

NPPD GeoEnergy

Ground Source Heat Pump System Review

Facility: Scottsbluff High School

Date: May 16, 2007

Participants: Larry Davis (Scottsbluff High School), Bryce Landen, John Koperski and Steve Zach (Nebraska Public Power District)

A review of the control system for the ground source heat pump system at the Scottsbluff High School was conducted on August 29, 2006. The purpose of the review was to determine the operating parameters of the system and to make recommendations to improve the cost effectiveness of the system.

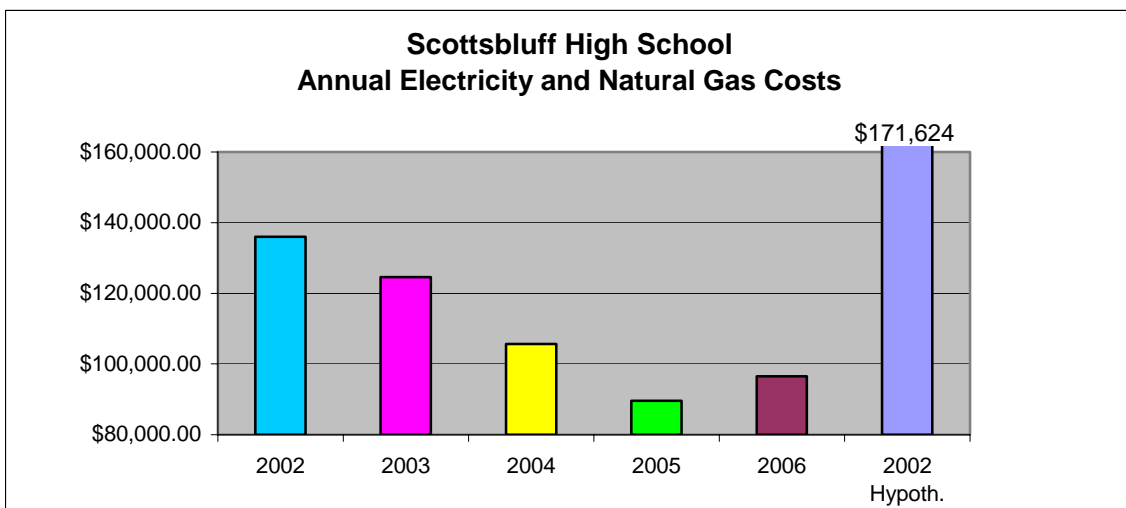
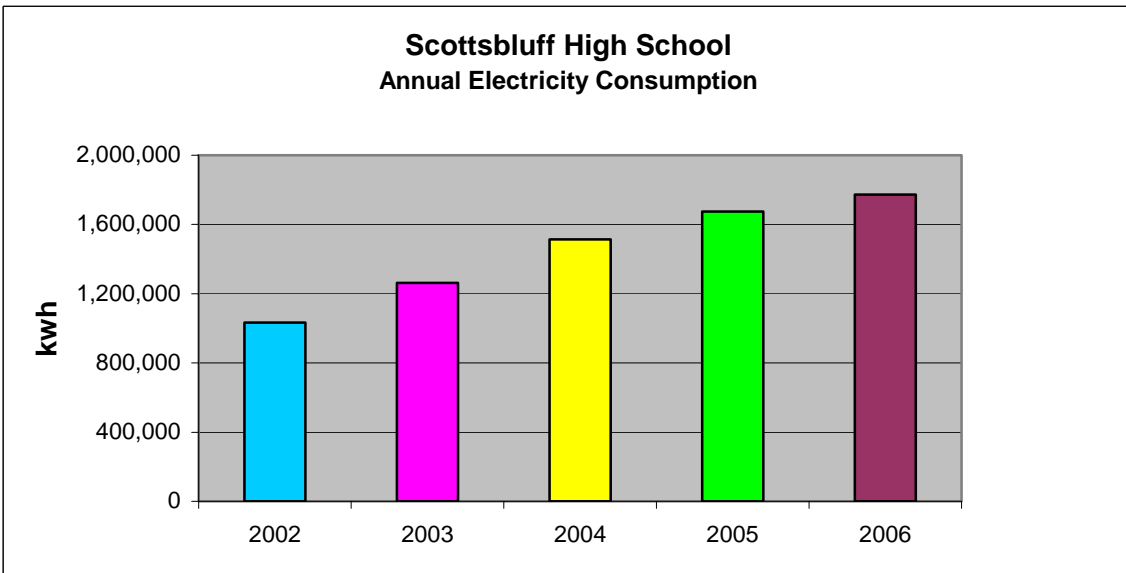
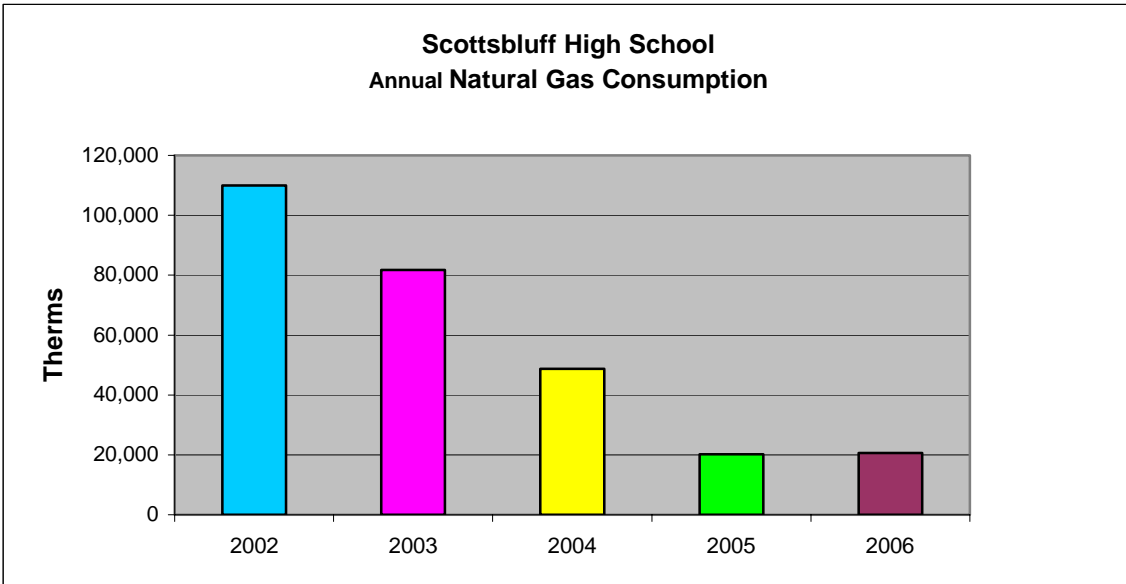
The 2006 – 2007 school year is the third full school year using the ground source heat pump system. The school has an area of 161,744 square feet.

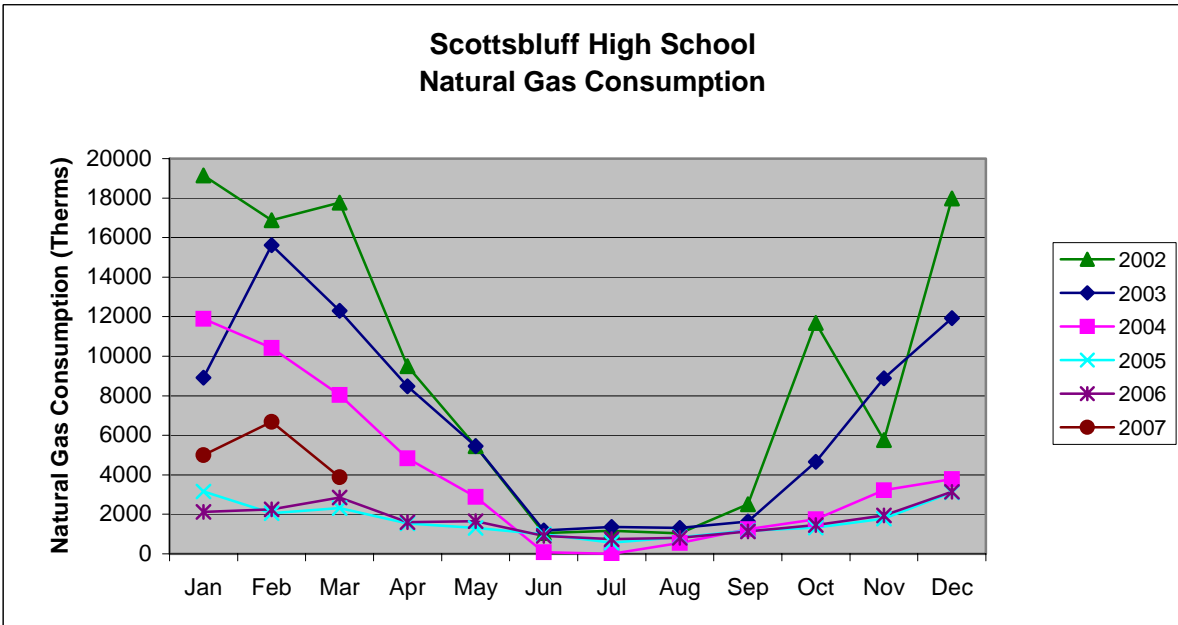
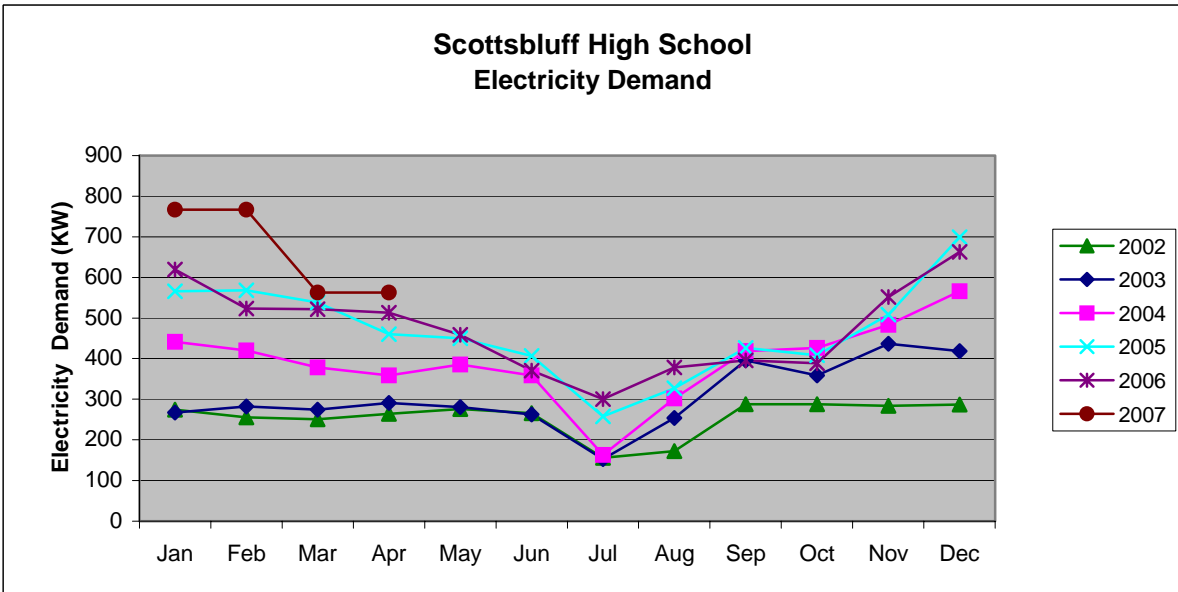
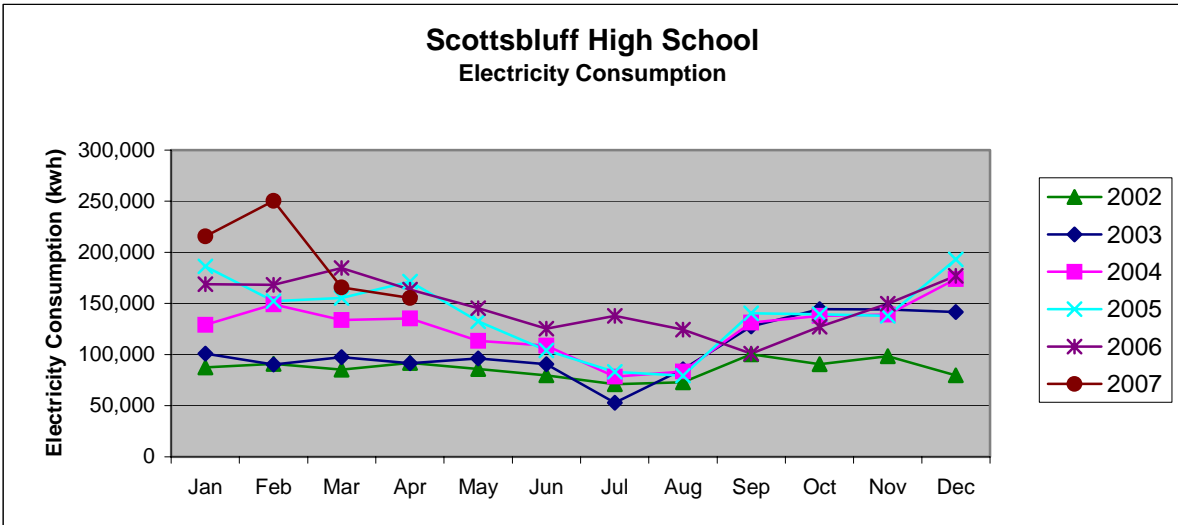
Energy Usage

The charts on page 2 show a dramatic decrease in natural gas usage since the ground source heat pump system went into operation. However, electrical energy usage has increased. This is to be expected since the school essentially changed from natural gas heating to electric heating, with the added benefit of air-conditioning throughout the facility. What is significant to note is that even in light of the addition of air-conditioning and ventilation air, the cost to operate the facility has decreased significantly. The third chart below shows this.

The column at the far right of the third chart shows hypothetical costs using 2002 electrical and natural gas energy, multiplied by current natural gas and electricity costs. This is the utility cost the school might have incurred had the school continued to use the natural gas boiler system to heat the school. The savings are about \$75,000 year.

On page 3 are three additional charts which show electricity consumption and demand, and natural gas usage, on a monthly basis. The charts are provided to show that there appeared to be an issue in January and February of this year. While there were some cold spells during this time frame, this jump in electricity and natural gas usage does not look normal. As of March, however, it appears that usages are returning to normal levels.





The energy data used to create the preceding charts is provided on pages 7 and 8.

Benchmarking

The last page of this report shows how Scottsbluff High School's energy usage compares to other air-conditioned schools in Nebraska.

The charts show that the school is operating fairly efficiently compared to other schools in Nebraska. An energy index of 51,163 btu/sqft is a fair rating. Much of this success in performance can be attributed to the highly efficient ground source heat pump system being utilized to heat and cool the school. It should be noted, however, that some of the best performing schools with ground source heat pumps have energy indexes of 35,000 btu/sqft and lower. By implementing the recommendations described in this report, we feel the school could reduce their energy consumption by to 10% to 20%.

Observations

During the review, we observed many features of the system that provide for energy efficient operation. For example:

- A direct digital control system is in place to allow setting of room temperatures and operating schedules from one central location.
- Variable frequency drives are installed on the main circulating pumps, to slow down the pumps during periods of low heating or cooling loads. (The VFD was running at 22% of rated speed during our review, which indicates a lot of pumping energy was being saved.)
- Energy recovery ventilators (ERVs) are being used to bring in outside air. This is a very efficient way to provide ventilation air for the building.
- The gymnasium has two rooftop units, one of which is normally in standby and is operated by a manual timer when large occupant loads are expected.
- Override buttons on classroom thermostats allow a teacher to put his/her classroom into occupied mode during "after hours" use.
- Loop differential setpoint was at 10 psi, which is typical for these types of systems.
- Loop temperatures run in the 50s in the wintertime, and in the 60s during the summer. These temperatures indicate the ground heat exchanger is operating well.

Recommendations

During the review, we noted several items that could be improved to provide energy savings:

1. Classroom Occupancy Schedule

Current classroom occupancy schedule is typically 06:00 to 22:00.

We recommend changing this to 07:00 – 16:00. For those who are in the classrooms before 07:00 or after 16:00, the override button on the thermostat can be used to provide heating or cooling as needed.

This schedule change will save energy in two ways. First, heat pump fan energy will be saved, as the fans are currently programmed to run continuously during occupied mode. Second, the rooms will revert to their night setback temperatures sooner, saving compressor energy.

Estimated Cost to Implement: Less than \$50
Estimated Savings: \$3,000/year

In order for the occupied time to be changed to 07:00, it may be necessary to implement an “optimal start” feature in the control system. This feature starts heat pumps as needed during early morning hours to ensure that the rooms are at the required temperature setpoints by the time occupied mode begins. This feature is available on most control systems.

2. Energy Recovery Ventilator Schedules

Typical ERV schedules are 07:00 – 17:00.

We recommend compressing this schedule to say 08:00 – 15:30, since the outside air systems need to run only when the building is occupied.

Estimated Cost to Implement: Less than \$50
Estimated Savings: \$2,000/year

Further savings may exist if it is determined that the ERVs more than satisfy indoor air quality requirements, in particular, carbon dioxide. With carbon dioxide monitoring, it may be found that airflows could be reduced or the ERVs shutdown during parts of the day.

We also recommend evaluating whether some of the ERVs should have their own schedule. This would apply to areas that have different occupancy than a typical classroom.

3. Restroom Exhaust Fans

The restroom exhaust fans are not controlled by the Johnson Controls control system, and are thought to be running 24 hours per day, 7 days per week. In addition to the fan motor energy that could be saved by shutting the fans off during unoccupied hours, infiltration into the building would also be reduced.

We recommend connecting the exhaust fans into the Johnson Controls system, or providing a time clock, to allow the fans to be shutdown during unoccupied mode.

Estimated Cost to Implement: Need quote from Johnson Controls
Estimated Savings: \$1,500/year

4. Control of Gymnasium, Auditorium, and Lecture Hall ERVs

It is understood that when the Gym, Auditorium, and Lecture Hall are in occupied mode, their ERVs operate as well. Since these areas can have large fluctuations in occupant loads, we recommend the installation of carbon dioxide sensors to control outside air. During periods of no or low occupancy, the ERV will be off because carbon dioxide levels will be satisfactory. As the number of people in the room increases, the carbon dioxide level will rise. When it reaches a given setpoint, the sensor will automatically activate the ERV to bring in outside air to reduce the carbon dioxide level.

Estimated Cost to Implement: \$500 per area
Estimated Savings: \$750/year (Gym and Auditorium); \$250/year (Lecture Hall)

5. Summer Schedule

The table below indicates the high school's summer electrical energy usage from 2004 through 2006. Also shown in the table is an "Other Schools" column, which is the average usage for three other schools in Nebraska that have ground source heat pump systems.

Electrical Energy Usage - Summer Months				
kwh per sqft				
	2004	2005	2006	Other Schools
June	0.67	0.64	0.77	0.44
July	0.48	0.51	0.77	0.48
August	0.52	0.49	0.77	0.53

The table shows that usage was higher in 2006 than what it had been in the previous two years, and also higher than the average of the three other schools. Oftentimes, high summer energy usage can be attributed to running the heat pumps and ERVs on the same schedule that was used during the school year, even though student occupancy is greatly reduced. Therefore, we recommend ensuring that the heat pumps and ERVs are properly scheduled for the summer.

We thank you for the opportunity to provide this analysis for you. If you have any questions or comments regarding this information, please do not hesitate to contact us at the following numbers.

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This report has been kept intentionally brief and non-technical. The information is believed to be correct. However, since Nebraska Public Power District has no control or use of the building and its components, Nebraska Public Power District cannot be responsible for any results or lack of results from building changes undertaken following this report.

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-02	87,450	275	\$3,042.00	\$0.035	Jan-02	19143	\$ 15,075.97	\$0.79	\$18,117.97	13,681	0.11
Feb-02	90,900	255	\$3,180.69	\$0.035	Feb-02	16883	\$ 13,104.14	\$0.78	\$16,284.83	12,356	0.10
Mar-02	85,350	251	\$2,976.67	\$0.035	Mar-02	17775	\$ 14,509.31	\$0.82	\$17,485.98	12,791	0.11
Apr-02	91,950	264	\$3,206.84	\$0.035	Apr-02	9493	\$ 7,764.16	\$0.82	\$10,971.00	7,809	0.07
May-02	85,950	276	\$3,025.26	\$0.035	May-02	5457	\$ 4,477.11	\$0.82	\$7,502.37	5,188	0.05
Jun-02	79,650	266	\$3,888.27	\$0.049	Jun-02	1059	\$ 828.33	\$0.78	\$4,716.60	2,335	0.03
Jul-02	70,800	156	\$4,269.08	\$0.060	Jul-02	1162	\$ 906.82	\$0.78	\$5,175.90	2,212	0.03
Aug-02	72,750	173	\$4,386.67	\$0.060	Aug-02	1037	\$ 812.80	\$0.78	\$5,199.47	2,176	0.03
Sep-02	100,200	288	\$6,041.82	\$0.060	Sep-02	2512	\$ 1,822.30	\$0.73	\$7,864.12	3,667	0.05
Oct-02	90,600	288	\$4,125.62	\$0.046	Oct-02	11685	\$ 8,822.30	\$0.76	\$12,947.92	9,136	0.08
Nov-02	98,400	284	\$3,431.79	\$0.035	Nov-02	5758	\$ 9,797.93	\$1.70	\$13,229.72	5,636	0.08
Dec-02	79,650	287	\$2,954.66	\$0.037	Dec-02	17978	\$ 13,555.96	\$0.75	\$16,510.62	12,796	0.10
Totals:	1,033,650		\$44,529.37	\$0.043		109,942	\$91,477.13	\$0.83	\$136,006.50	89,784	\$ 0.84

Square feet:	161,744
\$/sqft:	\$0.84
kwh/sqft:	6.4
therms/sqft:	0.68
Btus/sqft:	89,784

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-03	100,800	267	\$3,515.50	\$0.035	Jan-03	8917	\$ 12,961.72	\$1.45	\$16,477.22	7,640	0.10
Feb-03	90,300	282	\$2,994.51	\$0.033	Feb-03	15610	\$ 11,774.73	\$0.75	\$14,769.24	11,556	0.09
Mar-03	97,650	275	\$3,392.05	\$0.035	Mar-03	12296	\$ 9,281.91	\$0.75	\$12,673.96	9,663	0.08
Apr-03	91,500	291	\$3,178.42	\$0.035	Apr-03	8481	\$ 6,412.24	\$0.76	\$9,590.66	7,174	0.06
May-03	96,150	281	\$3,339.95	\$0.035	May-03	5449	\$ 4,131.55	\$0.76	\$7,471.50	5,398	0.05
Jun-03	90,750	263	\$4,552.51	\$0.050	Jun-03	1176	\$ 1,017.19	\$0.86	\$5,569.70	2,642	0.03
Jul-03	52,800	153	\$3,334.74	\$0.063	Jul-03	1361	\$ 1,154.36	\$0.85	\$4,489.10	1,956	0.03
Aug-03	85,650	254	\$5,409.47	\$0.063	Aug-03	1318	\$ 1,103.07	\$0.84	\$6,512.54	2,622	0.04
Sep-03	127,350	396	\$8,043.16	\$0.063	Sep-03	1642	\$ 1,373.97	\$0.84	\$9,417.13	3,702	0.06
Oct-03	144,450	359	\$6,942.15	\$0.048	Oct-03	4667	\$ 3,798.49	\$0.81	\$10,740.64	5,933	0.07
Nov-03	144,150	437	\$5,007.32	\$0.035	Nov-03	8885	\$ 7,207.10	\$0.81	\$12,214.42	8,535	0.08
Dec-03	141,450	419	\$4,913.53	\$0.035	Dec-03	11930	\$ 9,761.66	\$0.82	\$14,675.19	10,361	0.09
Totals:	1,263,000		\$54,623.31	\$0.043		81,732	\$69,977.99	\$0.86	\$124,601.30	77,183	\$ 0.77

Square feet:	161,744
\$/sqft:	\$0.77
kwh/sqft:	7.8
therms/sqft:	0.51
Btus/sqft:	77,183

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-04	129,000	441	\$4,481.05	\$0.035	Jan-04	11898	\$ 10,042.54	\$0.84	\$14,523.59	10,078	0.09
Feb-04	148,950	420	\$5,174.05	\$0.035	Feb-04	10415	\$ 8,716.79	\$0.84	\$13,890.84	9,582	0.09
Mar-04	133,800	378	\$4,647.79	\$0.035	Mar-04	8042	\$ 6,637.69	\$0.83	\$11,285.48	7,795	0.07
Apr-04	135,300	359	\$4,699.89	\$0.035	Apr-04	4844	\$ 4,032.04	\$0.83	\$8,731.93	5,850	0.05
May-04	113,400	386	\$3,939.16	\$0.035	May-04	2881	\$ 2,444.26	\$0.85	\$6,383.42	4,174	0.04
Jun-04	108,900	359	\$5,480.13	\$0.050	Jun-04	81	\$ 96.16	\$1.19	\$5,576.29	2,348	0.03
Jul-04	78,300	164	\$4,456.21	\$0.057	Jul-04	0	\$ 4.15	#DIV/0!	\$4,460.36	1,652	0.03
Aug-04	83,550	302	\$5,276.84	\$0.063	Aug-04	546	\$ 523.41	\$0.96	\$5,800.25	2,101	0.04
Sep-04	131,400	419	\$8,298.95	\$0.063	Sep-04	1244	\$ 1,126.45	\$0.91	\$9,425.40	3,542	0.06
Oct-04	137,700	426	\$6,495.46	\$0.047	Oct-04	1745	\$ 1,589.23	\$0.91	\$8,084.69	3,985	0.05
Nov-04	139,050	483	\$4,830.16	\$0.035	Nov-04	3223	\$ 3,030.10	\$0.94	\$7,860.26	4,927	0.05
Dec-04	173,850	566	\$6,039.00	\$0.035	Dec-04	3781	\$ 3,575.48	\$0.95	\$9,614.48	6,006	0.06
Totals:	1,513,200		\$63,818.69	\$0.042		48,700	\$41,818.30	\$0.86	\$105,636.99	62,040	\$ 0.65

Square feet:	161,744
\$/sqft:	\$0.65
kwh/sqft:	9.4
therms/sqft:	0.30
Btus/sqft:	62,040

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-05	186,300	566	\$6,471.47	\$0.035	Jan-05	3160	\$ 2,882.20	\$0.91	\$9,353.67	5,885	0.06
Feb-05	152,250	569	\$5,288.68	\$0.035	Feb-05	2061	\$ 1,891.27	\$0.92	\$7,179.95	4,487	0.04
Mar-05	155,250	539	\$5,392.89	\$0.035	Mar-05	2315	\$ 2,124.50	\$0.92	\$7,517.39	4,707	0.05
Apr-05	171,150	461	\$5,945.21	\$0.035	Apr-05	1545	\$ 1,460.30	\$0.95	\$7,405.51	4,567	0.05
May-05	132,450	450	\$4,600.89	\$0.035	May-05	1304	\$ 1,222.50	\$0.94	\$5,823.39	3,601	0.04
Jun-05	103,950	407	\$5,135.74	\$0.049	Jun-05	979	\$ 1,010.44	\$1.03	\$6,146.18	2,799	0.04
Jul-05	83,100	258	\$5,248.42	\$0.063	Jul-05	569	\$ 601.19	\$1.06	\$5,849.61	2,105	0.04
Aug-05	79,500	327	\$5,021.05	\$0.063	Aug-05	849	\$ 880.90	\$1.04	\$5,901.95	2,202	0.04
Sep-05	140,400	426	\$8,867.37	\$0.063	Sep-05	1157	\$ 1,182.41	\$1.02	\$10,049.78	3,678	0.06
Oct-05	139,350	408	\$6,573.28	\$0.047	Oct-05	1327	\$ 1,358.42	\$1.02	\$7,931.70	3,761	0.05
Nov-05	137,850	509	\$4,788.47	\$0.035	Nov-05	1783	\$ 1,813.96	\$1.02	\$6,602.43	4,011	0.04
Dec-05	193,050	699	\$6,705.95	\$0.035	Dec-05	3102	\$ 3,131.65	\$1.01	\$9,837.60	5,991	0.06
Totals:	1,674,600		\$70,039.42	\$0.042		20,151	\$19,559.74	\$0.97	\$89,599.16	47,795	\$ 0.55

Square feet:	161,744
\$/sqft:	\$0.55
kwh/sqft:	10.4
therms/sqft:	0.12
Btus/sqft:	47,795

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-06	168,900	620	\$5,867.05	\$0.035	Jan-06	2123	\$ 2,153.63	\$1.01	\$8,020.68	4,877	0.05
Feb-06	168,150	524	\$5,841.00	\$0.035	Feb-06	2245	\$ 2,275.51	\$1.01	\$8,116.51	4,936	0.05
Mar-06	184,650	522	\$6,414.16	\$0.035	Mar-06	2854	\$ 2,883.88	\$1.01	\$9,298.04	5,661	0.06
Apr-06	163,350	513	\$5,674.26	\$0.035	Apr-06	1608	\$ 1,639.14	\$1.02	\$7,313.40	4,441	0.05
May-06	145,200	459	\$5,043.79	\$0.035	May-06	1652	\$ 1,683.10	\$1.02	\$6,726.89	4,085	0.04
Jun-06	125,250	371	\$6,192.03	\$0.049	Jun-06	912	\$ 1,041.67	\$1.14	\$7,233.70	3,207	0.04
Jul-06	137,700	300	\$7,910.79	\$0.057	Jul-06	745	\$ 856.93	\$1.15	\$8,767.72	3,366	0.05
Aug-06	124,350	378	\$7,853.68	\$0.063	Aug-06	813	\$ 932.16	\$1.15	\$8,785.84	3,127	0.05
Sep-06	100,950	396	\$6,375.79	\$0.063	Sep-06	1129	\$ 1,290.35	\$1.14	\$7,666.14	2,828	0.05
Oct-06	127,200	389	\$5,914.45	\$0.046	Oct-06	1460	\$ 1,652.99	\$1.13	\$7,567.44	3,587	0.05
Nov-06	149,550	552	\$5,194.89	\$0.035	Nov-06	1939	\$ 2,177.77	\$1.12	\$7,372.66	4,354	0.05
Dec-06	176,850	663	\$6,143.21	\$0.035	Dec-06	3136	\$ 3,489.20	\$1.11	\$9,632.41	5,671	0.06
Totals:	1,772,100		\$74,425.10	\$0.042		20,616	\$22,076.33	\$1.07	\$96,501.43	50,140	\$ 0.60

Square feet:	161,744
\$/sqft:	\$0.60
kwh/sqft:	11.0
therms/sqft:	0.13
Btus/sqft:	50,140

Scottsbluff High School

Month	Electricity Consumption	Demand	Electric Billing	Cost Per KWH	Month	Gas Consumption	Gas Billing	Cost Per Therm	Total Cost	Btus/sqft	\$/sqft
Jan-07	215,700	767	\$7,492.74	\$0.035	Jan-07	5005	\$ 5,787.22	\$1.16	\$13,279.96	7,646	0.08
Feb-07	250,200	767	\$8,842.79	\$0.035	Feb-07	6684	\$ 7,716.19	\$1.15	\$16,558.98	9,412	0.10
Mar-07	165,600	563	\$5,926.74	\$0.036	Mar-07	3889	\$ 4,505.06	\$1.16	\$10,431.80	5,899	0.06
Apr-07	155,250	563	\$5,556.32	\$0.036	Apr-07				\$5,556.32	3,276	0.03
May-07					May-07				\$0.00	-	-
Jun-07					Jun-07				\$0.00	-	-
Jul-07					Jul-07				\$0.00	-	-
Aug-07					Aug-07				\$0.00	-	-
Sep-07					Sep-07				\$0.00	-	-
Oct-07					Oct-07				\$0.00	-	-
Nov-07					Nov-07				\$0.00	-	-
Dec-07					Dec-07				\$0.00	-	-
Totals:	786,750		\$27,818.59	\$0.035		15,578	\$18,008.47	\$1.16	\$45,827.06	26,233	\$ 0.28

Square feet:	161,744
\$/sqft:	\$0.28
kwh/sqft:	4.9
therms/sqft:	0.10
Btus/sqft:	26,233