Statistical Path Analysis Performance Evaluation Of ElectroFlow™

For

Del Monte Kenya - TX2

.,Kenya

March-30-2006

PowerFul Corporation
"Legendary Performance"
Columbia - Missouri, U.S.A.

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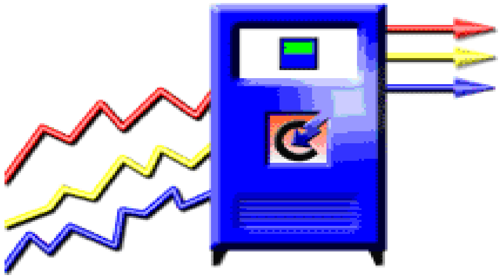
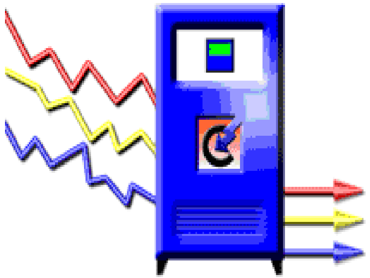
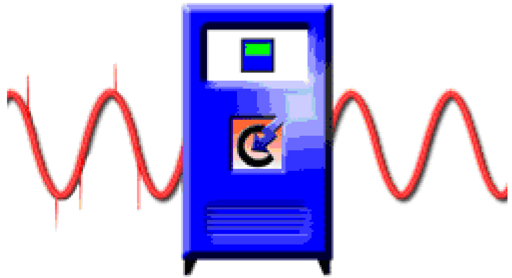
Executive Summary

We are delighted to report that, following the receipt of series of actual data for ElectroFlow™ "OFF", and ElectroFlow™ "ON" conditions. The subsequent comprehensive Statistical Path Analysis (SPA), for the purpose of ElectroFlow™ performance verification, revealed that the actual reduction greatly exceeded those initially projected!

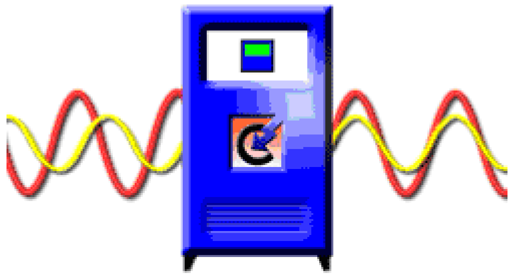
ElectroFlow™ Standard Features

		
1. Voltage Improvement and Stability Improves and stabilizes the voltage supplied to the load, thereby minimizing heat generation, resulting in energy savings, improved production, and increased equipment efficiency and longevity.	2. Three-Phase Balancing Real-time reduction of phase current, and balancing of load over the three phases, based on X/R and Z, thereby reducing negative voltage sequence and circulating currents; resulting in energy savings and reduced equipment maintenance and failure.	3. Surge and Transient Suppression Shields against an infinite number of surges, transients, and spikes, thereby protecting your investment in plant and equipment, while saving money.

ElectroFlow™ Standard Features

4. Broadband Harmonics Mitigation

Mitigation broadband harmonics, resulting in increased equipment longevity, while proportionally reducing the effects of harmonics on monthly electric bills. It is modular in structure and expandable.



5. Power Factor Improvement

Optimizes system power factor to a nominal .95 - unity, at a fraction of standard capacitor bank, but without any deleterious capacitor side effects

6. Releasing KVA capacity

It effectively reduces all three components of power, in a balanced form. It reduces Apparent Power (KVA), Real Power (KW), and Reactive Power (KVAR). Hence, allowing loads to be added without increasing the size of transformer(s), switchgear(s), or cabling.

Savings Projected For : XFMR MAINS

Transformer Size: 800 KVA

Measurement Location: TX2

Preliminary projected savings from the Baseline Energy Audit, as reflected in the proposal:

Estimated Reduction-Annual Consumption (KWH): 2,265

Estimated Reduction-Annual Demand (KWD): 813,545

Estimated,Annual,Demand Savings (USD): $ 5,807

Estimated Annual Consumption Savings (USD): $ 45,892

Estimated Annual Electric Bill Savings (USD): $ 51,699

Phase	Voltage		Current		Power Factor	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
A-Phase	428	432	376	496	0.85	0.91
B-Phase	427	430	337	457	0.81	0.89
C-Phase	425	430	345	463	0.85	0.91

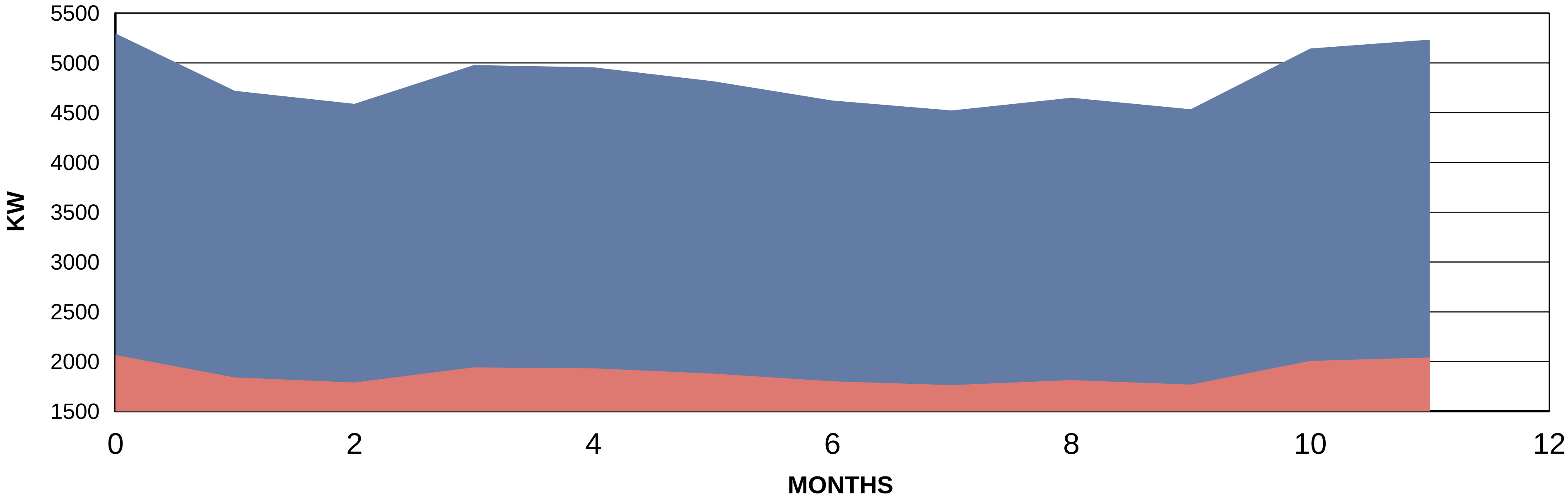
Highest Current THD of the Three phases(%):	3.28	For Phase C
Voltage THD of the phase with the highest Current THD (%):	1.10	For Phase C

Power Quality Issues:

- Voltage Improvement and Stability
- Three-Phase Current Balancing
- Power Factor Improvement
- Broadband Harmonics Mitigation
- Surge and Transient Suppression
- Releasing KVA Capacity

Load profile -Electric Bill 's Baseline
12-Month Demand Graphs

Demand Graphs

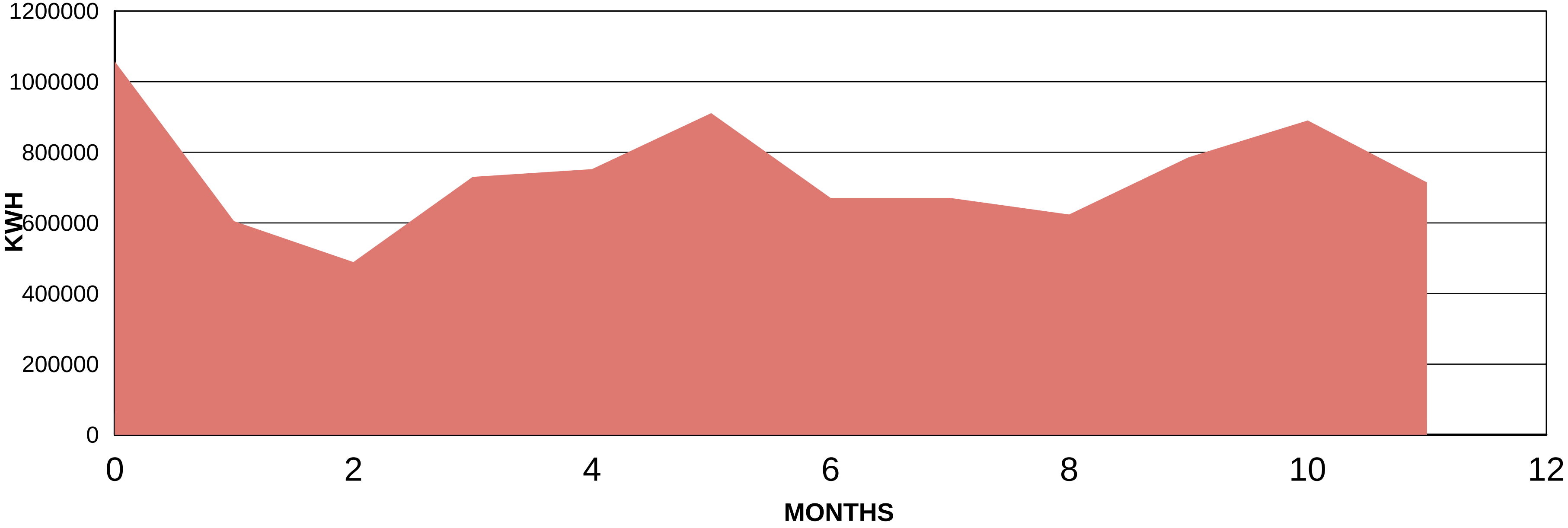


Average Monthly Demand : 1,887.50 KW

Average Monthly Demand Charge: $ 4,839.33

Load profile -Electric Bill 's Baseline
12-Month Usage Graphs

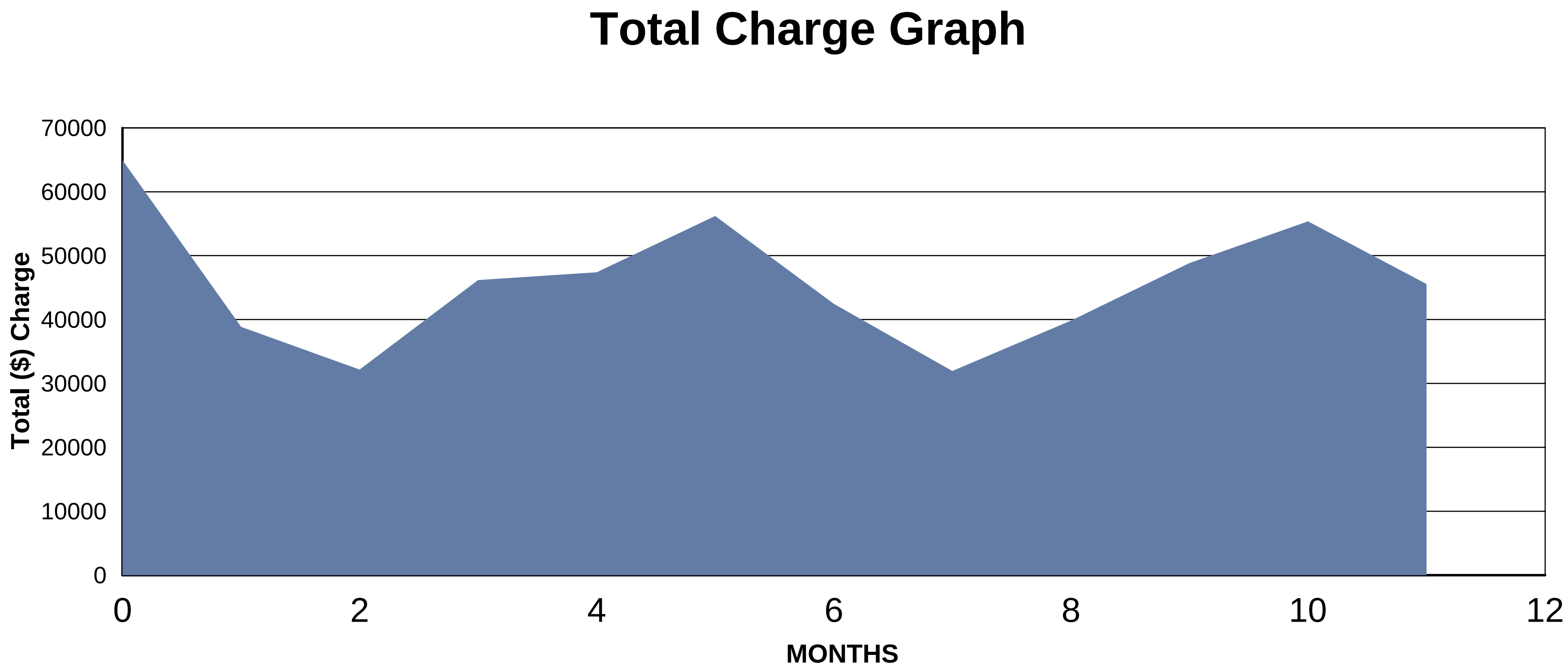
Usage Graphs



Average Monthly Consumption: 741,760.00 Units

Average Monthly Consumption Charge: $ 40,975.00

Load profile -Electric Bill 's Baseline
12-Month Total Charge Graph



Average Monthly Total Charge: $ 45,814.33

SPA Baseline Methodology

The purpose of the SPA analysis is to answer following two questions?

1. Does ElectroFlow™ address the power quality issue as expected?
2. Does ElectroFlow™ meet or exceed the energy savings projected?

It is very important to establish a baseline methodology for the purpose of answering these two questions.

Hence, the following facts should be used as guidelines for accurately verifying performance of any energy saving devices, including ElectroFlow™:

- ElectroFlow™ is a passive system, and does not consume measurable real power (KW). This can easily be verified by actual measurements taken at ElectroFlow™ main breaker/disconnect switch.

SPA Baseline Methodology

- ElectroFlow™ connects in parallel. As a result, if ElectroFlow™ system fails, it will not affect the facility load. Hence it is guaranteed that the system is fail-safe, in comparison to energy saving devices that connect in series. ElectroFlow™ can easily be turned "ON", or "OFF", to collect data for verification of the effects of ElectroFlow™ on the load.
- For both ElectroFlow™ "ON", and ElectroFlow™ "OFF" conditions, it is required to tabulate all of the pertinent Dependent Variables: Demand (KWD), and Consumption (KWH), as well as all the power quality variables: Voltage, Current, Power Factor, Total Harmonics Distortion for all of the three phases.
- The collected data such as Demand (KW), and/or Usage (KWH) should not be simply averaged, added, or subtracted; as means to analyze the variables. Because it does not take into account the load variation/load profile, and Load Factor. Such incorrect method completely ignores the "Apples-To-Apples" comparison of the data, as well as other pertinent variables.

SPA Data Collection Methodology

Data collection for performing accurate SPA analysis should be conducted based on the following conditions:

- Testing and measurements must be conducted using a three-phase power analyzer capable of data logging at a minimum rate of 128 samples per cycle, which equates to 7,680 times per second at 60 Hz, or 6,400 samples per second at 50 Hz. The three-phase variables to be measured, for the purpose of power quality, as well as energy savings, are: voltage, current, power factor, harmonics, Demand (KW), and Usage (KWH).
- All of the three-phase values must be displayed per-minute, for several consecutive periods of 15 minutes "ON", and 15 minutes "OFF". This is practically recommended, because most of utility companies' Demand Meters register Maximum monthly KW Demand, based on the highest sliding 15-minute interval in that month; which is subsequently billed to, and paid by the customer. In addition, such short-duration sampling and comparison, minimizes effects of other independent variables such as: load variation/load profile and change of weather, in such comparison testing.

SPA Data collection Methodology

- For the purpose of this study Harmonitor™ 3000 is used, with sampling rate of 256 samples per cycle, at 60/50 Hz frequency. It collects Voltage,Current, Power Factor, Harmonics, Demand, and Usage for all of the three-phases.

SPA Analysis Methodology

For performing scientific and accurate SPA analysis, following guidelines are set:

- In order to correctly analyze effects of the ElectroFlow™ "ON", and ElectroFlow™ " OFF", conditions of Demand (KW), and/or Usage (KWH), theoretically, the load should be kept constant. One can then proceed to analyze Demand reduction from the test data of both conditions, where Usage (KWH) reduction can be calculated from the cumulative values for both conditions.
- However, practically speaking, it is clear that the load is variable, even on the per-minute basis, which makes "Apples-To-Apples" comparison difficult.
- In such a case, the most accurate method is to use linear/non-linear regression method to predict Demand (KW), based on the measured conditions. Such an analysis allows to predict the accurate comparison of Demand (KW), and/or Usage (KWH) with respect to changes in the status of ElectroFlow™ based on the per-minute data collected, and accurately determine demand and/or energy savings; even when the load is fluctuating in a rapidly variable load profile.

SPA Analysis Methodology

$$P = P_{\alpha\beta} + P_0 \qquad (1)$$

$$P_{\alpha\beta} = \bar{P}_{\alpha\beta} + \tilde{P}_{\alpha\beta} \qquad (2)$$

$$\bar{P}_{\alpha\beta} = \sum_{n=1}^{\infty} 3V_{+n} I_{+n} Cos\,(\phi_{V_{+n}} - \phi_{I_{+n}}) + \sum_{n=1}^{\infty} 3V_{-n} I_{-n} Cos\,(\phi_{V_{-n}} - \phi_{I_{-n}})$$

$$\tilde{P}_{\alpha\beta} = \sum_{n=1}^{\infty} -3V_{+n} I_{-n} Cos\,(2\omega_n t + \phi_{V_{+n}} + \phi_{I_{-n}}) + \sum_{n=1}^{\infty} -3V_{-n} I_{+n} Cos\,(2\omega_n t + \phi_{V_{-n}} + \phi_{I_{+n}}) +$$
$$\sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} 3V_{+m} I_{+n} Cos\left((\omega_m - \omega_n)t + \phi_{V_{+m}} - \phi_{I_{+n}}\right)\right] + \sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} 3V_{-m} I_{-n} Cos\left((\omega_m - \omega_n)t + \phi_{V_{-m}} - \phi_{I_{-n}}\right)\right] +$$
$$\sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} -3V_{+m} I_{-n} Cos\left((\omega_m + \omega_n)t + \phi_{V_{+m}} + \phi_{I_{-n}}\right)\right] + \sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} -3V_{-m} I_{+n} Cos\left((\omega_m + \omega_n)t + \phi_{V_{-m}} + \phi_{I_{+n}}\right)\right]$$

$$P_0 = \bar{P}_0 + \tilde{P}_0 \qquad (3)$$

$$\bar{P}_0 = \sum_{n=1}^{\infty} 3V_{0n} I_{0n} Cos\,(\phi_{V_{0n}} - \phi_{I_{0n}})$$

$$\tilde{P}_0 = \sum_{n=1}^{\infty} -3V_{0n} I_{0n} Cos\,(2\omega_n t + \phi_{V_{0n}} + \phi_{I_{0n}}) + \sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} 3V_{0m} I_{0n} Cos\left((\omega_m - \omega_n)t + \phi_{V_{0m}} - \phi_{I_{0n}}\right)\right] +$$
$$\sum_{\substack{m=1 \\ m\neq n}}^{\infty} \left[\sum_{n=1}^{\infty} -3V_{0m} I_{0n} Cos\left((\omega_m + \omega_n)t + \phi_{V_{0m}} + \phi_{I_{0n}}\right)\right]$$

SPA Analysis Methodology

Formula **(1):** This represents the Real Power components, including the balanced/symmetrical Real Power, and the imbalanced/Asymmetrical Real Power, as well as the zero sequence.

Formula **(2):** The non-zero sequence components of Real Power are accurately considered. The balanced three-phase Real Power, and imbalanced components of Real Power, as well as Positive, and Negative sequence harmonics can be integrated in the same formula, and may be accurately calculated and accounted for, based on the direction of harmonics; in the formula. Furthermore, the negative voltage sequence, as well as the positive voltage sequence can be calculated and accounted for using the same methodology.

SPA Analysis Methodology

Formula **(3):** The zero-sequence components of Real Power are accurately considered. The balanced three-phase zero-sequence Real Power, as well as imbalanced components of zero-sequence Real Power are accounted for.

The regression analysis is performed on the Statistical Path Analysis (SPA) data collected at the facility with ElectroFlow™ "ON", and "OFF", as compared against the load data previously collected at the Audit stage, and the pertinent information supplied about the electrical distribution layout.

MATLAB software, which is the standard software used by the scientific community and professionals for this purpose, is used to perform the mathematical analysis.

Data collected For ElectroFlow™ 'ON' Period

KW	V(A)	V(B)	V(C)	I(A)	I(B)	I(C)	I_{THD} (A)	I_{THD} (B)	I_{THD} (C)
277.43	425.45	425.47	424.15	384.05	396.15	396.09	3.80	3.27	3.53
293.37	419.86	420.11	419.15	409.78	419.57	417.32	3.05	2.75	2.95
284.11	425.06	424.25	423.62	390.42	400.90	398.75	3.66	2.70	2.84
281.64	424.18	425.12	423.60	386.60	399.95	397.27	3.72	2.75	2.69
258.98	423.51	424.10	422.55	376.37	390.64	387.44	2.95	2.56	2.56
311.04	424.39	424.82	423.46	428.65	442.01	441.41	3.24	2.85	3.23
274.00	425.39	426.19	424.86	377.61	382.39	384.57	3.77	2.87	2.82
275.33	426.04	426.00	425.67	380.93	392.63	391.40	3.67	3.16	3.51
255.39	425.18	426.05	424.74	358.84	362.09	364.93	3.75	3.65	3.58
265.36	426.20	425.98	424.91	365.52	376.43	377.46	4.13	3.49	3.65
291.04	423.80	424.54	423.20	405.78	413.26	414.07	3.44	2.82	3.19
272.29	425.72	425.63	424.91	379.62	387.07	386.74	3.68	3.11	3.35
264.73	425.90	425.10	424.52	367.01	371.22	372.24	4.05	3.35	3.66
293.66	424.90	425.30	424.55	405.50	413.74	413.34	3.48	2.86	3.21
293.32	424.36	425.06	424.24	405.32	413.89	413.00	3.31	2.53	2.87
318.62	424.97	424.62	424.40	440.91	456.46	454.72	3.68	2.94	3.50

Data collected For ElectroFlow™ 'OFF' Period

KW	V(A)	V(B)	V(C)	I(A)	I(B)	I(C)	I_{THD} (A)	I_{THD} (B)	I_{THD} (C)
311.47	414.28	415.10	413.99	626.46	648.84	641.46	0.93	1.02	1.15
326.28	414.23	414.20	413.02	641.82	669.85	657.93	0.96	1.09	0.85
327.92	413.95	413.76	412.82	640.48	666.95	657.30	0.88	1.14	0.96
321.60	415.34	415.06	414.82	640.37	661.24	653.25	0.99	1.06	1.03
331.39	414.86	414.65	414.05	654.88	677.75	670.00	0.97	1.16	0.98
329.36	414.23	413.94	413.12	650.68	674.44	666.91	1.00	1.16	1.08
309.47	415.46	415.18	414.46	621.12	641.82	633.51	0.94	1.19	1.13
313.65	415.30	414.96	414.57	623.50	646.11	636.86	0.96	1.18	0.94
333.00	413.31	413.50	412.15	653.61	680.00	669.04	0.87	1.16	0.95
314.41	414.08	414.47	413.11	626.74	645.65	639.97	0.95	1.17	1.03
313.53	415.81	415.17	414.92	619.91	641.05	631.89	1.10	1.28	1.13
299.01	415.25	415.07	414.53	599.92	619.39	610.56	0.84	1.04	0.90
307.79	416.38	416.22	415.36	613.42	635.35	626.14	0.90	0.91	0.80
317.87	416.30	416.12	415.34	619.52	641.87	631.93	0.79	0.90	0.87
309.93	415.55	415.28	414.49	622.71	644.63	635.72	0.92	1.02	0.93
328.73	414.36	414.48	413.49	646.02	670.61	661.82	1.04	1.17	1.19

Regression Model

The regression model to be used for accurately predicting Demand is as described below:

$$KWD = \beta_1 P_a(t) + \beta_2 P_b(t) + \beta_3 P_c(t) + \beta_4 P_{asymmetric}(t) + \beta_5 P_{Harmonic}(t) + \beta_6 P_n(t) + \alpha$$

Where

$P_{a,b,c}$ is computed for each phase using V, I, PF for the respective phase, per Sample data collected of Voltage, Current, and Power Factor .

$P_{Harmonic}$ is computed using V_{THD}, and I_{THD} for each phase, per sample data collected .

$P_{Asymmetrical}$ is computed using V, I, PF for each phase, per sample data collected, of Voltage, Current, Power Factor; respectively.

Regression Model

P_n is computed using V, I_n for the three phase imbalance, per sample data collected .

Coefficient β_1 , β_2 , β_3 , β_4 , β_5 , β_6 and α are estimated by the regression analysis.

Based on the regression analysis performed on the data, the model is as shown below:

β_1	1.00
β_2	1.00
β_3	1.00
β_4	1.75
β_5	1.27
β_6	1.84
α	62.43

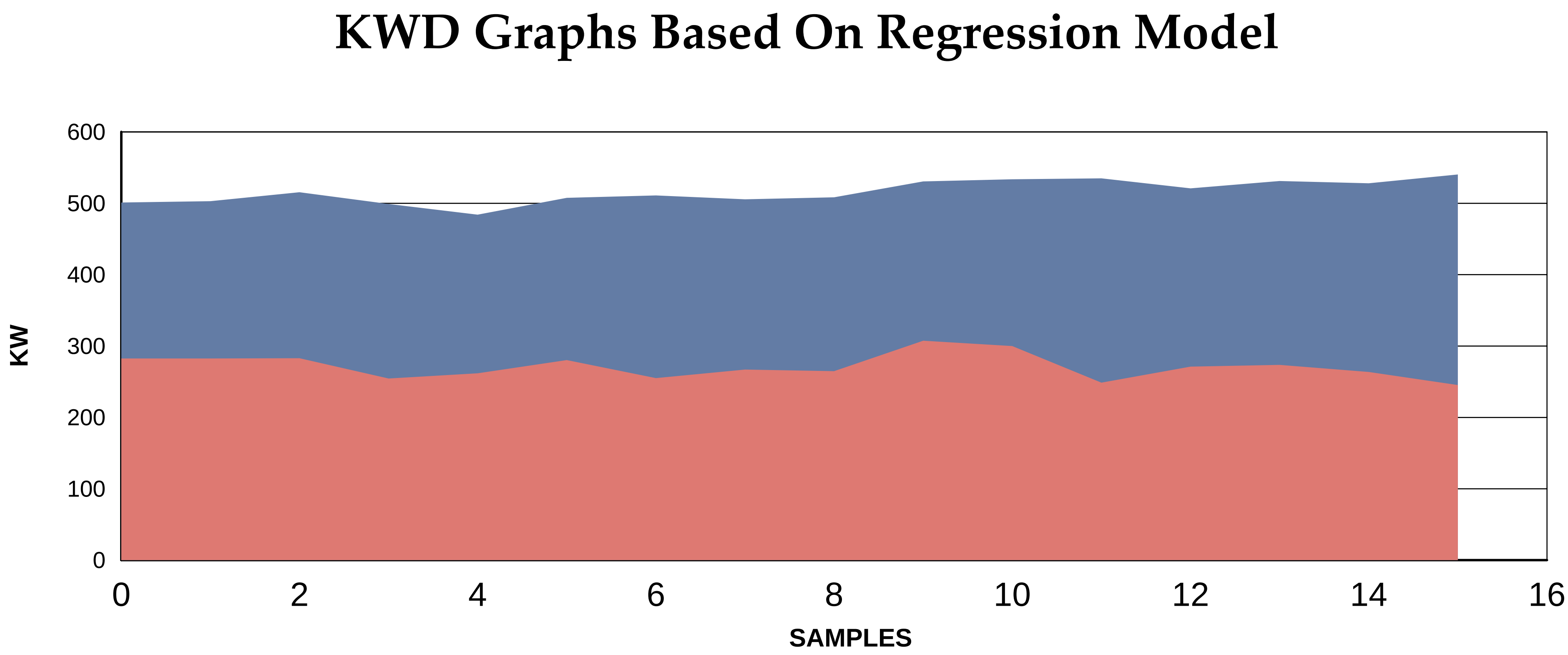
Regression Model

The Statistical indices used to evaluate regression models in accordance to the following:

Coefficient of Determination R2 (%) = 1.00
Mean Bias Error, MBE (%) = 0.00

- As can be seen, the model is therefore a very close representation of the facility's real conditions, and subsequent power quality effects on the load is clearly identified.
- The regression model is then applied based on the data collected for ElectroFlow™ "ON", and ElectroFlow™ "OFF" conditions, in order to verify the exact magnitude of savings.

KWD Graphs Based On Regression Model

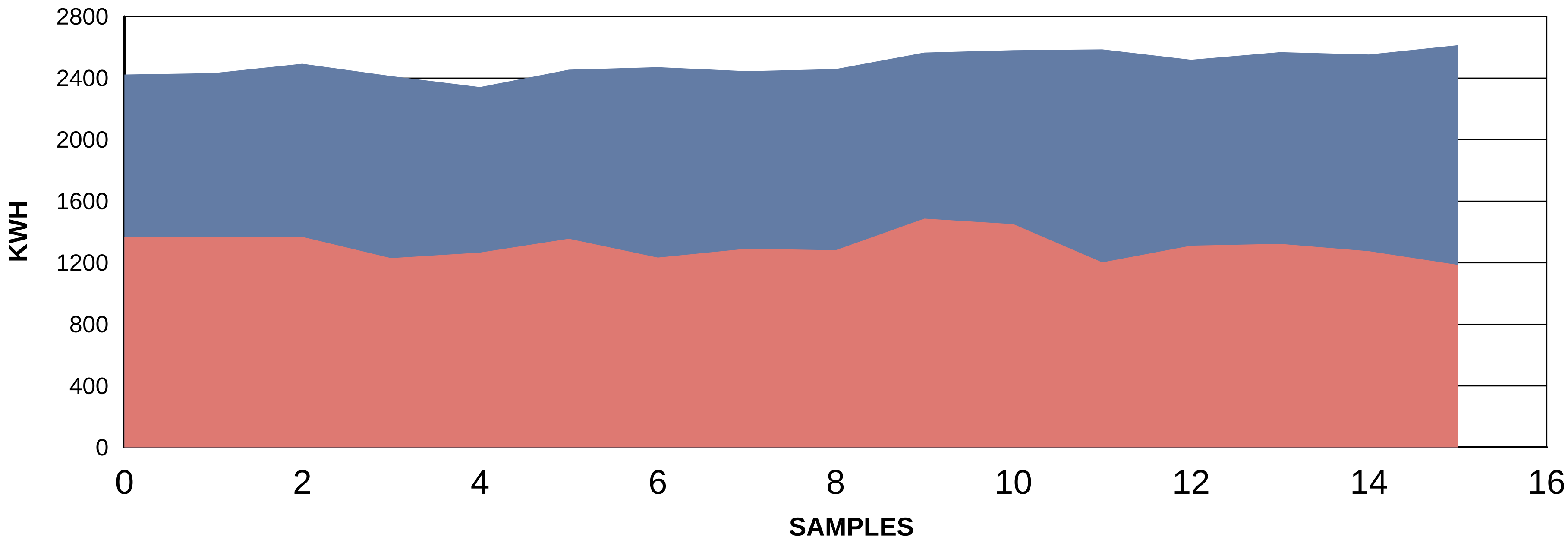


Average KWD ElectroFlow "ON" : 271.36 KW

Average KWD ElectroFlow "OFF" : 515.96 KW

KWH Graphs Based On Regression Model

KWH Graphs Based On Regression Model

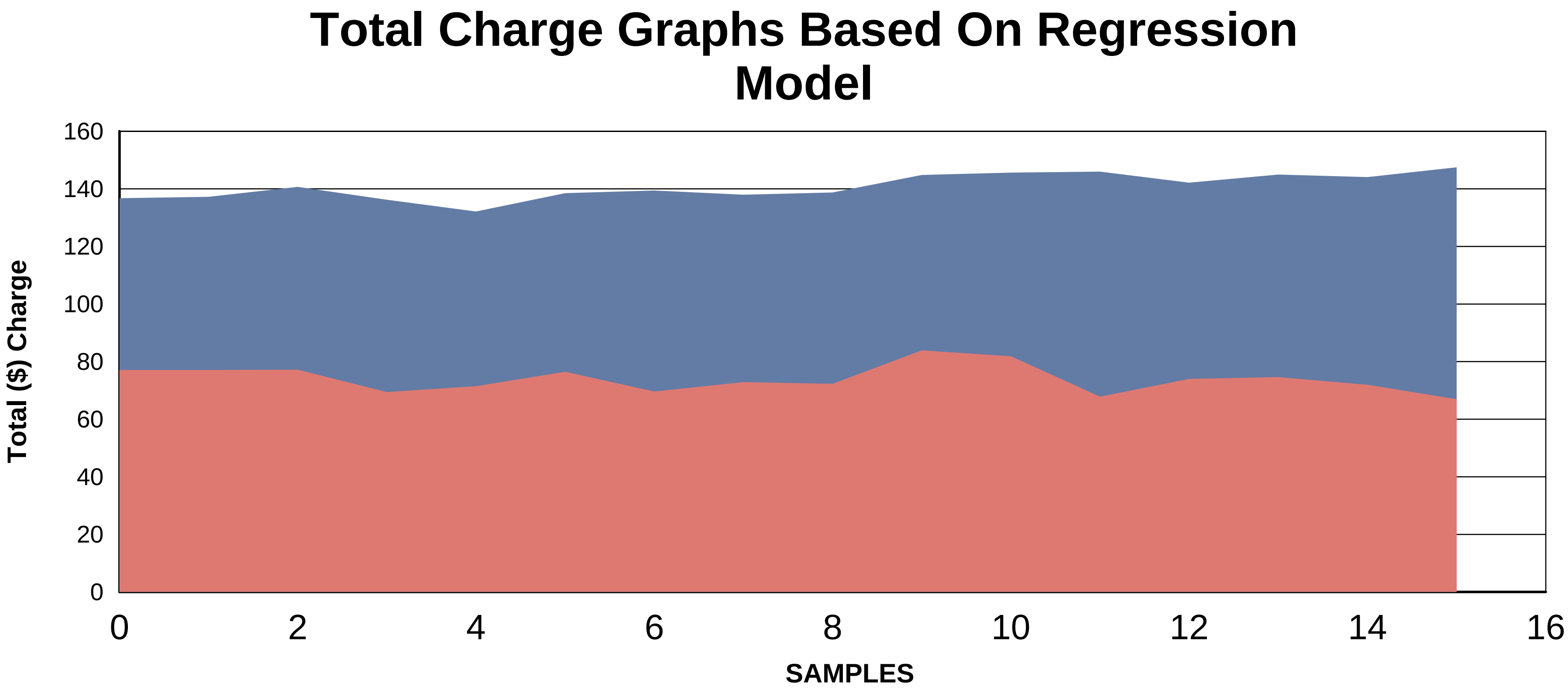


Average KWH ElectroFlow "ON" :	1,312.29	Units
Average KWH ElectroFlow "OFF" :	2,495.20	Units

Del Monte Kenya -

Performance Evaluation of:
ElectroFlow™

Total Charge Graphs Based On Regression Model



Average Total Charge ElectroFlow "ON" : $ 74.04

Average Total Charge ElectroFlow "OFF" : $ 140.78

Resultants Of Regression Analyses

Based on the regression model, it is concluded that:

Demand (KWD) with ElectroFlow™ "OFF" 515.96

Demand (KWD) with ElectroFlow™ "ON" = 271.36

- Hourly Demand (KWD) Savings =

(Demand (KWD) with ElectroFlow™ "OFF" - Demand (KWD) with ElectroFlow™ "ON") x Adjustment based on Baseline Energy Audit

Hourly Demand (KWD) Savings =

(515.96 - 271.36)X(266.03 KW/ 515.96)= 244.6

- Annual Demand (KWD) Savings = Hourly Demand (KWD) Savings x 12

Annual Demand (KWD) Savings = 244.6 KW x12= 2935.2

Adjustment based on Baseline Energy Audit = Demand (KWD) based on Baseline Energy Audit / Demand (KWD) with ElectroFlow "OFF"

Resultants Of Regression Analyses

Based on the regression model it is concluded that:

- Annual Usage (KWH) savings = Hourly Demand (KWD) Savings x Hours of Operation of Facility per week x 52 weeks

Hours of Operation of Facility per week = 93 hours/week (Based on Baseline Energy Audit)

Annual Usage (KWH) savings = 244.6 x 93 x52 = 1182885.6 Kwh

Resultants Of The SPA Study

	Projected		Actual	
	Value	%	Value	%
Annual KWD	2265	10	2935	12.96
Annual KWD ($)	5807	10	7525	12.96
Annual KWH	813545	9.33	1182886	13.57
Annual KWH ($)	45892	9.33	66726	13.57
Total ($)	51699	9.4	74251	13.51

Project Realization Rate

Realization Rate (%) = (Verified Savings/Expected Savings) x 100

KWD Savings Realization Rate(%) = 2935 / 2265)x 100= 130

KWH Savings Realization Rate(%) = (1182886 / 813545)x 100= 145

Total Charge Savings Realization Rate(%) = (74251 / 51699)x 100= 144.00