :
	INSURER C :
	INSURER D :
	INSURER E :
	INSURER F :

COVERAGES CERTIFICATE NUMBER: REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	GENERAL LIABILITY COMMERCIAL GENERAL LIABILITY CLAIMS-MADE / OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: POLICY / PRO-JECT / LOC						EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG	\$ \$ \$ \$ \$ \$ \$
	AUTOMOBILE LIABILITY ANY AUTO ALL OWNED AUTOS / SCHEDULED AUTOS HIRED AUTOS / NON-OWNED AUTOS						COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (PER ACCIDENT)	\$ \$ \$ \$ \$
	UMBRELLA LIAB / OCCUR EXCESS LIAB / CLAIMS-MADE DED / RETENTION \$						EACH OCCURRENCE AGGREGATE	\$ \$ \$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A					WC STATU-TORY LIMITS / OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 \$ \$ \$
A	Prof Liability			DPR9705993	12/31/2012	12/31/2013	Each Claim	2,000,000
A	Ded - \$100,000			DPR9705993	12/31/2012	12/31/2013	Aggregate	4,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)

For Professional Liability coverage, the aggregate limit is the total insurance available for all covered claims presented within the policy period. The limit will be reduced by payments of indemnity and expense.

CERTIFICATE HOLDER	CANCELLATION
For informational purposes Can be updated with Certificate holder information	SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS. AUTHORIZED REPRESENTATIVE

HARRI14 OP ID: AC

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 12/19/2013

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
VARNEY AGENCY-AUBURN
232 CENTER ST, SUITE D2
AUBURN, ME 04210
MICHAEL VARNEY

CONTACT NAME:
PHONE (A/C, No, Ext): FAX (A/C, No):
E-MAIL ADDRESS:

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : PEERLESS INSURANCE CO.	24198
INSURER B : MAINE EMPLOYERS MUTUAL	11149
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
Harriman Associates
46 Harriman Drive
Auburn, ME 04210

COVERAGES CERTIFICATE NUMBER: REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	GENERAL LIABILITY COMMERCIAL GENERAL LIABILITY CLAIMS-MADE [X] OCCUR [X] Business Owners GEN'L AGGREGATE LIMIT APPLIES PER: [X] POLICY PRO-JECT LOC			BOP1032093	02/01/2013	02/01/2014	EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG $	$ 2,000,000 $ 200,000 $ 5,000 $ 2,000,000 $ 4,000,000 $ 4,000,000
A	AUTOMOBILE LIABILITY ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS [X] HIRED AUTOS [X] NON-OWNED AUTOS			BOP 1032093	02/01/2013	02/01/2014	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (PER ACCIDENT) $	$ 2,000,000 $ $ $
A	[X] UMBRELLA LIAB OCCUR EXCESS LIAB CLAIMS-MADE DED [X] RETENTION $ 10000			CU8898358	02/01/2013	02/01/2014	EACH OCCURRENCE AGGREGATE $	$ 5,000,000 $ 5,000,000
B	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A		5101800100	02/01/2013	02/01/2014	WC STATU-TORY LIMITS OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 $ 500,000 $ 500,000 $ 500,000
							BUILDING PROPERTY	4,311,986 551,720

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)
Architects & Engineers

CERTIFICATE HOLDER

For Information al Purposes.
Can be updated with
Certificate holder
Information

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
MICHAEL VARNEY

K-12 SCHOOL ENERGY USE

BUILDING INFO				RECORDED DATA														
				ENTERED CONSUMPTION							ENTERED ANNUAL COSTS ($)							
JOB NUMBER	SCHOOL NAME	SCHOOL YEAR	SQUARE FOOTAGE	ELECTRICITY (KWH)	#2 OIL (GAL)	PROPANE (GAL)	NATURAL GAS (FT3)	WOOD PELLETS (TONS)	WOOD CHIPS (TONS)	WATER (GAL)	ELECTRICITY	#2 OIL	PROPANE	NATURAL GAS	WOOD PELLETS	WOOD CHIPS	WATER	TOTAL ENERGY $/YR
not HAE	Gorham Middle School (new)	07/09-06-10	135,914	1,146,480			312,060				$178,341			$2,918				$181,259
not HAE		07/10-06-11	135,914	1,275,600			291,390				$166,682			$2,745				$169,427
not HAE		07/11-06-12	135,914	1,278,720			245,260				$149,348			$2,799				$152,147
not HAE		07/12-06-13	135,914	1,351,440			246,670				$143,595			$2,856				$146,451
not HAE	Mallet School, Farmington	2011-2012	52,000	197,657	1,700						$30,076	$5,132						$35,208
not HAE		2012-2013	52,000	251,200	1,007			77			$26,646	$2,982			$13,580			$43,208
not HAE		2013-2014	52,000	224,429				102			$28,361				$17,766			$46,127
not HAE	Ridge View Community School, Dexter	2011-2012	125,000	533,400	1,990	1,804			296		$ 59,080	$5,292	$5,446			$17,439		$87,257
not HAE		2012-2013	125,000	586,400		2,254			337		$ 65,948		$4,610			$20,232		$90,790
not HAE		2013-2014	125,000	588,960		1,713			368		$ 81,889		$3,606			$22,094		$107,590
	Durham ES	2010-2011	87,521	857,471		3332					$99,401		$7,974					$107,375
		2011-2012	87,521	869,760							$97,549							$97,549
		2012-2013	87,521	896,880							$98,549							$98,549

K-12 SCHOOL ENERGY USE

BUILDING INFO				CALCULATED DATA																	
				COST/ UNIT							COST/ SQFT										
JOB NUMBER	SCHOOL NAME	SCHOOL YEAR	SQUARE FOOTAGE	ELECTRICITY ($/KWH)	#2 OIL ($/GAL)	PROPANE ($/GAL)	NATURAL GAS ($/CCF)	WOOD PELLETS ($/TON)	WOOD CHIPS ($/TON)	WATER ($/GAL)	ELECTRICITY ($/SQFT)	#2 OIL ($/SQFT)	PROPANE ($/SQFT)	NATURAL GAS ($/SQFT)	WOOD PELLETS ($/SQFT)	WOOD CHIPS ($/SQFT)	WATER ($/SQFT)	HEATING FUEL (D$/SQFT)	TOTAL ($/SQFT)		
not HAE	Gorham Middle School (new)	07/09-06-10	135,914	$0.156			$0.935				$1.31			$0.02				$0.21	$1.33		
not HAE		07/10-06-11	135,914	$0.131			$0.942				$1.23			$0.02				$0.20	$1.25		
not HAE		07/11-06-12	135,914	$0.117			$1.141				$1.10			$0.02				$0.21	$1.12		
not HAE		07/12-06-13	135,914	$0.106			$1.158				$1.06			$0.02				$0.21	$1.08		
not HAE	Mallet School, Farmington	2011-2012	52,000	$0.152	$3.02						$0.58	$0.10						$0.99	$0.68		
not HAE		2012-2013	52,000	$0.106	$2.96			177			$0.51	$0.06			$0.26			$3.19	$0.83		
not HAE		2013-2014	52,000	$0.126				175			$0.55				$0.34			$3.42	$0.89		
not HAE	Ridge View Community School, Dexter	2011-2012	125,000	$0.111	$2.66	$3.02			59		$0.47	$0.04	$0.04			$0.14		$2.25	$0.70		
not HAE		2012-2013	125,000	$0.112		$2.05			60		$0.53		$0.04			$0.16		$1.99	$0.73		
not HAE		2013-2014	125,000	$0.139		$2.10			60		$0.66		$0.03			$0.18		$2.06	$0.86		
	Durham ES	2010-2011	87,521	$0.116		$2.39					$ 1.14		$0.09					$0.91	$1.23		
		2011-2012	87,521	$0.112							$ 1.11							$0.00	$1.11		
		2012-2013	87,521	$0.110							$ 1.13							$0.00	$1.13		

K-12 SCHOOL ENERGY USE

BUILDING INFO				CALCULATED DATA															
				UNIT/SQFT							ENERGY CHECKS								
JOB NUMBER	SCHOOL NAME	SCHOOL YEAR	SQUARE FOOTAGE	ELECTRICITY (kWh/SQFT)	#2 OIL (GAL/SQFT)	PROPANE (GAL/SQFT)	NATURAL GAS (CCF/SQFT)	WOOD PELLETS (LBS/SQFT)	WOOD CHIPS (LBS/SQFT)	WATER	TOTAL ENERGY (kBTU/YR/SF)	TOTAL ENERGY MBTU/YR	ELECTRIC (kBTU/YR/SF)	# 2 OIL (kBTU/YR/SF)	PROPANE (kBTU/YR/SF)	NAT. GAS (kBTU/YR/SF)	WOOD PELLETS (kBTU/YR/SF)	WOOD CHIPS (kBTU/YR/SF)	WATER (GAL/YR/SF)
not HAE	Gorham Middle School (new)	07/09-06-10	135,914	8.44			2.30				31.1	4,232	28.8			2.36			
not HAE		07/10-06-11	135,914	9.39			2.14				34.2	4,651	32.0			2.20			
not HAE		07/11-06-12	135,914	9.41			1.80				34.0	4,615	32.1			1.85			
not HAE		07/12-06-13	135,914	9.94			1.81				35.8	4,864	33.9			1.86			
not HAE	Mallet School, Farmington	2011-2012	52,000	3.80	0.03						17.5	911	13.0	4.5					
not HAE		2012-2013	52,000	4.83	0.02			2.94			42.7	997	16.5	2.7			24		
not HAE		2013-2014	52,000	4.32				3.90			46.0	766	14.7				31		
not HAE	Ridge View Community School, Dexter	2011-2012	125,000	4.27	0.02	0.01			4.73		39.4	2,261	14.6	2.2	1.313			21	
not HAE		2012-2013	125,000	4.69		0.02			5.39		41.9	2,206	16.0		1.641			24	
not HAE		2013-2014	125,000	4.71		0.01			5.89		43.8	2,165	16.1		1.247			27	
	Durham ES	2010-2011	87,521	9.80		0.04					36.9	3,229	33.4		3.464				
		2011-2012	87,521	9.94							33.9	2,968	33.9						
		2012-2013	87,521	10.25							35.0	3,060	35.0						

K-12 SCHOOL ENERGY USE

BUILDING INFO				MECHANICAL DESCRIPTION		
JOB NUMBER	SCHOOL NAME	SCHOOL YEAR	SQUARE FOOTAGE			
not HAE	Gorham Middle School (new)	07/09-06-10	135,914	FULL A/C COMPARTMENTAL GEOTHERMAL		
not HAE		07/10-06-11	135,914	FULL A/C COMPARTMENTAL GEOTHERMAL		
not HAE		07/11-06-12	135,914	FULL A/C COMPARTMENTAL GEOTHERMAL		
not HAE		07/12-06-13	135,914	FULL A/C COMPARTMENTAL GEOTHERMAL		
not HAE	Mallet School, Farmington	2011-2012	52,000	WOOD PELLET		
not HAE		2012-2013	52,000	WOOD PELLET		
not HAE		2013-2014	52,000	WOOD PELLET		
not HAE	Ridge View Community School, Dexter	2011-2012	125,000	WOODCHIP		
not HAE		2012-2013	125,000	WOODCHIP		
not HAE		2013-2014	125,000	WOODCHIP		
	Durham ES	2010-2011	87,521	FULL A/C CENTRAL GEOTHERMAL	FULL A/C	GEOTHERMAL
		2011-2012	87,521			
		2012-2013	87,521			

Durham Elementary School

Location	**Durham, ME**	
Building owner	**RSU #5**	
Program user	**Jeff LaPierre**	
Company	**Harriman Architects and Engineers**	
Comments		
By	**Harriman**	
Dataset name	**H:\2013\13786\3-Project-Dev\Dept\Mech\Load-Calcs\DURHAM-HPS.TRC**	
Calculation time	**03:05 PM on 07/30/2014**	
TRACE® 700 version	**6.3**	
Location	**Portland, Maine**	
Latitude	**44.0**	**deg**
Longitude	**70.0**	**deg**
Time Zone	**5**	
Elevation	**61**	**ft**
Barometric pressure	**29.9**	**in. Hg**
Air density	**0.0759**	**lb/cu ft**
Air specific heat	**0.2444**	**Btu/lb·°F**
Density-specific heat product	**1.1128**	**Btu/h·cfm·°F**
Latent heat factor	**4,898.6**	**Btu·min/h·cu ft**
Enthalpy factor	**4.5526**	**lb·min/hr·cu ft**
Summer design dry bulb	**84**	**°F**
Summer design wet bulb	**72**	**°F**
Winter design dry bulb	**-1**	**°F**
Summer clearness number	**1.02**	
Winter clearness number	**1.02**	
Summer ground reflectance	**0.20**	
Winter ground reflectance	**0.20**	
Carbon Dioxide Level	**400**	**ppm**
Design simulation period	**January - December**	
Cooling load methodology	**TETD-TA1**	
Heating load methodology	**UATD**	

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MONTHLY ENERGY CONSUMPTION

By Harriman

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Durham Elementary School**												
Electric													
On-Pk Cons. (kWh)	100,026	91,512	93,463	84,022	63,555	41,243	36,838	30,236	61,378	86,440	88,672	100,989	878,373
On-Pk Demand (kW)	383	394	369	349	374	413	311	321	385	359	360	389	413

Energy Consumption		
Building	35,263	Btu/(ft2-year)
Source	105,800	Btu/(ft2-year)
Floor Area	85,015	ft2

Environmental Impact Analysis	
CO_2	463,728 lbm/year
SO_2	1,636 gm/year
NOX	997 gm/year

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 2	**Maine Benchmark**												
Electric													
On-Pk Cons. (kWh)	77,456	69,773	76,843	73,471	83,029	61,281	56,986	48,396	80,357	77,533	74,308	77,251	856,685
On-Pk Demand (kW)	403	404	404	401	424	458	391	395	440	412	405	402	458
Gas													
On-Pk Cons. (therms)	2,398	2,261	1,872	1,237	127	140	3	17	161	1,262	1,687	2,466	13,631
On-Pk Demand (therms/hr)	15	15	14	12	6	2	0	1	5	12	14	15	15

Energy Consumption		
Building	50,426	Btu/(ft2-year)
Source	120,065	Btu/(ft2-year)
Floor Area	85,015	ft2

Environmental Impact Analysis	
CO_2	452,278 lbm/year
SO_2	1,596 gm/year
NOX	972 gm/year

ENERGY CONSUMPTION SUMMARY

By Harriman

	Elect Cons. (kWh)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 1				
Primary heating				
Primary heating	69,430	7.9 %	236,963	710,960
Other Htg Accessories	20	0.0 %	68	203
Heating Subtotal	**69,449**	**7.9** %	**237,031**	**711,163**
Primary cooling				
Cooling Compressor	16,514	1.9 %	56,361	169,100
Tower/Cond Fans		0.0 %	0	0
Condenser Pump		0.0 %	0	0
Other Clg Accessories	167	0.0 %	570	1,710
Cooling Subtotal....	**16,681**	**1.9** %	**56,931**	**170,810**
Auxiliary				
Supply Fans	121,345	13.8 %	414,152	1,242,579
Pumps	7,984	0.9 %	27,251	81,761
Stand-alone Base Utilities	158,394	18.0 %	540,600	1,621,962
Aux Subtotal....	287,724	32.8 %	982,003	2,946,302
Lighting				
Lighting	104,341	11.9 %	356,117	1,068,459
Receptacle				
Receptacles	400,177	45.6 %	1,365,805	4,097,824
Cogeneration				
Cogeneration		0.0 %	0	0
Totals				
Totals**	**878,373**	**100.0** %	**2,997,886**	**8,994,557**

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

ENERGY CONSUMPTION SUMMARY

By Harriman

	Elect Cons. (kWh)	Gas Cons. (kBtu)	% of Total Building Energy	Total Building Energy (kBtu/yr)	Total Source Energy* (kBtu/yr)
Alternative 2					
Primary heating					
Primary heating		822,520	19.2 %	822,520	865,811
Other Htg Accessories			0.0 %	0	0
Heating Subtotal		**822,520**	**19.2** %	**822,520**	**865,811**
Primary cooling					
Cooling Compressor	41,862		3.3 %	142,874	428,664
Tower/Cond Fans	2,990		0.2 %	10,204	30,615
Condenser Pump			0.0 %	0	0
Other Clg Accessories	148		0.0 %	503	1,510
Cooling Subtotal....	**44,999**		**3.6** %	**153,581**	**460,790**
Auxiliary					
Supply Fans	124,498		9.9 %	424,912	1,274,863
Pumps	130,647		10.4 %	445,898	1,337,829
Stand-alone Base Utilities		540,600	12.6 %	540,600	569,053
Aux Subtotal....	255,145	540,600	32.9 %	1,411,410	3,181,744
Lighting					
Lighting	156,363		12.5 %	533,669	1,601,166
Receptacle					
Receptacles	400,177		31.9 %	1,365,805	4,097,824
Cogeneration					
Cogeneration			0.0 %	0	0
Totals					
Totals**	**856,685**	**1,363,121**	**100.0** %	**4,286,985**	**10,207,335**

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 7 utilities. If additional utilities are used, they will be included in the total.

Energy Cost Budget / PRM Summary

By Harriman

Project Name: Durham Elementary School	Date: July 30, 2014
City: Durham, ME	Weather Data: Portland, Maine

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 Durham Elementary Sch			Alt-2 Maine Benchmark		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	356.1	12	161	533.7	150	233
Space Heating	Electricity	237.0	8	312	0.0	0	0
	Gas	0.0	0	0	822.5	0	1,236
Space Cooling	Electricity	56.9	2	279	143.4	252	399
Pumps	Electricity	27.3	1	92	445.9	1,636	51
Heat Rejection	Electricity	0.0	0	0	10.2	0	35
Fans - Conditioned	Electricity	414.2	14	337	424.9	103	313
Receptacles - Conditioned	Electricity	1,365.8	46	719	1,365.8	100	719
Stand-alone Base Utilities	Electricity	540.6	18	240	0.0	0	0
	Gas	0.0	0	0	540.6	0	240
Total Building Consumption		**2,997.9**			**4,287.0**		

		* Alt-1 Durham Elementary Sch	Alt-2 Maine Benchmark
Total	**Number of hours heating load not met** **Number of hours cooling load not met**	4,515 0	4,770 0

	* Alt-1 Durham Elementary Sch		Alt-2 Maine Benchmark	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	2,997.9	136,207	2,923.9	138,172
Gas	0.0	0	1,363.1	35,441
Total	**2,998**	**136,207**	**4,287**	**173,613**

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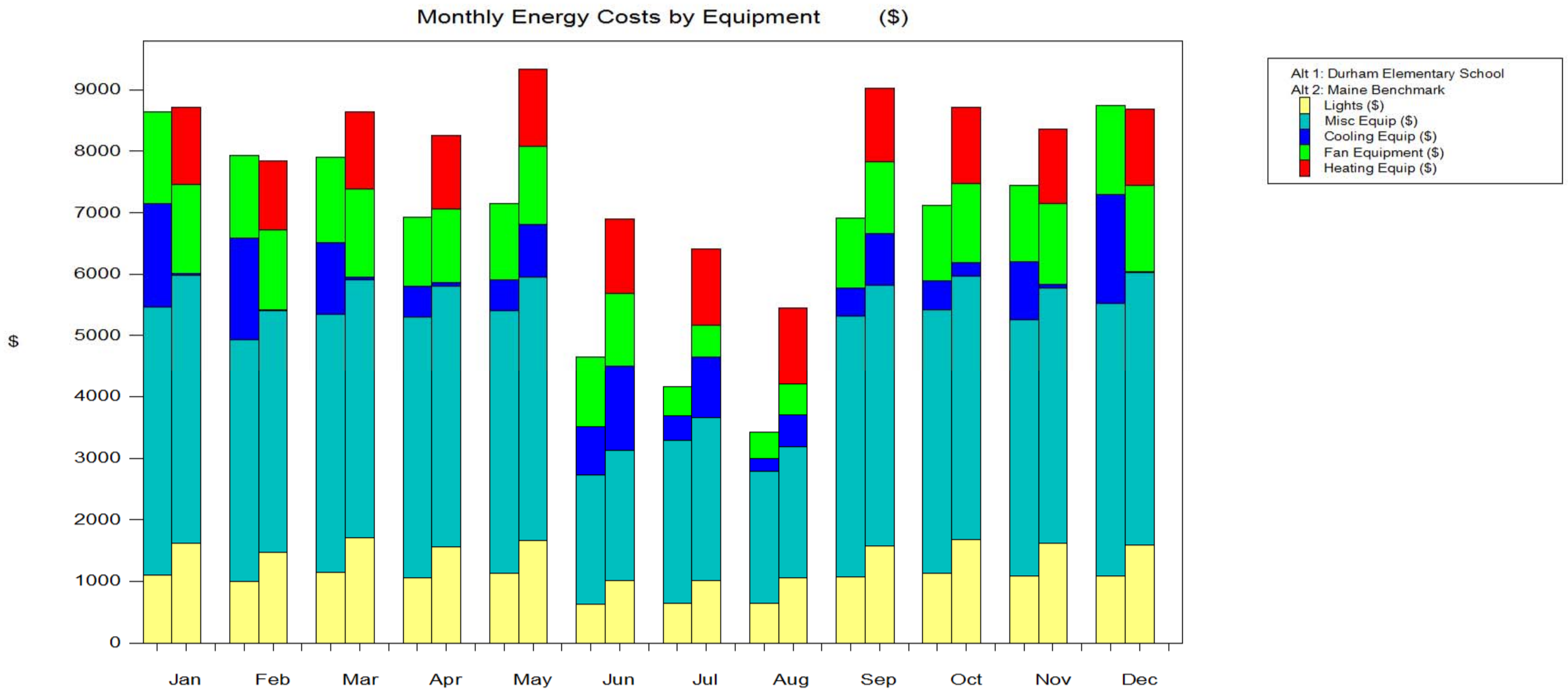

Monthly Energy Costs by Equipment ($)
$
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Alt 1: Durham Elementary School
Alt 2: Maine Benchmark
Lights ($)
Misc Equip ($)
Cooling Equip ($)
Fan Equipment ($)
Heating Equip ($)

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Economic Summary

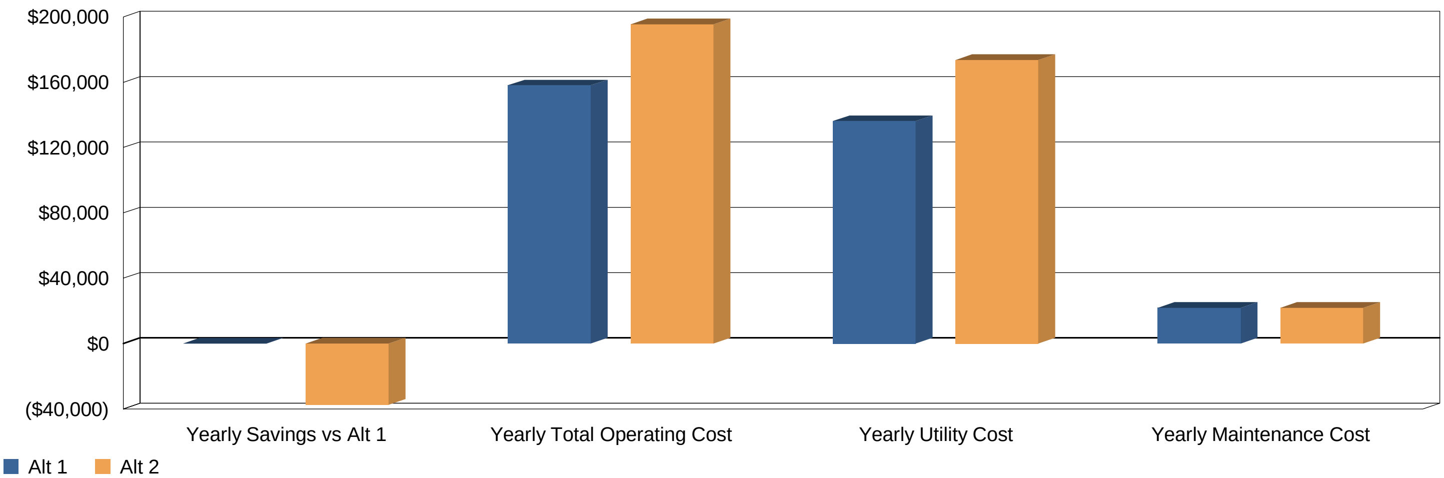
Project Information

Location	Durham, ME	Study Life:	20 years
Project Name	Durham Elementary School	Cost of Capital:	10 %
User	Jeff LaPierre	Alternative 1:	Durham Elementary School
Company	Harriman Architects and Engineers	Alternative 2:	Maine Benchmark
Comments			

Economic Comparison of Alternatives

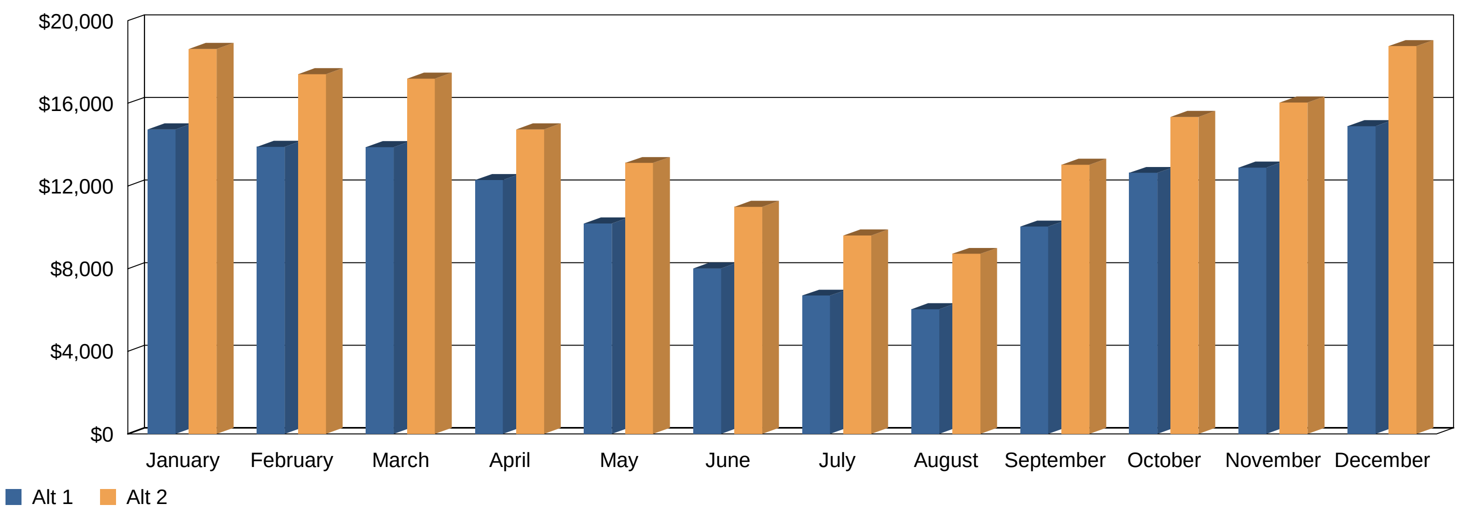
	Yearly Savings ($)	First Cost Difference ($)	Cumulative Cash Flow Difference ($)	Simple Payback (yrs.)	Net Present Value ($)	Life Cycle Payback (yrs.)	Internal Rate of Return (%)	Life Cycle Cost
Alt 1 vs Alt 2	37,406	624,328	380,782	16.7	-233,419	No Payback	4.5	-233,419.00

Annual Operating Costs



	Yearly Savings vs Alt 1	Yearly Total Operating Cost ($)	Yearly Utility Cost ($)	Yearly Maintenance Cost ($)	Plant kWh/ton-hr
Alt 1	0	158,087	136,207	21,880	0.360
Alt 2	-37,406	195,493	173,613	21,880	1.035

Monthly Utility Costs



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