BASICPOWER

TRU·WATTS

PQ & ENERGY SUMMARY FOR [redacted]

2/21/22

Contents

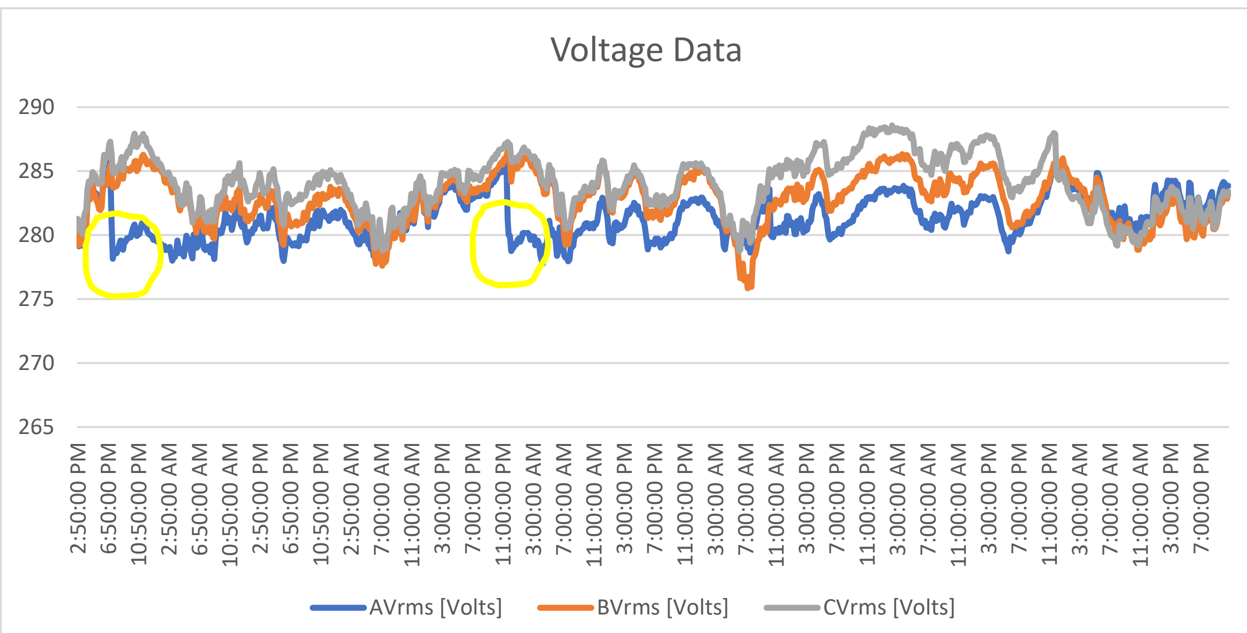
Notes

Power Quality analysis

Voltage

According to the Regulations for Power distribution of Electric Equipment (Electricity Business Act Article 18 Maintenance of Electricity Quality) voltage levels should remain within a boundary of 280 (±38V). Although variations in the values were recorded these are within standard limits. Voltage drops observed on Phase A at 8.20pm & 11.40 pm, may be due to a mono-linear load on this phase outside of the facility as it does not appear to be triggered by any additional amperage draw on the phase data collected by the Dranetz meter at [redacted]'s Main Distribution Panel, and because the building is empty with NO production equipment running.

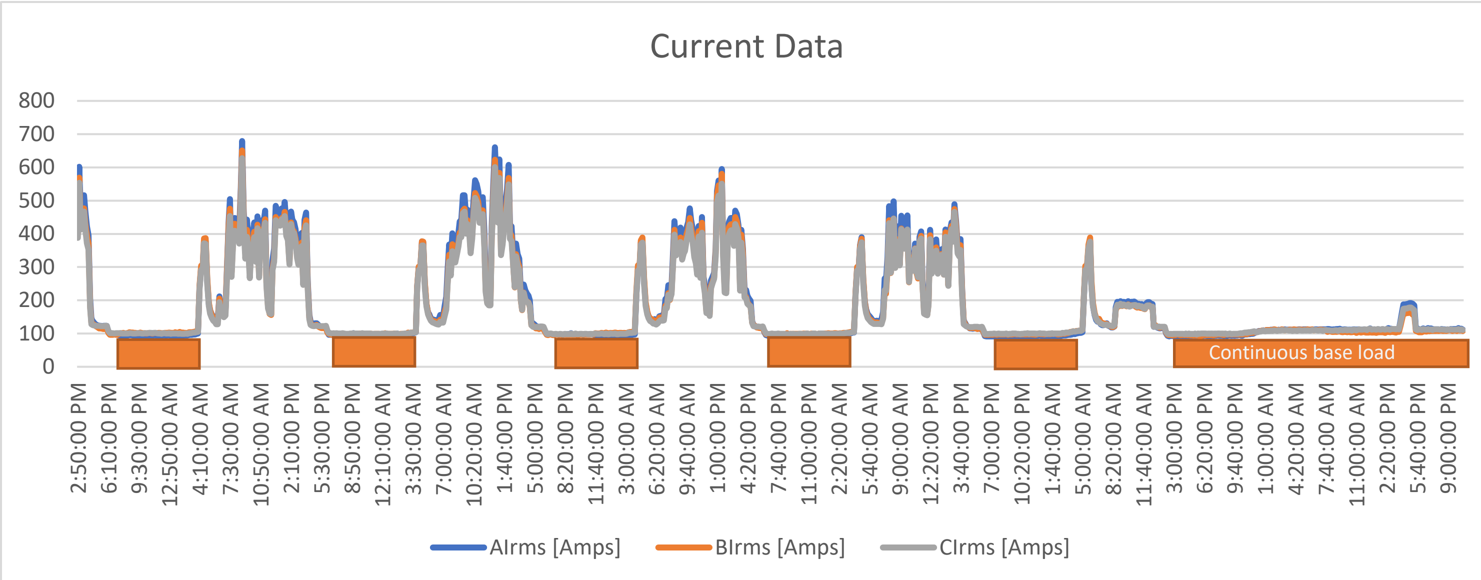
Category	A		B		C		N	
Voltage [V]	Max	Min	Max	Min	Max	Min	Max	Min
	286.33	275.30	286.9	273.54	288.91	276.77	0.32	0.07
Voltage (Avg)	281.42		282.72		283.94		0.10	



Current

It was observed in the data that there are current peak values of 1302 Amps during production shifts. This peak load is due to the simultaneous operation of the two major loads the Tempering Machine and Fan. There is a fixed current consumption in hours where the manufacturing plant is not in operation of 100 Amp rms per phase. This represents the power consumption of lights, electronic equipment, computers and HVAC and any idling loads that still draw power. It is recommended that [redacted] seek to reduce this total 300 amp load during weekends and evenings that is not directly related to production.

The values presented in the following graph will be the average RMS values.



Voltage Variations

Multi-cycle voltage variations, especially voltage sags, are responsible for a significant number of upsets and nuisance trips of sensitive electrical equipment.

- **Interruption** (The complete loss of voltage for a period of time.)

No events were found in this category

- **Overvoltage** (A rms increase in the AC voltage, at the power frequency, for duration greater than a few seconds)

No events were found in this category

- **Undervoltage** (A rms decrease in the AC voltage, at the power frequency, for duration greater than a few seconds)

No events were found in this category

- **Swell** ((A rms increase in the AC voltage, at the power frequency, for duration from a half- cycle to a few seconds)

No events were found in this category

- **Sag** (A rms reduction in the AC voltage, at the power frequency, for duration from a half-cycle to a few seconds)

A Voltage Sag was detected around 9:00 a.m. probably caused by a load external to the [redacted] facility.

Symptoms Sags: Computer rebooting or locking-up, contactors chatter or open, PLCs Locking-up and process stoppage, corrupted data, HID lamps shutting off, incandescent lamps flickering.

- **Flicker** A repetitive variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity

The maximum Flicker values of 0.225 occurred during hours of machine operation, the values are within the range of tolerable values.

- **Brownout** A reduction of voltage by utility for long duration (Hour)

No events were found in this category

- **Voltage Notching** is the voltage interruption in the opposite position to the voltage waveform.

No events were found in this category

Surges/Transients

The two sources of surges and transient overvoltage that account for the majority of all events are switching and lightning.

Seven transients were detected that could be due to external capacitor switching behavior or large load switching.

Common External Sources: Lightning, Capacitor Switching, Short circuits

Common internal sources: Load switching, short circuits, Capacitor switching, Imaging equipment operation, Variable Speed driver operation. Arc welders, light dimmers

- Impulse Transient (A sudden, non-power frequency change in the steady state voltage or current, which has a unidirectional polarity)

Harmonic Distortion

Harmonic are produced by the operation of nonlinear loads. A load is nonlinear if the voltage and current do not have a direct or continuous relationship.

Harmonic Symptoms

- Transforms heating
- Motor and generator heating and vibrations
- Neutral heating
- Nuisance fuse operations
- Insulation deterioration
- Electronic control malfunctioning
- Inconsistent meter readings
- Voltage regulations mis operations

General categories of nonlinear loads are:

- Power electronic equipment
- Arcing devices
- Iron saturating devices
- Rotating machines

IEEE 519 Harmonic Statistic report – Summary

From 02/07/2022 to 02/14/2022 the harmonics currents exceeded IEEE 519 limits.

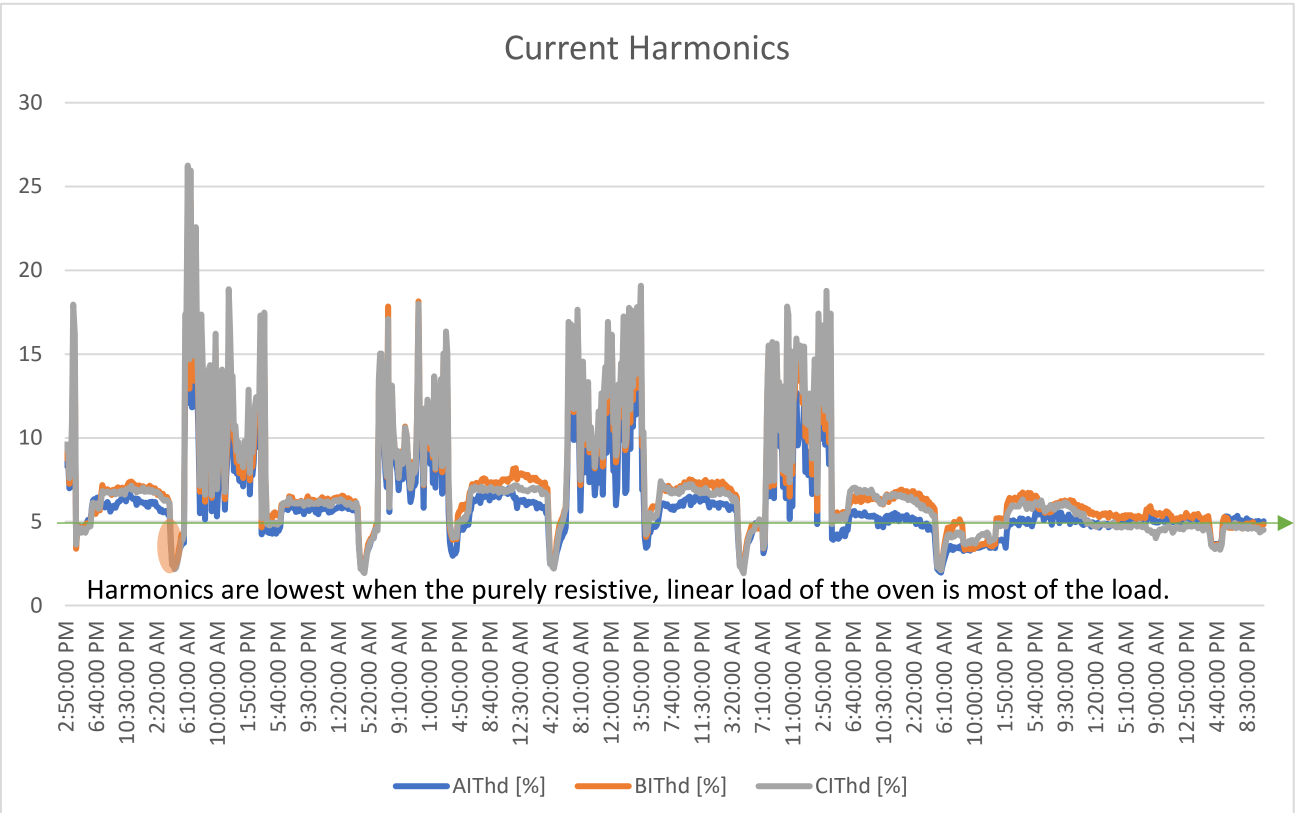
The Tempering Machine Oven is a resistive load and therefore, linear, and does not create harmonic currents when it is switched on in the early morning. Once the day's production starts, harmonics are observed in the waveforms of the current probably originating in variable speed drives (VFD). This may be due to the motor that is connected to the fan, which represents one of the largest loads. The maximum value of harmonic distortion in the current was found on Tuesday at 6:40 in the morning with a value of 25.9%, this was due to the operation of some equipment with VFD, since the waveform of the instantaneous current shows it clearly. It is observed that the dominant harmonics are the 3rd, 5th, and 7th harmonics representing approximately 100 A per phase of the instantaneous electrical load.

Data also indicates a DC current component of 30 A Avg per phase, continuously during all 7 days of the test. These currents are due to LED lighting and electronic equipment in an "always on" state.

There is an opportunity to reduce the electrical load of up to 130 A by mitigating the harmonics. This will help to decongest the electrical network of the production plant and reduce the IR losses and inefficiencies caused by harmonics.

CURRENT HARMONICS

Category	Current Harmonic (%) at Maximum THD							THD(%) Total THD	TDD (Avg)
	DC	1st 60Hz)	3rd (180Hz)	5th (300Hz)	7th (420Hz)	9th (540Hz)	11th (660Hz)		
A	29.1	100	1.4	16.4	13.5	0.5	3.7	**6.3**	57.13
B	30.7	100	1.6	18.1	13.2	0.4	4.0	**7.1**	60.53
C	35.7	100	1.7	19.1	14.6	0.4	4.3	**7.1**	59.58



Grounding Systems – Identifying Problems
Grounding Systems include:

- Standard Grounding
- Enhanced grounding
- Lightning protection
- High Resistance
- Low Resistance
- Single reference Grid

A thorough inspection of the grounding systems was not performed.

The ground value of the grounding conductor was measured, and the following was observed:

Ground ohm values 0.19 ohms with current values 1.95 A *and loop ground*

"Ideally a ground should be of zero ohms resistance. However, the NFPA and IEEE have recommended a ground resistance value of 5.0 ohms or less. The NEC has stated to "Make sure that system impedance to ground is less than 25 ohms specified in NEC 250.56."

"Ground loops are a potential cause of noise interference on the PCB. If one component on the loop is noisy and the return current flows through shared ground connectors, this noisy component is then the source for an introduction of noise to other components on the loop."

Ground loops, where there are two or more earth grounds of different potentials, are of particular concern because voltage and current will flow between the highest and the lowest potential and any surges, including transient surges caused by nearby lightning strikes, will not be diverted directly to the earth but will remain longer in the electrical system and travel through it to the lowest resistive ground point.

It is recommended that the source of the ground loop be identified and that all grounds be tied together to provide a single reference point.

Power Report

ACTIVE POWER (KW)

Category	A		B		C		Transformer Utilization ratio
Active Power [kW]	Max	Min	Max	Min	Max	Min	5.45
	318.15	9.17	318.05	9.67	306.74	10.75	
Average	41.14		39.41		38.59		
Apparent Power [S-kVA]	Max	Min	Max	Min	Max	Min	
	321.92	23.30	324.02	23.88	310.74	25.10	
Average	51.81		50.29		49.91		
Reactive Power [Q-kVAR]	Max	Min	Max	Min	Max	Min	
	97.67	11.30	90.03	11.50	91.55	8.94	
Average	18.93		19.77		18.81		Light load

Total Max Active Power (W)

The total max active power was 937.6 and occurred at 13:30:00. This load increase is associated with the operation of different machines at the same time, especially the electric furnace, the fan, and others.

Total Max Apparent Power (VA)

The total active max power was 949.2 on 02/10/2022 at 13:30:00 this load increase is associated with the operation of different machines at the same time, especially the electric furnace, the fan, and others.

Total Max Reactive Power (VAR)

The total max reactive power was 216.92 on 02/14/2022 at 08:50:00 this load increase is associated with the operation of inductive motors, it is associated with the biggest load which is the motor that has the fan to remove the heat from the glass after it comes out of the furnace.

Power Factor, PF (PU)

It is observed that the minimum power factor values are 0.413 and are found at night and on weekends, where there is no production and there is a constant load of reactive power of 45.71 KVAR that affects the power factor values. The maximum power factor values are 0.994 (PU) and are found in hours where the electric furnace is on since the furnace is a purely resistive load and increases the total load but without increasing the reactive load, the opposite happens when the electric motors are turned on, they produce an inductive load that affects the power factor negatively.

DEMAND -REAL POWER DEMAND

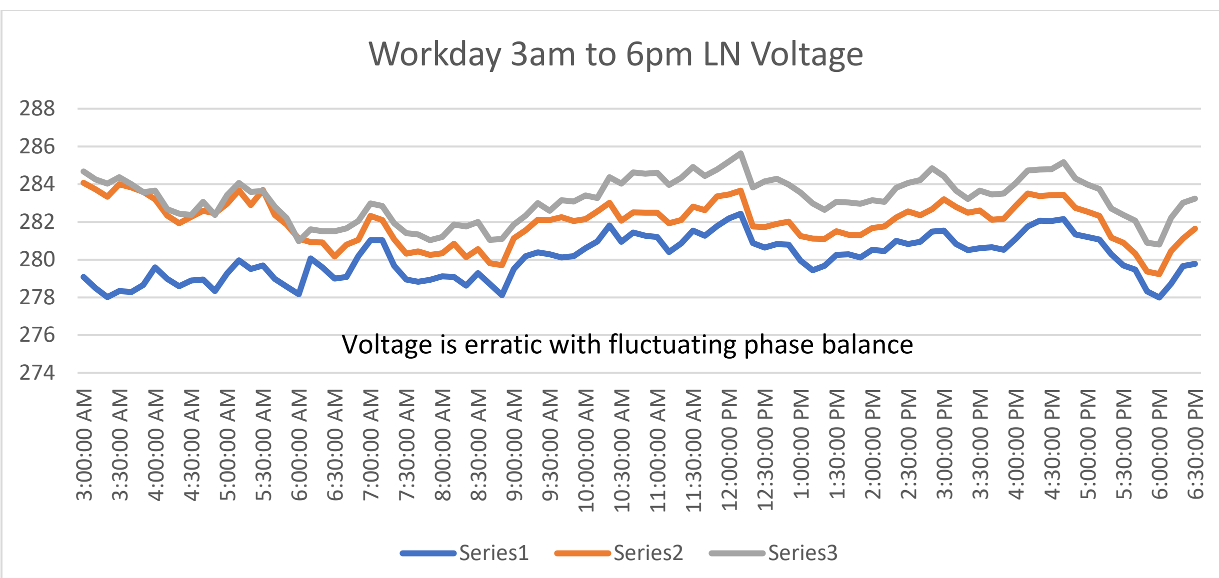
Min kWh/h	38.1 on 02/12/2022 17:30:00
Max kWh/h	493.4 on 02/09/2022 17:30:00
Media kWh/h	61.0
Average kWh/h	118.9

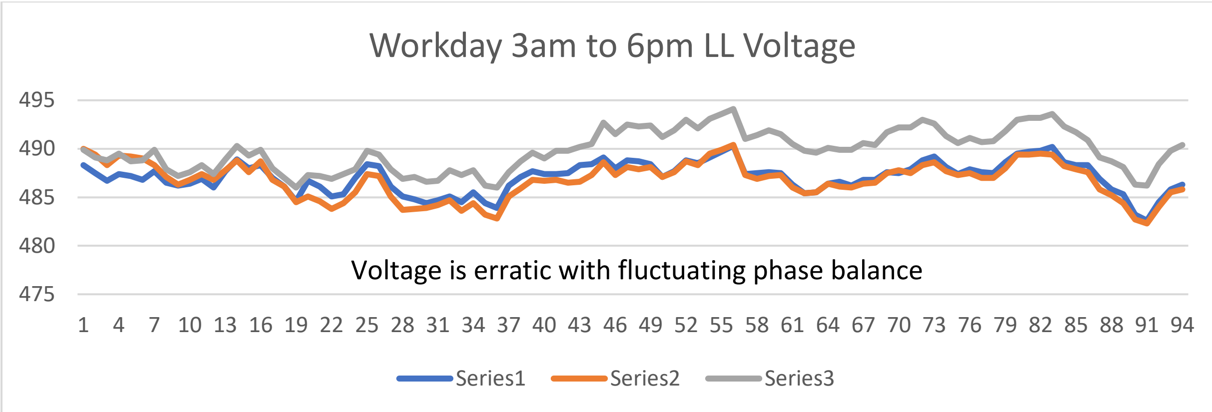
Minimum demand is observed at night and on weekends of around 40 kWh. The hours when the plant is out of operation are from 6:00 PM to 4:00 AM, which represents 40 hours per week and 58 hours on weekends. Hours per week and weekends with no plant operation: 98 hours

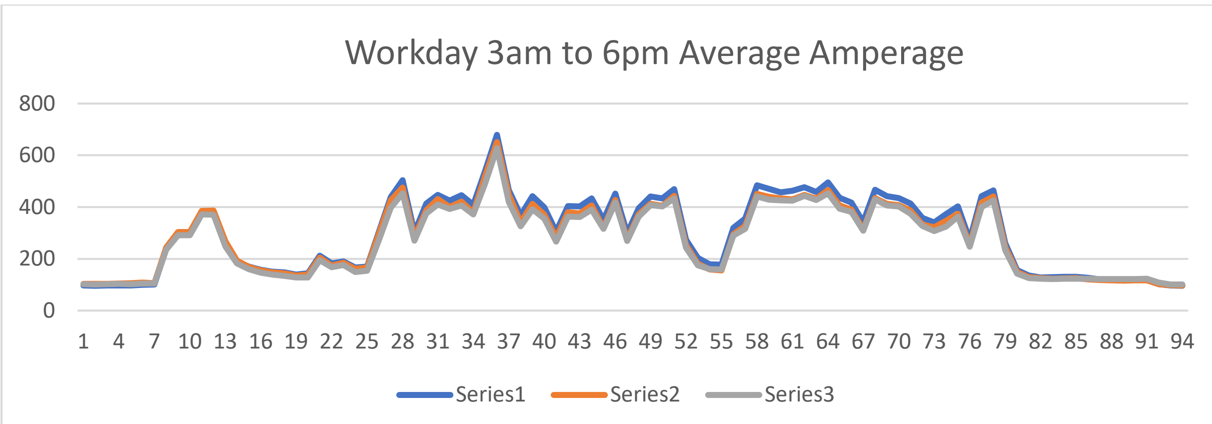
- Weeks per month: 4
- Number of months per year: 12
- Actual power demand during hours of plant non-operation: 40 kWh
- Average payment price per kWh 0.10 $/kWh

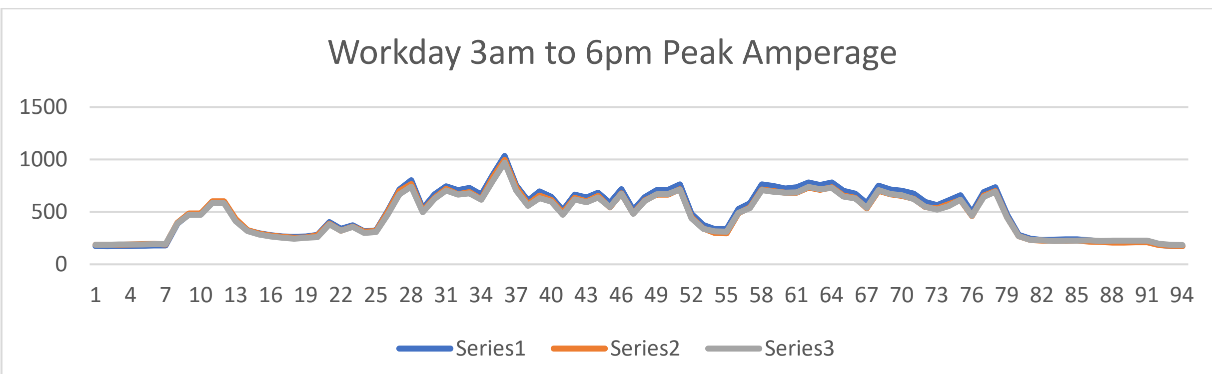
It is estimated that the consumption of electricity demand during non-operating hours of the plant is 188,160.00 kWh per year, and it is estimated that this is costing [redacted] about $18,800 per year for this consumption based upon an approximate cost of $0.10 per kWh when all delivery and demand costs, fees and taxes are combined.

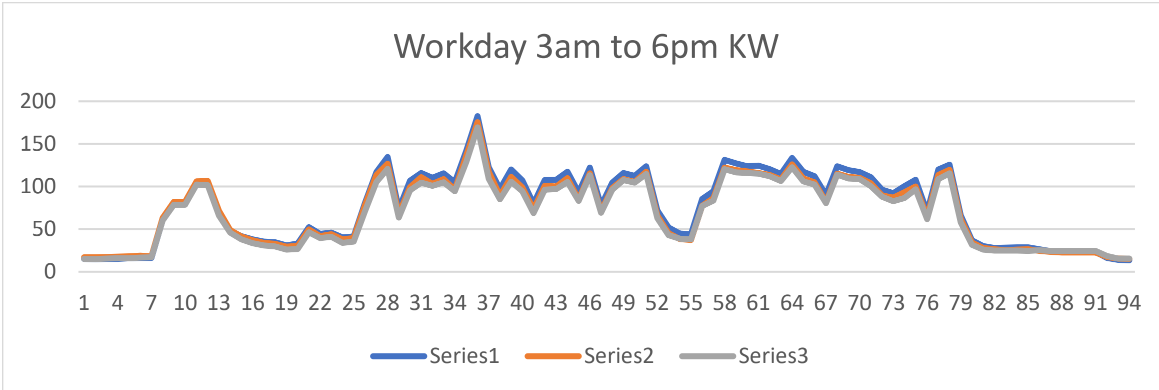
WORKDAY HOURS

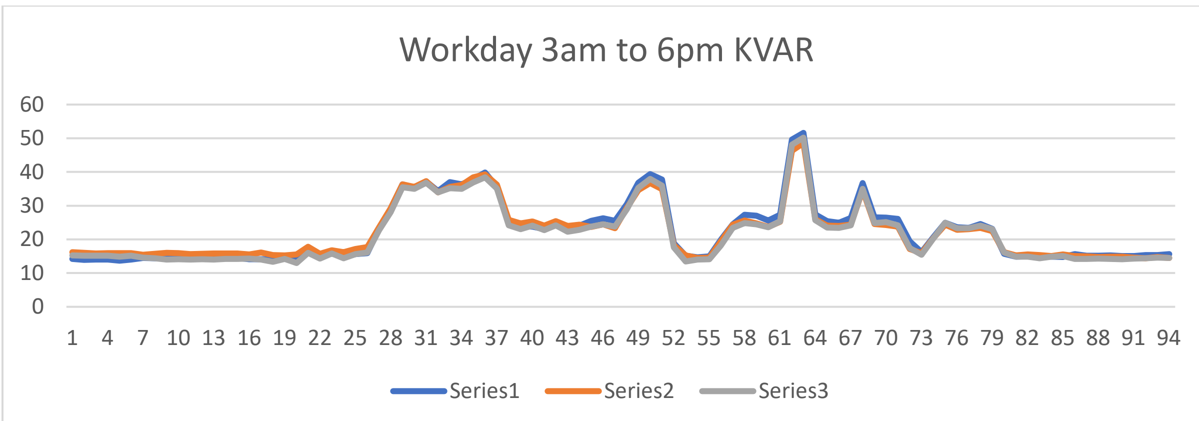


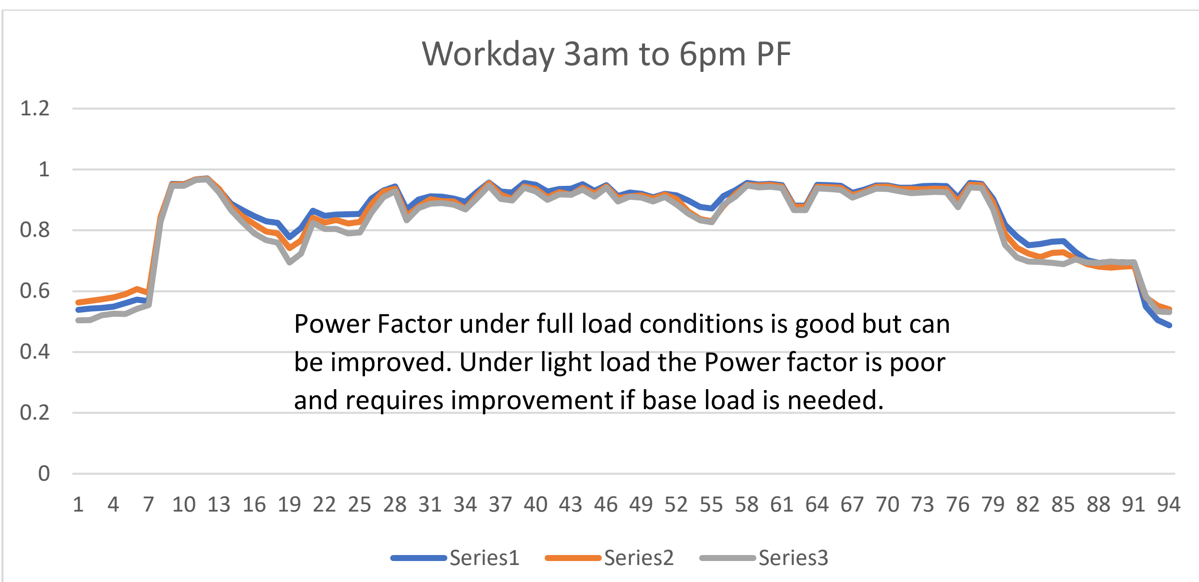

Workday 3am to 6pm LL Voltage
495
490
485
480
475
Voltage is erratic with fluctuating phase balance
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

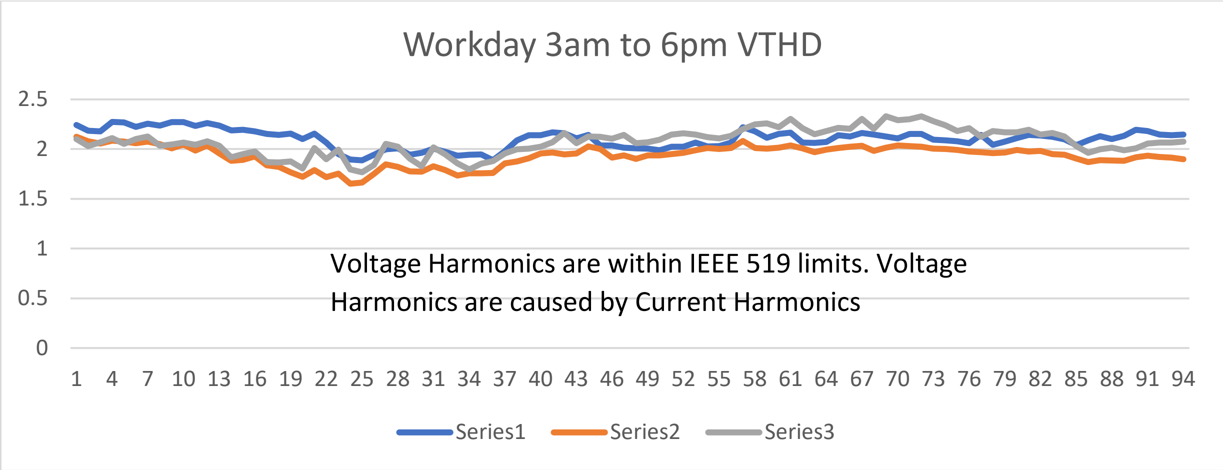

Workday 3am to 6pm Average Amperage
800
600
400
200
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

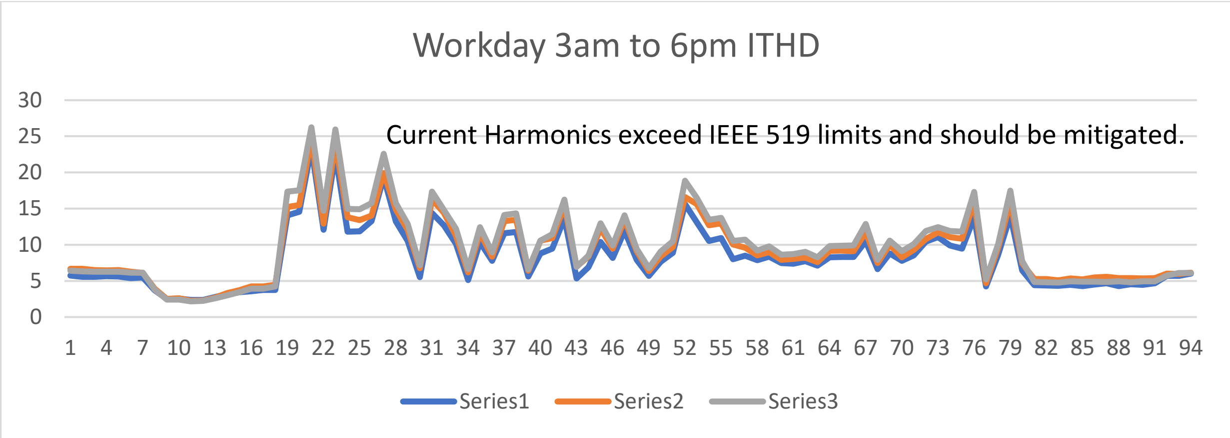

Workday 3am to 6pm Peak Amperage
1500
1000
500
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

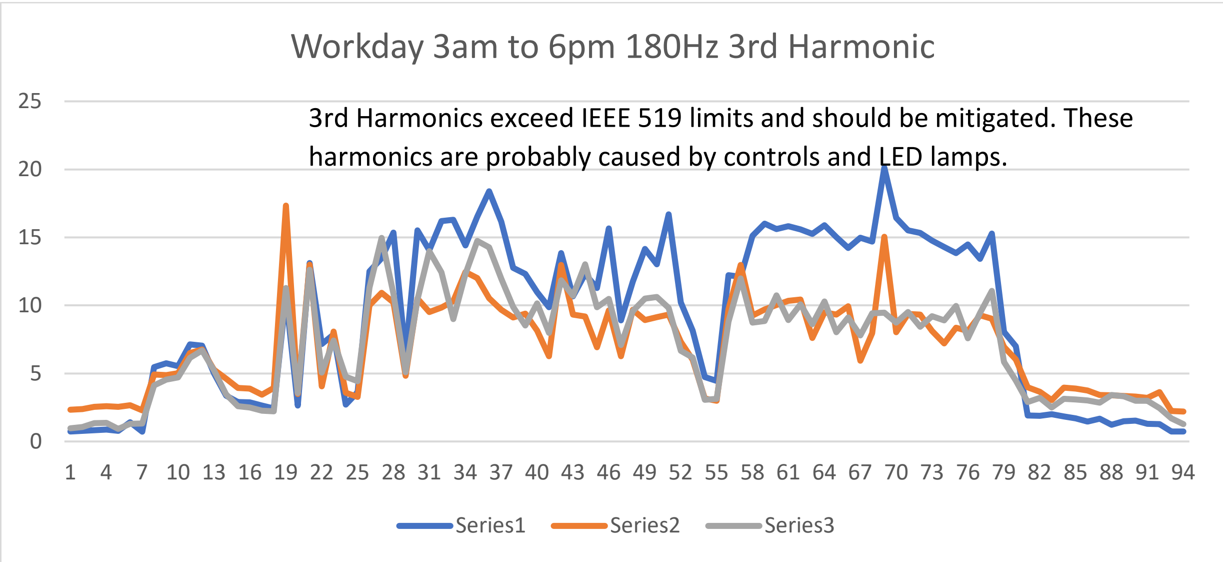

Workday 3am to 6pm KW
200
150
100
50
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1
Series2
Series3

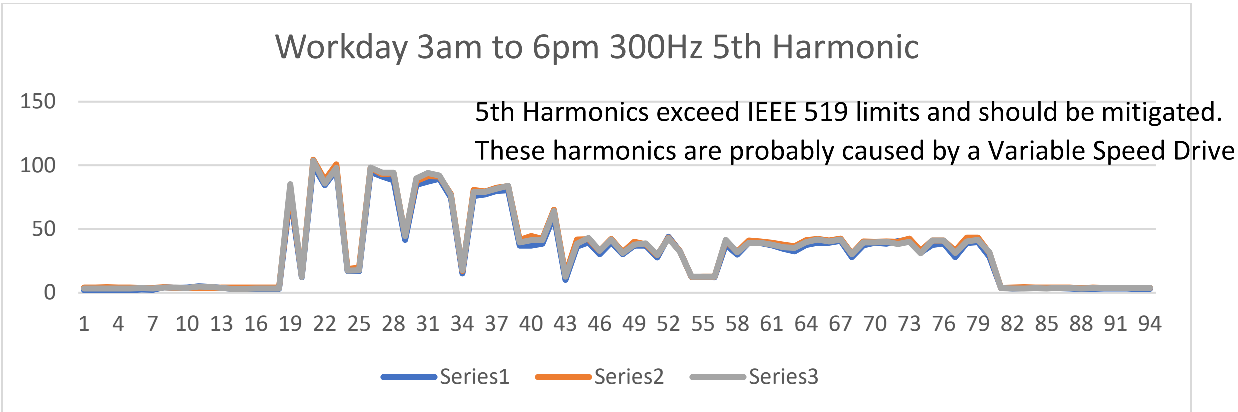

Workday 3am to 6pm KVAR
60
50
40
30
20
10
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1
Series2
Series3

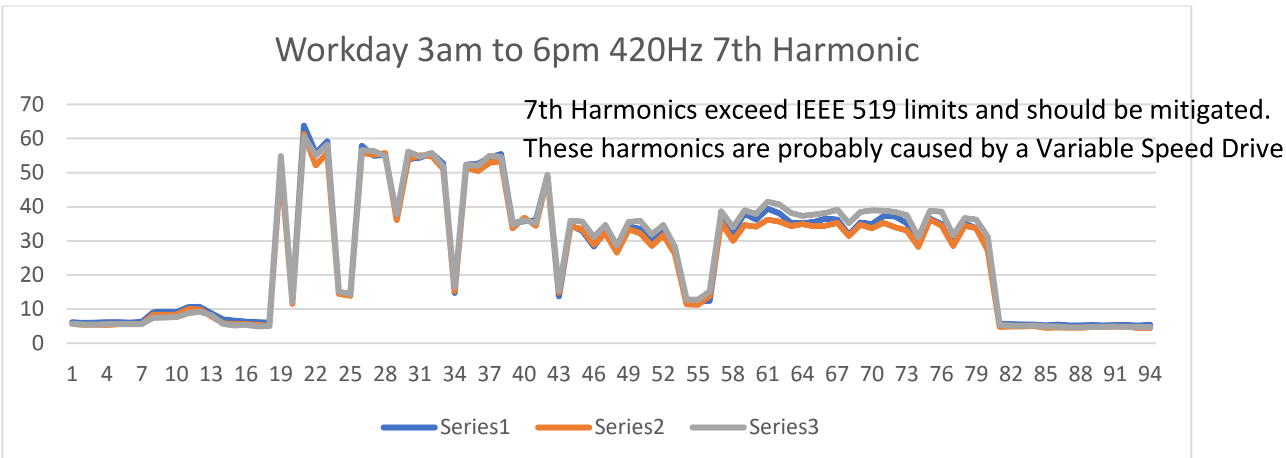

Workday 3am to 6pm PF
1.2
1
0.8
0.6
0.4
0.2
0
Power Factor under full load conditions is good but can be improved. Under light load the Power factor is poor and requires improvement if base load is needed.
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1
Series2
Series3


Workday 3am to 6pm VTHD
2.5
2
1.5
1
0.5
0
Voltage Harmonics are within IEEE 519 limits. Voltage Harmonics are caused by Current Harmonics
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

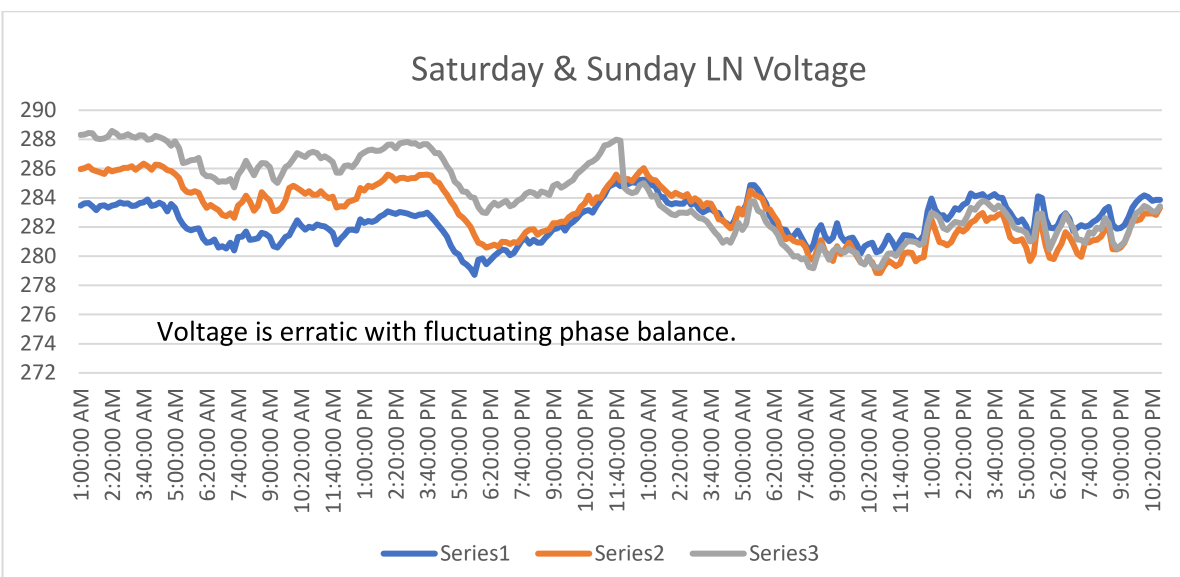

Workday 3am to 6pm ITHD
30
25
20
15
10
5
0
Current Harmonics exceed IEEE 519 limits and should be mitigated.
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

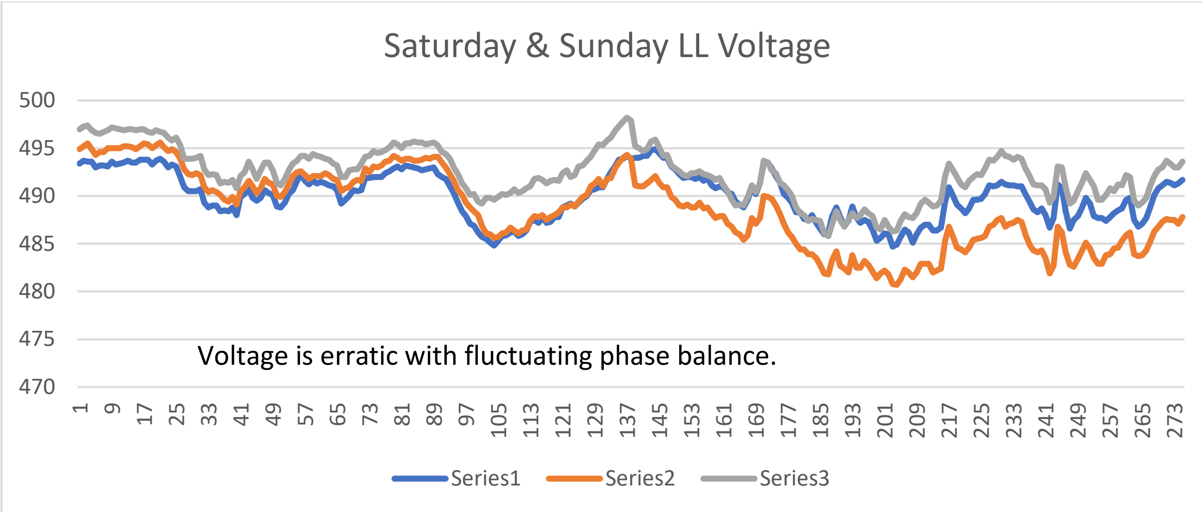

Workday 3am to 6pm 180Hz 3rd Harmonic
25
20
15
10
5
0
3rd Harmonics exceed IEEE 519 limits and should be mitigated. These harmonics are probably caused by controls and LED lamps.
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Series1 Series2 Series3

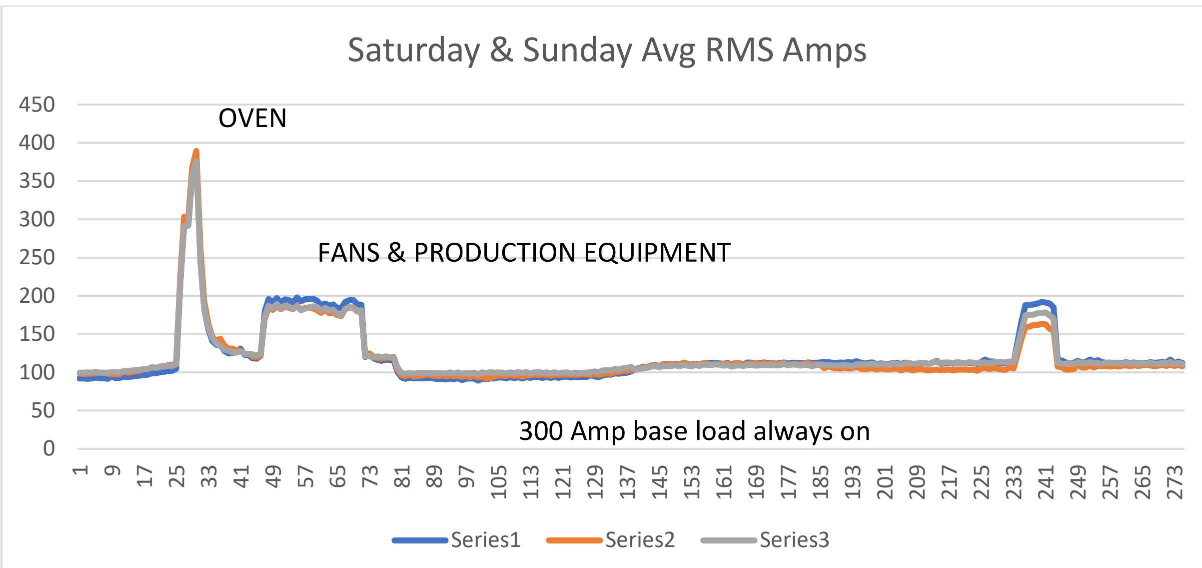


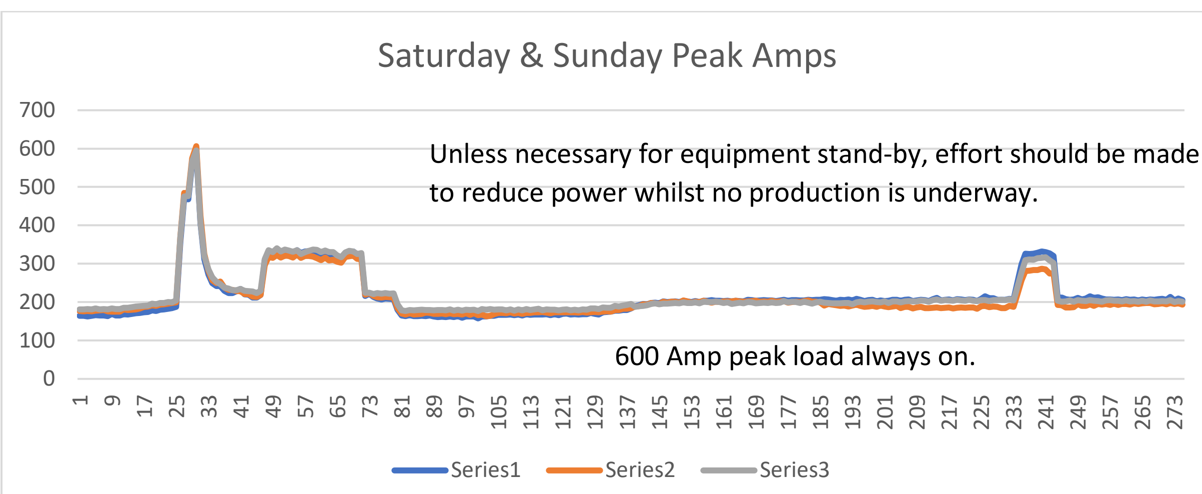


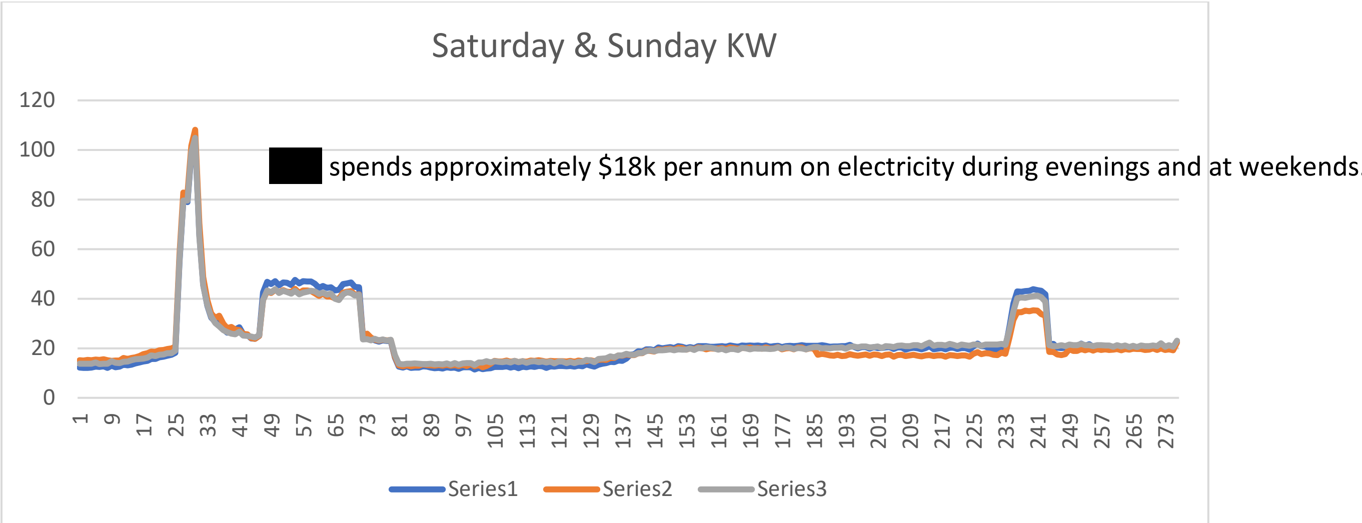
NON PRODUCTION HOURS

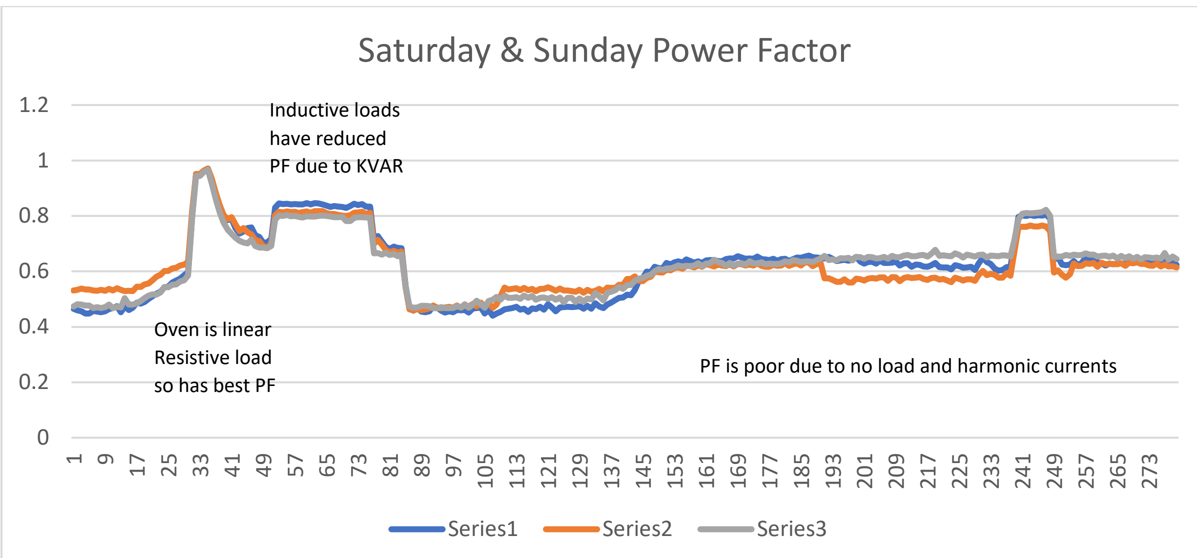


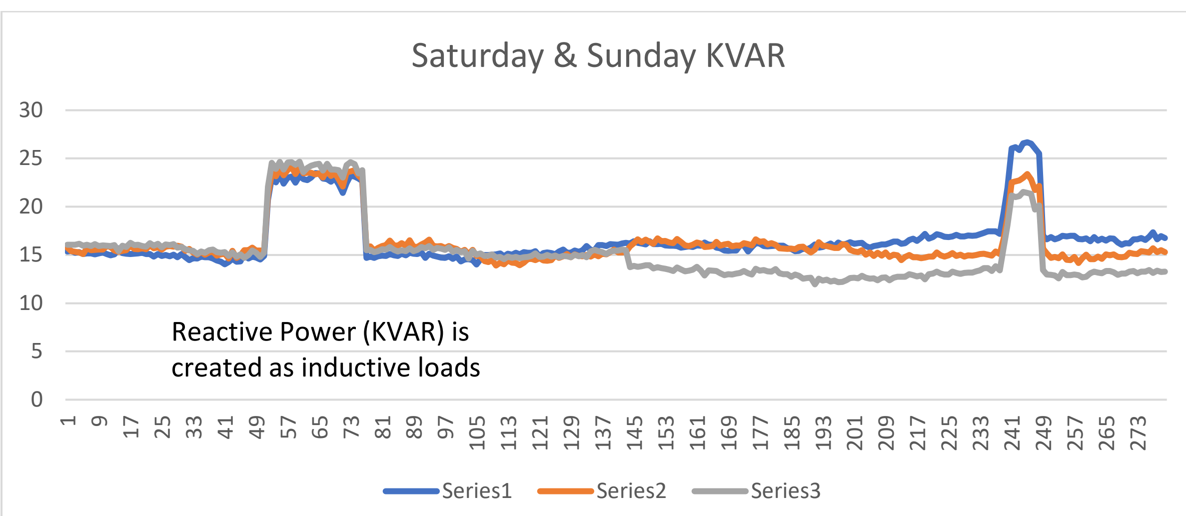

Saturday & Sunday LL Voltage
500
495
490
485
480
475
470
Voltage is erratic with fluctuating phase balance.
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3

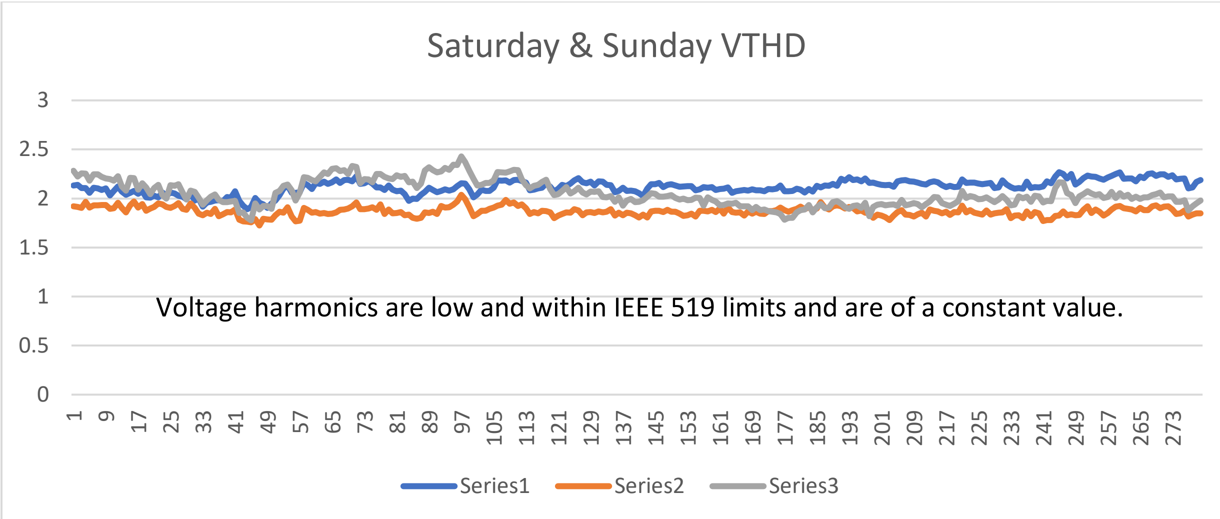

Saturday & Sunday Avg RMS Amps
450
400
350
300
250
200
150
100
50
0
OVEN
FANS & PRODUCTION EQUIPMENT
300 Amp base load always on
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3

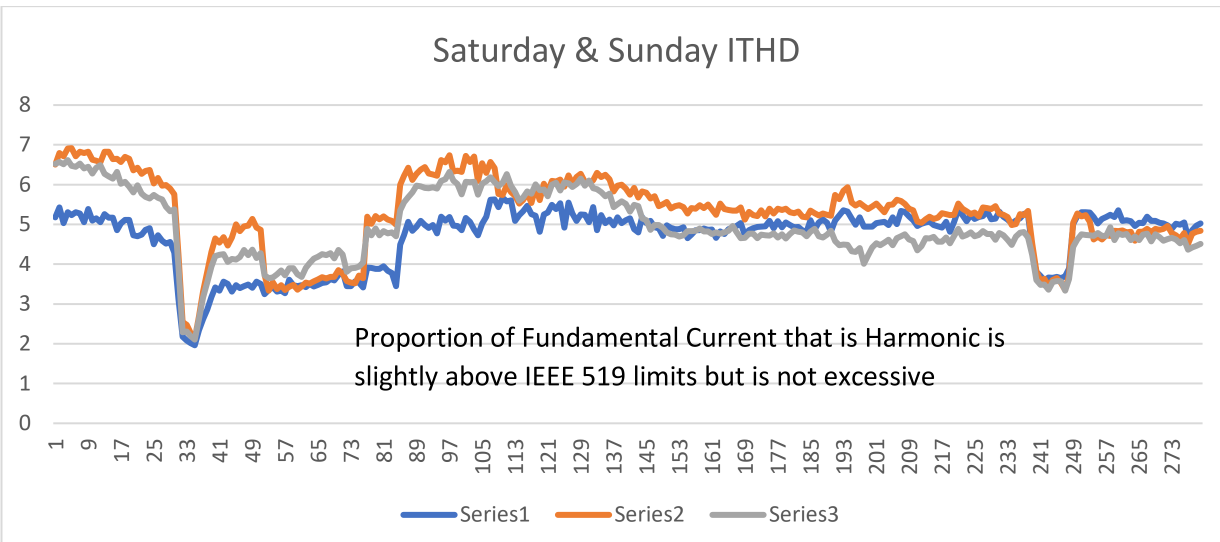

Saturday & Sunday Peak Amps
700
600
500
400
300
200
100
0
Unless necessary for equipment stand-by, effort should be made
to reduce power whilst no production is underway.
600 Amp peak load always on.
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3

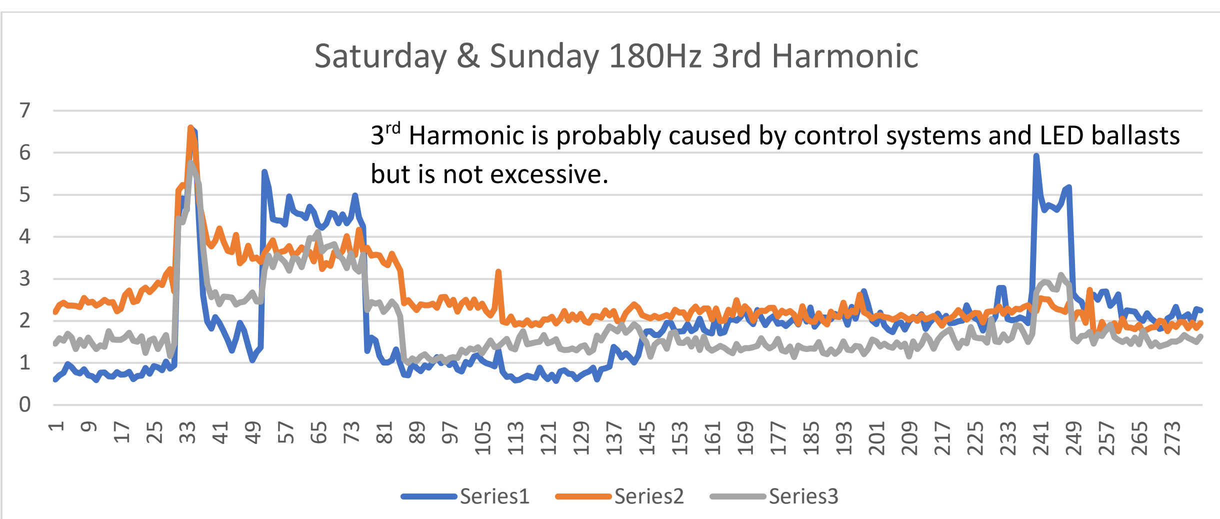

Saturday & Sunday KW
120
100
80
60
40
20
0
[redacted] spends approximately $18k per annum on electricity during evenings and at weekends.
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3

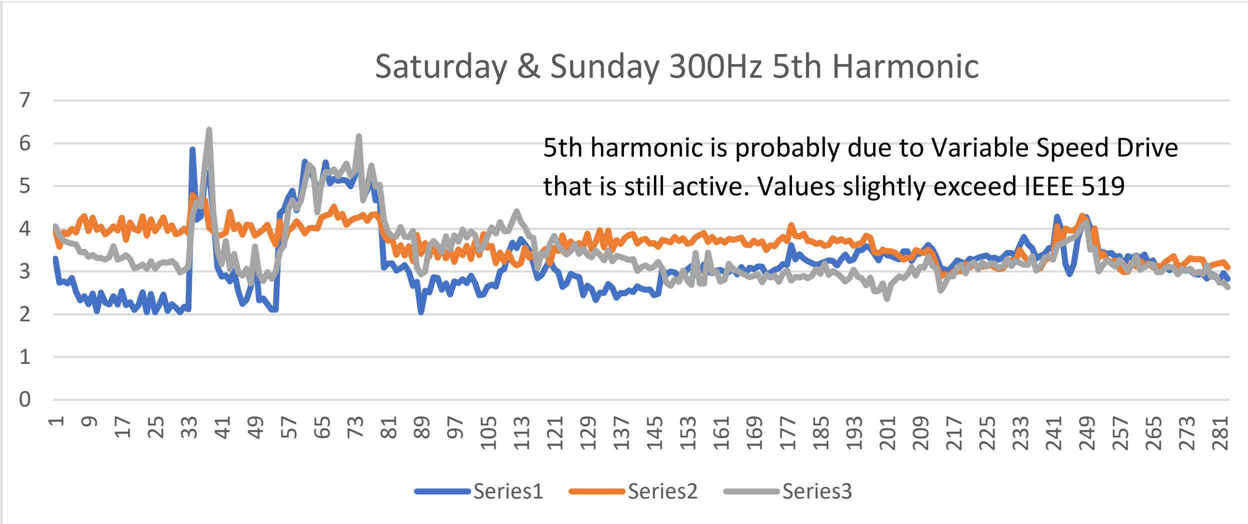

Saturday & Sunday Power Factor
1.2
1
0.8
0.6
0.4
0.2
0
Inductive loads
have reduced
PF due to KVAR
Oven is linear
Resistive load
so has best PF
PF is poor due to no load and harmonic currents
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3


Saturday & Sunday KVAR
30
25
20
15
10
5
0
Reactive Power (KVAR) is
created as inductive loads
1 9 17 25 33 41 49 57 65 73 81 89 97 105 113 121 129 137 145 153 161 169 177 185 193 201 209 217 225 233 241 249 257 265 273
Series1
Series2
Series3

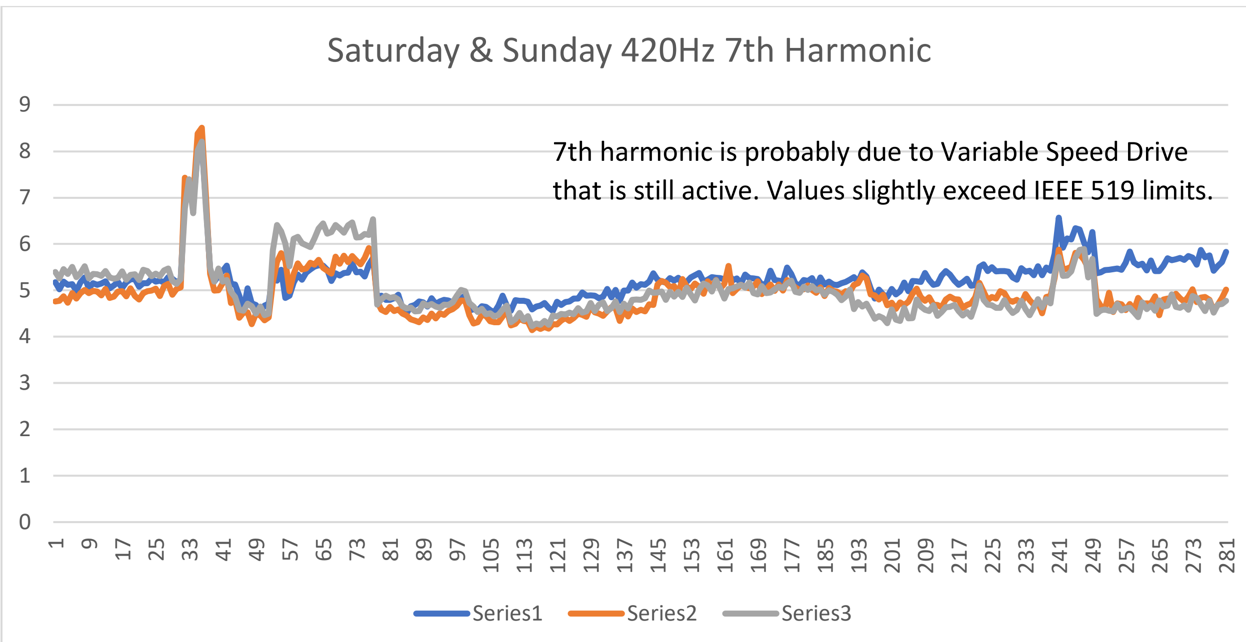

Saturday & Sunday VTHD
3
2.5
2
1.5
1
0.5
0
Voltage harmonics are low and within IEEE 519 limits and are of a constant value.
Series1
Series2
Series3


Saturday & Sunday ITHD
8
7
6
5
4
3
2
1
0
Proportion of Fundamental Current that is Harmonic is slightly above IEEE 519 limits but is not excessive
Series1
Series2
Series3


Saturday & Sunday 180Hz 3rd Harmonic
7
6
5
4
3
2
1
0
3rd Harmonic is probably caused by control systems and LED ballasts but is not excessive.
Series1
Series2
Series3



Saturday & Sunday 300Hz 5th Harmonic
5th harmonic is probably due to Variable Speed Drive that is still active. Values slightly exceed IEEE 519
Series1
Series2
Series3



Saturday & Sunday 420Hz 7th Harmonic
7th harmonic is probably due to Variable Speed Drive that is still active. Values slightly exceed IEEE 519 limits.
Series1
Series2
Series3

PQ COMPENSATION - ESTIMATED KW & AMPERAGE REDUCTION

Diagnostic results

- Current unbalance is Max (29.37 %), Min (0.02 %), Avg (5.37 %). The result of Current unbalance is Good. Please keep it below 30%.

- Average Active Power (39.71 kW), Average Apparent Power (50.67 kVA), Average Reactive Power (19.51 kVAR) and Transformer Utilization Rate (5.45 %). Light Load.

- The average Power Factor is (68.2%). Caution.

- Note that the phase angle of the current is (324.5), (204.4), (85.9).

- Frequency is from maximum (60.04 Hz) to minimum (59.94 Hz). It is within limits.

- Total THD of voltage harmonics is (2.16 %), (1.94 %), (2.10 %). Improvement is required.

- Note that the total THD of the current harmonics is (6.31 %), (7.14 %), (7.10 %) and the TDD is (57.13 %), (60.53 %), (59.58 %).

It is established that a Qcomp of 65 kVAr will be made to improve the power factor from 0.84 to 0.95, obtaining the following savings data.

Imax= 1302 A
Iavg=183 A
Kfactor = 1.5
Ro= 0.05 ohm
System losses PJoule = 5.1 kW
K-losses (Parasitic losses) = 0.337 kW
Total Losses = 5.43 kW
Energy losses (kWh/h) = 5.43 kWh/h

Demand
Power (kW) = 119.1 kW
Total Demand (kWh/h) = 118.9 kWh/h
Hour use per year =8683 hour
Total Demand (kWh/Year) = 1,0.32,408.70 kWh/Year

Saving %
Energy recovered (kWh/Year) = 47,209 kWh/h ENERGY RECOVERED PER YEAR
Energy recovered (kWh/h) = 5.43 kWh/h ENERGY RECOVERED PER HOUR
Total Saving % = 47,209 kWh/h / 1,0.32,408.70 kWh/h *100 = 4.57 %.
Total Saving % = 5.43 kWh/h / 118.9 kWh/h *100 = 4.57 %.

Reduction in Amperes
current reduction with reactive compensation = 30 Amperes per phase
harmonic current reduction = up to 35 A per phase when the load is at high ITHD
Total reduced current = 75 A

Summary

This summary is based on energy and power quality data collected over the second week of February 2022 and, due to seasonal variations of power consumption, should only be viewed as an estimate for a full calendar year.

With analysis of the the load data obtained the installation of **1 TruWatts® 480-3** model is recommended and will result in an estimated savings of:

Total kWh Consumption Saving = 4.57%

Total kW Demand Saving = 4.57%

Total Peak Amperage Reduction = 75 Amps

This unit has been sized to provide a fixed level of compensation that addresses the load profile of both production and non-production hours.

		Capacitors L-N	A			B			C			Total		
Model Unit	# Unit	UPG	60 (uF)	80 (uF)	Total C (uF)	60 (uF)	80 (uF)	Total C (uF)	60 (uF)	80 (uF)	Total C (uF)	60 (uF)	80 (uF)	Total C (uF)
I-480-3	1		2.4	7.2	720	2.4	7.2	720	2.4	7.2	720	7.2	21.6	2160

	Qcomp (kVAr)	New PF	Qcomp (kVAr)	New PF	Qcomp (kVAr)	New PF	Qcomp (kVAr)	New PF				
UPG	21		0.94	21.7		0.95	22		0.95	65		0.95

In addition to the estimated kWh energy, based upon the reduction of line losses because of improved power factor and harmonic mitigation, the TruWatts® technology will also provide transient surge protection for external and internal power fluctuations and suppression of sub-harmonics, interharmonics and supraharmonics by its integral TVSS/Snubber Network.

The utility supplied voltage to this facility shows some erratic behavior that, although conforming with allowed limits in deviation during the week that data was collected, may indicate performance issues in a utility transformer or interference from an electrical load on Phase A in an adjacent building, outside of the facility. Further investigation by Potomac Edison is warranted to provide an explanation as to the source of this issue and remedy the problem if it is negatively impacting production at. Our full Dranetz PQ report is provided and can be transmitted to the utility for their engineers to review.

Daniel Andrade-Torres EE

Lead Engineer – Basic Power, Inc.