Review of Equipment Trial

Blackhawk Power Conditioner
City of Edmonton
Grand Trunk Leisure and Fitness Centre
July 2013

Executive Summary

A trial of the Blackhawk power conditioner was conducted at the Grand Trunk Leisure and Fitness Centre, with the cooperation of the City of Edmonton, during the month of July 2013.

The unit was found to reduce energy consumption by an average of 350 kW.h per day resulting in an estimated reduction of 127,750 kW.h consumed per year. Associated CO2 emissions reductions are 115 tonnes annually. The Blackhawk installation has an estimated simple payback of 1.6 years and a ten year 61% return on investment.

Benefits associated with equipment longevity are noted as being significant, but are not included in the economic analysis.

Analysis of the results also suggests that the unit installed may be undersized for the kVAR inductance of the facility. As a special note, some City facilities may be on rate DAS-MC, which charges based on peak kilo Volt Ampere (kVA) demand. The economics of the Blackhawk power conditioner would be further improved when used on these facilities.

Introduction

Gray Energy Economics Inc. has been retained to review the results of a trial of a Blackhawk power conditioner installed at Grand Trunk Leisure and Fitness Centre, 13025 112 St, Edmonton, AB. The facility combines a swimming pool, water slides, hot tub and other aquatic features with a large fitness facility, gymnasiums, offices and meeting facilities.

The trial consisted of installation of a 35 kVAR Blackhawk power conditioner and comparison of energy consumption with the unit on and off. The Blackhawk power conditioner, among other things, provides capacitance to the building electric system, balancing inductance and improving the building power factor.

Data and Methodology

Data analysis was conducted on hourly kW.h (hourly energy), kW (peak kilowatt demand) and kVA (peak kilo volt ampere demand) for the period July 1, 2013 to July 31, 2013 from meter data provided by the City and read by EPCOR. The Blackhawk power conditioning unit was on during the period July 1 to hour 12 of July 22.

Two methods were used to evaluate the data provided, for the purpose of determining the effect of operation of the Blackhawk power conditioner on energy consumption, power factor and kVA demand:

1 Load duration comparison: The largest determinant of energy consumption is the pattern of usage of the electrical equipment in the facility. In order to isolate the effect of the Blackhawk power conditioner on energy consumption, two large sub-samples of data were selected with matching days of the week, one sub-sample with the Blackhawk on and one with it off. The sample data was re-ranked from highest energy consumption hour to lowest energy consumption hour to derive the load duration curve for each sub-sample.

2. Regression analysis: In order to normalize the sample data for weather and to isolate the effect of the Blackhawk power conditioner, a multivariate regression analysis was performed using three formulations of temperature data and a dummy variable for Blackhawk operation.

Gray Energy Economics Inc.

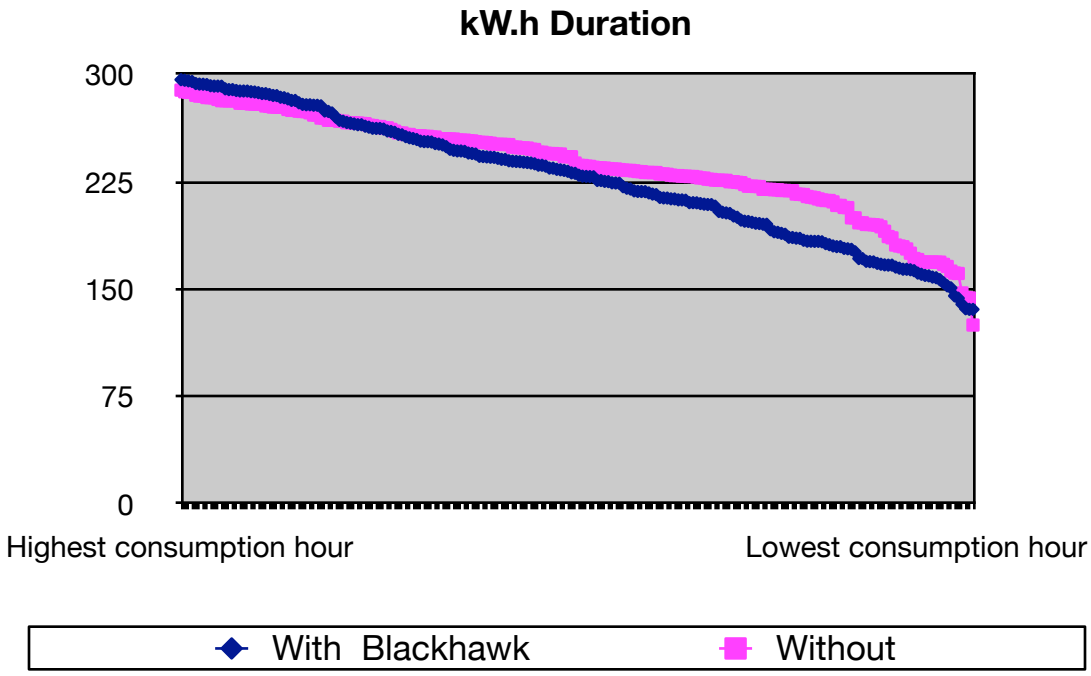
Load Duration Comparison

The two largest data-subsets with matching days of the week were Tuesday, July 2 to Wednesday July 10, 2013 and Tuesday July 23, 2013 to Wednesday July 31, 2013. Statutory holiday, July 1, 2013, was excluded from all analysis.

	With Blackhawk	Without Blackhawk	Difference	Percentage
Total Energy Consumption	49042	51156	2114	4.13%
Average Hourly	227	237	10	4.13%
Min	136	125	-11	-8.73%
Max	296	289	-7	-2.52%

Without adjusting for temperature, the reduction in consumption attributable to the Blackhawk power conditioner is estimated by this method at 235 kW.h per day.

In the following chart, the 216 hours of data for each sub-sample has been reordered from highest energy consumption to lowest energy consumption hours. Graphing the resulting duration curve for the two sub-sample periods appears as follows:



The Blackhawk power conditioner appears to have had the greatest effect at the lower range of load levels in the sub-samples. This suggests that the unit may be undersized for the inductive load at the facility.

Regression Analysis for Weather Normalization

In order to correctly separate the effects of ambient temperature on building cooling requirements and the operation of the Blackhawk power conditioner, the hourly energy consumption at the facility was used as the dependent variable in all linear regression models, with daily cooling degree days and a dummy variable for operation of the Blackhawk unit as independent variables. For July 22, 2013, the dummy variable value was set to 0.5 for 1/2 day of operation.

Three formulations were evaluated:

1 Daily energy consumption vs. same day cooling degree days and Blackhawk dummy variable
2 Daily energy consumption vs. prior day cooling degree days and Blackhawk dummy variable
3 Daily energy consumption vs. average of same and prior day cooling degree days and Blackhawk dummy variable

Model 3, using a moving average of the current and prior cooling degree days was the best fit model, with the following results:

Daily Energy Consumption	Constant	Cooling Degree Days	Blackhawk
Estimate	5550.4	150.6	-350.4
Variance	107.7	60.0	183.5
Statistically Significant at 90% Confidence	Yes	Yes	Yes

This method indicates that the effect of the Blackhawk power conditioner is a reduction of 350.4 kW.h per day, temperature normalized. This is a reduction of 6.2% in energy consumption for the facility.

Using the temperature adjustment factor of 150.6 kW.h/day consumption per cooling degree day (2 day average), one can also adjust the previous estimate for savings derived from the sub-samples.

Comparing the two sub-sample periods, cooling degree days totaled 22.5 during the period when the Blackhawk was operating, and 5.5 when it was not operating. The difference of 17 degree days between the sample periods would add another 2560.2 kW.h or 284.6 kW.h per day to the savings attributable to the Blackhawk over the nine day sample periods. Adding this to the estimate of 235 kW.h per day savings from the sub-sample analysis totals 519 kW.h savings per day.

As the regression analysis explicitly accounts for temperature difference and is statistically the best, linear, unbiased estimate of the underlying parameters, the estimate of 350.4 kW.h per day savings is used for subsequent economic analysis. The higher value determined by adjusting the sub-sample analysis corroborates and validates this estimate as conservative and reasonable.

Energy Conclusion

After adjusting for differences in cooling degree days over the sample periods, the Blackhawk power conditioner is estimated to have saved 350.4 kW.h per day of operation. Extending these savings for one year, annual energy savings are estimated to be 127,750 kW.h.

At 900 kg of CO2 produced per 1,000 kW.h (1 MW.h) of Alberta electricity generation, greenhouse gas reductions associated with this installation are estimated to be 115 tonnes per year.

Economic Evaluation

The facility is served by EPCOR Distribution on rate DAS-TOU applicable to commercial or industrial facilities using between 150 and 5,000 kVA. This rate uses peak kW to determine demand charges and an on-peak charge per kW.h of $0.00854.

The rate paid for electric energy has not been provided, but is estimated at $0.075 per kW.h. Estimating that 60% of energy consumed is on-peak, the effective rate per kW.h is $0.08124.

Annual savings from use of the Blackhawk power conditioner at the facility are estimated to be $10,378. The installed cost of the unit was $16,805. Simple payback on the device is 1.6 years. The 10 year rate of return on investment is estimated to be 61%.

No estimate of improvements to equipment life have been included in this estimate. In the author’s experience, extended equipment life is a significant factor in power factor correction investments.

Special note

For facilities that consume between 50 and 150 kVA, the applicable EPCOR distribution tariff is DAS-MC. This tariff has a ratcheted demand charge based on peak kilovolt ampere (kVA) demand. The economic benefit of improving power factor via the Blackhawk power conditioner would be enhanced further for any facilities on this particular tariff.

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