A Brief Report to the Alaska Energy Authority

On the Installation of a Geothermal Heat Pump System at

Juneau International Airport

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Juneau International Airport

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Background.

In 2008, the Juneau International Airport (JNU) received grant funding in the amount of $513,000 to assist in the construction of a geothermal heat pump system for the heating, cooling, and ventilation needs in the airport terminal. This work was part of a multi-phase renovation and expansion of the airport terminal. The loop field was designed by mechanical engineer, Douglas Murray, PE. The life cycle cost analysis (basis of AEA grant application) was developed collaboratively by Mr. Murray and mechanical engineer James Rehfeldt, PE.

The geothermal loop field is located under the pavement of the commuter plane airfield ramp. It consists of 108 vertical borings to a depth of 350 feet each (fig 1). A mix of 88% water and 12% methanol circulates through a continuous underground loop of more than 16 miles of HDPE piping. The piping enters the building and is distributed to 31 electric heat pumps that provide heating, cooling, and ventilation to interior spaces, as well as heat to the building's front sidewalk that prevents build-up of ice and snow. The heat pumps are digitally controlled to efficiently respond to changing air conditions.

Construction of the loop field was completed in the fall of 2009. Installation of the heat pumps inside the building began in early 2010 and continued alongside other renovation work until May, 2011.

Figure 1. Vertical borings for JNU Airport loop field. *Image courtesy of JNU staff*

Figure 2. Schematic rendering of closed loop heat pump system. *Image from www.mcquay.com*

Performance Data.

The completed geothermal heat pump system has not yet been operating under design conditions long enough to draw substantive conclusions. Additionally, nearly half of the 96,000 sq. ft. building area is not using the new geothermal system and will continue to be served by diesel boilers until funds can be obtained to replace these older portions of the terminal. Regardless of these obstacles, data gathered to date show promising evidence of a successful conversion from traditional diesel fired boilers to renewable geothermal heat pumps. Preliminary findings are documented below.

Diesel Fuel Usage:

A decrease in diesel fuel usage since installation of the geothermal heat pump system can be seen in fig. 3 below. Fiscal years are highlighted by color in order to provide two methods by which to compare diesel usage through seasonal cycles. The geothermal heat pump installation was fully operational in May, 2011, so calendar year 2011 represents the best available period of post-construction data; Calendar year 2008 represents a full 12 month period prior to any installed heat pumps.

MONTH	2008	2009	2010	2011
	GALLONS	GALLONS	GALLONS	GALLONS
JANUARY	9636	8939	9920	9307
FEBUARY	9725	8462	11776	1116
MARCH	4722	10220	10733	7788
APRIL	10327	2988	7100	3199
MAY	6451	1150	1841	5350
JUNE	8075	7812	1908	999
JULY	1425	7225	0	1900
AUGUST	5659	2000	1200	3600
SEPTEMBER	8679	4600	2638	4400
OCTOBER	8227	4712	4995	1377
NOVEMBER	8314	9844	3333	4209
DECEMBER	8442	10165	4391	9355
TOTAL Calendar Year (Jan-Dec)	**89,682 gal**	**78,117 gal**	**59,835 gal**	**52,600 gal**
TOTAL Fiscal Year (July 1 – June 30)		**FY 2009 (grey) 80,317 gal**	**FY 2010 (aqua) 81,824 gal**	**FY 2011 (yellow) 46, 216 gal**

Figure 3. Diesel Usage at JNU Terminal prior to, during, and after geothermal heat pump installation.

Electrical Usage:

While diesel usage has declined, electrical usage, noted in fig. 4 below, has increased. Fiscal years are highlighted by color in order to provide two methods by which to compare electrical usage through seasonal cycles. The geothermal heat pump installation was fully operational in May, 2011, so calendar year 2011 represents the best available period of post-construction data; calendar year 2008 represents a full 12 month period prior to any installed heat pumps. Electric spaces heaters were used extensively for temporary heat during construction from 2009 through 2010.

MONTH	2008	2009	2010	2011
	KWHR	KWHR	KWHR	KWHR
JANUARY	192,960	191,840	189,280	232,800
FEBUARY	209,280	166,400	175,840	200,000
MARCH	181,280	161,440	186,720	233,760
APRIL	175,520	152,160	201,760	209,760
MAY	153,760	163,840	186,880	191,520
JUNE	149,280	151,680	158,560	197,440
JULY	158,880	166,400	169,600	186,400
AUGUST	185,600	182,880	177,440	184,160
SEPTEMBER	170,080	174,240	165,920	184,160
OCTOBER	171,840	168,960	180,320	180,160
NOVEMBER	181,920	180,960	190,560	218,720
DECEMBER	163,200	172,160	220,480	227,840
TOTAL Calendar Year (Jan-Dec)	**2,093,600** KWHR	**2,032,960** KWHR	**2,203,360** KWHR	**2,262,560** KWHR
TOTAL Fiscal Year (July 1 – June 30)		**FY 2009 (grey) 2,018,880** KWHR	**FY 2010 (aqua) 2,144,640** KWHR	**FY 2011 (yellow) 2,369,600** KWHR

Figure 4. Electrical Usage at JNU Terminal prior to, during, and after geothermal heat pump installation.

Operational Cost Savings Summary.

The savings in fuel oil between Calendar Year 2008 (pre-construction) and Calendar Year 2011 (post-construction) is 37,082 gallons. The average cost of fuel oil diesel #2 in Juneau during the period of this analysis is $3.52 per gallon. Therefore, the cost of fuel oil saved between Calendar Year 2008 and Calendar Year 2011 is approximately $130,529.

The airport terminal project added approximately 12,000 sq. ft. of new area to the building. The difference in electrical usage between Calendar Year 2008 (pre-construction) and Calendar Year (post-construction that includes 12,000 sq. ft. building expansion) is approximately 168,960 KWHR. The electrical local cost, including demand charges, used for purposes of this analysis is $0.092 per KWHR. Therefore, the additional cost of electricity for the airport terminal is approximately $15,544. Subtracting the additional electrical usage cost from the fuel oil cost savings results in **$114,985 in direct annual fuel cost savings for the Juneau International Airport facility with the installation of the ground source heat pump system.**

Another significant benefit that the airport has seen is the decrease in operations costs due to the snowmelt system. This is a new system, and while it demands significant energy to operate, the safety and passenger comfort issues are very positive. The snow melt system is energized by three water-to-water electric heat pumps that are integrally tied to the geothermal loop field. While not analyzed in detail, it is expected that operating this system by an equivalent diesel energy source would have made the installation cost prohibitive for the airport's annual operating budget. The geothermal snow melt system savings over traditional snow removal operations is approximately **$10,000 per year in staff labor, and $1,000 in equipment and supplies.**

Note:
This operational cost savings summary is limited in scope. A full energy usage analysis of pre and post construction conditions would require more extensive investigation of electrical consumption from computers, lights, and other electric equipment used throughout the facility, as well as trending data from the control system operation for all ground source equipment. In order to produce a more accurate calculation, information would be required on how often each water-to-air heat pump operates in cooling mode and how often it operates in heating mode. Additional information that indicates the percentage of use of each of the two system circulation pumps would be required, as well. A similar usage question arises with the water-to-water heat pumps during shoulder months (ie transition from times of snow and no snow) when heat pumps are intermittently in operation, rather than having all three in full operation 24/7, as the rough electrical usage calculation implies.

Further Analysis of additional operational savings is expected to be done as the airport implements energy conservation measures recommended from a recent energy audit, and performs ongoing minor renovation projects in the terminal building. Most notably, as the airport learns more about the intricacies of the geothermal heat pump system, it is expected that additional savings will be realized through more detailed control of heat pump set points and usage patterns. Of particular interest is the May-October period (when snow melt system is not in operation) when the ground source system average power consumption drops significantly as the building's heating and cooling needs are "balanced" and the system does not require recirculation through the outside loop field.

Other operational and human comfort benefits of the geothermal heat pump system are still being realized, not the least of which is the building's new ability to provide cooling (air conditioning) throughout the occupied spaces which did not exist before.