



Independent Evaluation of Energy Savings Performance

The Powerhouse Energy Conditioning System

by Innovative Energy Solutions, Inc.

TESTING LOCATION: **Main Event**
9375 Dallas Parkway
Frisco, Texas 75033

PREPARED FOR: **Wayne Jones**
Product Development Manager
Innovative Energy Solutions, Inc.

REPORT DATE: **July 1, 2016**

CERTIFIER: **John J. Burdette III**
Certified Energy Manager (CEM)
CEM Certification ID# 19189
Date of Expiration: 12/31/2018

EXECUTIVE SUMMARY

JB3 Consulting, John J. Burdette III, a Certified Energy Manager has been retained by Wayne Jones, Manufacturer's Representative for Innovative Energy Solutions Inc., the manufacturer of the Black Hawk Powerhouse, to undertake an independent evaluation of the kWh savings arising from the installation of a Black Hawk Powerhouse Power Conditioner at the Main Event location at 9375 Dallas Parkway, Frisco, Texas, 70533. Alex McCann a certified Powerhouse dealer, installed the 480/100 kVAr unit in the spring of 2016.

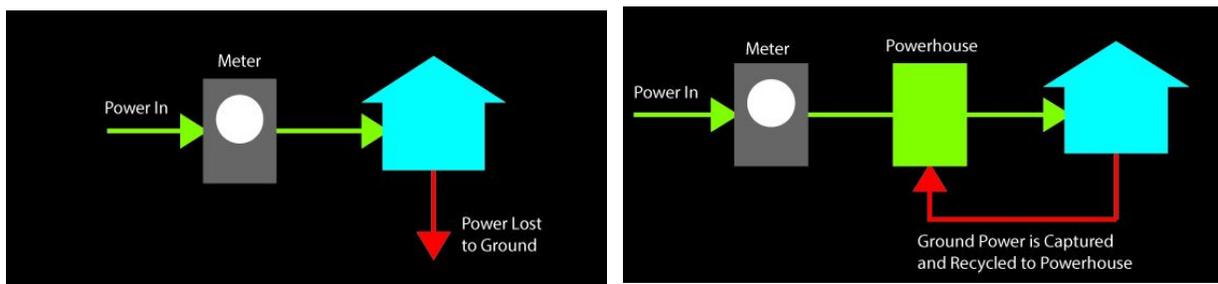
The Powerhouse Energy Conditioning System stated benefits;

- 1. Greatly reduces low voltage issues
- 2. Elevates voltage of the entire system
- 3. Stabilizes voltage of the complete system
- 4. Reduces voltage drops when demand increases.
- 5. Reduces tripped breakers caused by low voltage or power spikes
- 6. Reduces kilowatt hours (kWh) resulting in lower utility bills.

By capturing and balancing the energy, The Powerhouse ensures that equipment is running at its optimum voltages, which results in fewer mechanical problems and lower maintenance costs, thus increasing the lifespan of equipment.

How It Works

All electrical energy coming into a facility is known as Apparent Power, and the power actually used is defined as Real Power. A portion of the power entering an electrical system is lost to ground and never consumed. This is referred to as Reactive Power. The ultimate goal is to bring these two factors, Apparent Power and Real Power, closer together. The Black Hawk Powerhouse is able to accomplish this by capturing this lost energy, storing it and feeding it back into the electrical system:



Existing System

The Powerhouse

EVALUATION SITE

Dallas-based Main Event Entertainment is a 60,000 square foot facility featuring state-of-the-art bowling, multi-level laser tag, high ropes adventure courses, billiards, interactive and virtual video games, and food service. Founded in 1998, the rapidly growing subsidiary of Ardent Leisure Group (ASX: AAD) of Australia comprises 22 U.S. entertainment centers.



9375 Dallas Parkway, Frisco, Texas 75033

60,000 sq. ft. facility

28 bowling lanes, restaurant, huge arcade, laser tag and more

This is an excellent candidate for the Powerhouse due to the fact that there are a great deal of motors and inductive loads at this facility that will inherently lower the power factor and increase electric utility bills.

OBJECTIVE

The objective of this evaluation is to measure the differences in voltage, current, power factor and power reduction measured in kilowatts (kW) for a short duration while the device was on and conditioning the incoming power and while the device was off and not actively conditioning the incoming power.



480 Volt / 100 KVAR unit installed by Alex McCann shown above



480 Volt / 100 KVAR unit opened to expose the heart of the unit, the metal oxide Varistors shown above

Components of the Black Hawk Powerhouse:

- **Varistors**

A Varistor is an electronic component with an electrical resistance that varies with the applied voltage. Also known as a voltage-dependent resistor (VDR), it has a nonlinear, non-ohmic current-voltage characteristic that is similar to that of a diode. In contrast to a diode however, it has the same characteristic for both directions of traversing current. At low voltage it has a high electrical resistance which decreases as the voltage is raised.

Varistors are used as control or compensation elements in circuits either to provide optimal operating conditions or to protect against excessive transient voltages. When used as protection devices, they shunt the current created by the excessive voltage away from sensitive components when triggered.

The most common type of Varistor is the Metal-Oxide Varistor (MOV). This type contains a ceramic mass of zinc oxide grains, in a matrix of other metal oxides (such as small amounts of bismuth, cobalt, manganese) sandwiched between two metal plates (the electrodes). The boundary between each grain and its neighbor forms a diode junction, which allows current to flow in only one direction. The mass of randomly oriented grains is electrically equivalent to a network of back-to-back diode pairs, each pair in parallel with many other pairs. When a small or moderate voltage is applied across the electrodes, only a tiny current flows, caused by reverse leakage through the diode junctions. When a large voltage is applied, the diode junction breaks down due to a combination of thermionic emission and electron tunneling, and a large current flows. The result of this behavior is a highly nonlinear current-voltage characteristic, in which the MOV has a high resistance at low voltages and a low resistance at high voltages.

A Varistor remains non-conductive as a shunt-mode device during normal operation when the voltage across it remains well below its "clamping voltage", thus Varistors are typically used for suppressing line voltage surges. (Sources: Wikipedia, General Electric Technical Information Series December 1972 (ref. 1))

The MOVs used in the Powerhouse, 18 in all, are manufactured by GE and are rated at 50 kA each.

- **Capacitors**

A capacitor is a passive two-terminal electrical component that stores electric energy in an electric field. The capacitors used in the Black Hawk Powerhouse are manufactured by General Electric. They are liquid-filled (unlike the older solid-filled composition), and are projected to have a 20+ year lifespan.

- **Patented wiring configuration**

Reference U.S. Patent #897100. The wiring configuration allows for the neutral to be utilized as a secondary power source and is connected inside the Powerhouse so that current can be redirected in a capacitive or distributive function. In this way, the Powerhouse treats the neutral as a "phase D" within a three phase system. (Source: Powerhouse White Paper)

- **A secondary surge protector**

Protects the grid for up to 50,000 Volts

METHOD OF EVALUATION

A Dent Instruments Elite Pro XC Power Meter (ref. 2) connected with RoCoil mV Series of Flexible Current Transformers (ref. 3) to each of the three phases was installed to measure and log the following attributes of the supply power. I requested and received the most recent calibration statement from the manufacturer which indicates that the unit is in calibration and rarely if ever needs recalibration.

The meter was installed at the facility on May 20th, 2016 on a very hot day. We chose a hot day (ambient temperature 92 degrees Fahrenheit) to ensure that the air conditioners were running and the facility was occupied and loaded. Temperature inside the facility was 75 degrees Fahrenheit. Measurements were recorded with the Powerhouse *off* for one hour, and with the Powerhouse *on* for one hour. The Dent power meter collected data at one second intervals.

This meter measures each leg of voltage and provides an average measurement output in the data set collected. As a safety precaution, I also verified the averaging calculations that the unit provides. I found them to be accurate.

The meter also measures and calculates power factor and provides this output in the data set collected. As a safety precaution, I also verified the power factor calculations that the unit provides. I found them to be accurate, as well.

SUMMARY OF RESULTS

VOLTAGE

A slight improvement in Voltage was recorded on each phase.

Powerhouse On: Average Voltage = 282.78 volts

Powerhouse Off: Average Voltage = 279.93 volts

Overall Improvement: 1.11%

CURRENT

A significant reduction in Current was recorded.

Powerhouse On: Average Current = 281.83 amps

Powerhouse Off: Average Current = 390.99 amps

Overall Improvement: 27.92%

POWER FACTOR

A significant increase in Power Factor was recorded.

Powerhouse On: Average Power Factor = 0.96

Powerhouse Off: Average Power Factor = 0.80

Overall Improvement: 16.97%

KILOWATT

A significant reduction in Peak kW was recorded.

Powerhouse On: Average kW = 230.51 kW

Powerhouse Off: Average kW = 262.89 kW

Overall Improvement: 12.3%

KVA

A significant reduction in KVA was recorded.

Powerhouse On: Average kVA = 239.08 kVA

Powerhouse Off: Average kVA = 327.99 kVA

Overall Improvement: 27.11%

CONCLUSION

In conclusion, the test data supports the stated benefits that this unit will redirect power that is typically lost and recycle it back into the electric supply system. Our findings conclude that the Powerhouse Energy Conditioning System has proved to:

1. Improve the facilities supply voltages slightly.
2. Significantly reduce the electrical supply current.
3. Reduce the facility's peak kW (and kWh) billed by the utility resulting in lower energy costs for the owner.
4. Balance voltage across all phases (legs).
5. Significantly increase the Power Factor.
6. Reduce Reactive Power losses.
7. Reduce spikes in energy demand, resulting in lower peak demand charges.

CERTIFICATION

A handwritten signature in blue ink that reads "John J. Burdette III". The signature is stylized with a large, sweeping initial "J" and "B".

John J. Burdette III

Certified Energy Manager (CEM)

CEM Certification ID# 19189

Date of Expiration: 12/31/2018

Certified Demand Side Manager (CDSM)

CDSM Certification ID# 19189

Date of Expiration: 12/31/2018

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References

1.

GENERAL  ELECTRIC

General Electric Company
Corporate Research and Development
Schenectady, New York

**TECHNICAL INFORMATION
SERIES**

AUTHOR Harnden, J.D., Jr., Martzloff, F.D. Morris, W.G.†, Golden, F.B.‡		SUBJECT varistor	NO. 72CRD260
TITLE GE-MOV* Varistor -- The Super Alpha Varistor		DATE December 1972	GE CLASS 1
ORIGINATING COMPONENT Physics and Electrical Engineering Laboratory		CORPORATE RESEARCH AND DEVELOPMENT SCHENECTADY, N. Y.	
SUMMARY			
<p>Today there is considerable interest and development activity in a new class of metal oxide varistor which exhibits a high degree of non-linearity as compared with previous devices. Because of the metal oxide, the device has been named a metal oxide varistor and has been trademarked MOV.* This quest for "super" or higher performance is seemingly a continuous one -- which, for example, in the case of transistors has seen the emergence of the Darlington and super beta transistor.</p> <p>The voltage across a varistor and the current through it are related by a power law $I = k V^n$. The exponent n will typically have values 25 to 50 or more, leading to a characteristic very similar to that of a Zener diode. Over a wide current range, the voltage remains within a very narrow band for a specific device, and can be referred to as the "varistor voltage" for that device. The nonlinear electrical characteristic makes the device useful in voltage regulation applications, and in particular for limiting surges and transient voltages that may appear on power lines.</p> <p>Polycrystalline devices using zinc oxide have been the subject of much research over the past dozen or so years. Recent work on the zinc oxide-bismuth oxide system has shown many improvements in properties compared to other devices based on silicon carbide, selenium, etc.</p> <p>*Trademark of General Electric Company. †GE Semiconductor Products Dept., Schenectady, N. Y. ‡GE Semiconductor Products Dept., Auburn, N. Y.</p>			
KEY WORDS varistor, nonlinear varistor, metal oxide varistor, MOV, GE-MOV			

2.



DENT Instruments Launches the New ELITEpro XC Power Meter | July 2013

DENT Instruments is excited to announce the release of a new power meter, the ELITEpro XC. The ELITEpro XC, which succeeds the ELITEpro SP, is a portable power meter designed for measurement and verification projects or temporary load studies. New to the ELITEpro Xc are four analog input channels which can be configured for voltage (0-10V) or current (0 or 4-20mA) input used in any combination. Analog inputs are especially helpful when used in conjunction with power measurements to correlate the consumption of electricity with environmental conditions. Another key upgrade is the memory capacity of the ELITEpro XC, which has been increased to 16 MB internal non-volatile memory, twice the capacity of the previous-generation product.

Visit the [ELITEpro XC Product Page](#).

3.



The RoCoil mV Series of Flexible Current Transformers are Available Now | May 2009

DENT's RoCoil mV™ are a new line of flexible Rogowski Coil CTs. They complement DENT's existing CTs that are compatible with the ELITEpro/DATApro data loggers. These CTs offer significant advantages over conventional Split Core or Clamp-On CTs in certain installations. They offer installer-friendly™ features such as large window size, light weight, wide current range, and mechanical flexibility for mounting in tight quarters. RoCoils provide accurate, non-intrusive measurement of AC current combined with easy placement around cable bundles, large bus bars and irregular shaped conductors.