Phase Angle Capacitor Bank Study

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Date of Report:	June 11th, 2024

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June 11th, 2024

Justin Dunn, FEC, P.Eng.
Director, Facilities Management
Holland College

Attention (VIA Email): Mr. Justin Dunn

Re: Phase Angle Capacitor Bank Study

Dear Justin,

At your request, EA Engineering completed an analysis of the data collected for the Phase Angle Capacitor Bank Study. The attached report summarizes these findings.

We trust this report meets your requirements. Should you have any questions regarding the information contained in the report, please feel free to contact us at your convenience.

Sincerely,

Craig MacIntyre

Craig MacIntyre, P.Eng.,
EA Engineering

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1 EXECUTIVE SUMMARY

At the request of Mr. Justin Dunn, EA Engineering undertook a review of data collected for the Phase Angle Capacitor Bank Study at the following locations: Atlantic Tourism and Hospitality Institute (ATHI), Holland College Charlottetown Centre (CC), Holland College Summerside Waterfront Campus (SWC), Atlantic Police Academy (APA) in Summerside.

At each of these locations the Phase Angle Technology was placed on the electrical distribution system of the building and data was recorded as the technology was turned on and off at predetermined intervals.

The purpose of the study was to conduct an evaluation of the data to determine the following:

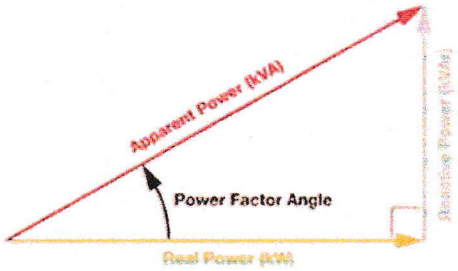
1. Did having the Phase Angle Technology turned on result in a change in the working power consumption (kWh).
2. Did having the Phase Angle Technology turned on result in a change in the apparent power consumption (kVA).
3. Did having the Phase Angle Technology turned on result in a change in the peak demand (KW and kva).
4. Did having the Phase Angle Technology turned on result in any utility bill savings.
5. Did having the Phase Angle Technology turned on result in a change to the electrical distribution systems power factor.
6. Did having the Phase Angle Technology turned on result in Green House Gas reductions.

Note, the Summerside Wellness Center was originally part of this study, but due to the limited data we decided not to include this building in the final report.

The following report summarizes our findings.

2 PROJECT BACKGROUND

Power factor is defined as the ratio between True (real or active) power (kW) and apparent power (VA). The intent of power factor correction is to obtain a power factor as close to unity (1) as possible. The power factor triangle below describes the relationship between real power, apparent power and reactive power.



3 ELECTRIC UTILITY BILLING STRUCTURE

To understand if power factor correction will generate savings on the electrical bills, it is important to understand the billing structure.

Each of the Holland College facilities falls under General Service 1 rate category –

1. Service charge of
    a. $24.37 per billing period.
2. Demand Charge
    a. No charge for the first 20kW or less.
    b. $13.43 per kW in excess of 20kW or 90% of the maximum kva demand – whichever is larger.
3. Energy Charge
    a. 19.91 cents per kWh for the first 5000kWh.
    b. 13.15 cents per kWh for the balance.

Note, Summerside Electric or Maritime Electric do not have any penalties for poor power factor.

4 METHODOLOGY

Oscar Robichaud Industrial Electric Ltd ("RIE") in joint venture with CFR Enterprises Inc. installed Phase Angle Capacitor technology at five facilities:

- Holland College ATHI (at the main electrical service entrance)
- Holland College Charlottetown Centre (not on the main service, on a sub panel)
- Holland College Summerside Waterfront Campus (at the main electrical service entrance)
- Holland College Atlantic Police Academy (at the main electrical service entrance)

The technology was tuned on and off at each of these locations over a period of time. The intervals and the time frame for each location are summarized in the table below.

Facility	Dates	Frequency of Readings	Switchover
ATHI	May 15th – July 25th	Every five minutes	Variable
Charlottetown Center	September 12th – November 7th	Every five minutes	Every Tuesday at 9:00 a.m.
Summerside Waterfront Campus	September 14th – November 9th	Every five minutes	Every Thursday at 9:00 a.m.
Atlantic Police Academy	May 16th – July 25th	Every five minutes	Variable
Credit Union Place			

5 SUMMARY DATA TABLES

The following tables summarize the data collected at each of the four sites.

Note, for Working Energy Consumption (KWhr) and Apparent Energy Consumption, there are not the same number of readings with the correction unit turned on as there is with the correction unit turned off. To make the data comparable we took the average energy usage per reading and extrapolated that out over 31 days, to provide a monthly energy usage.

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.1 Atlantic Tourism and Hospitality

Reading	On	Off
Total Number of Readings	12040	9262
Power		
Average KW (Active Power)	100	107
Average KVA (Apparent Power)	105	127
Average KVAR (Reactive Power)	26	68
Peak Average KW	202	226
Peak Average KVA	218	258
Energy		
KWhr Total	100251	82701
KVAhr Total	103807	98154
Average KWhr	8	9
Average KVA Hours	9	11
Average Power Factor	0.97	0.84

Working Energy (KWhr) - Extrapolated					
Per Hour		**Per Day**		**Per Month (31 days)**	
On	**Off**	**On**	**Off**	**On**	**Off**
100	107	2398	2572	74339	79719
Difference				5380	
Percentage				6.75%	

Apparent Energy (KVAhr) - Extrapolated					
Per Hour		**Per Day**		**Per Month (31 days)**	
On	**Off**	**On**	**Off**	**On**	**Off**
103	127	2483	3052	76976	94614
Difference				17639	
Percentage				18.6%	

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Utility Bill Savings Analysis - Consumption				
	kWh	Difference	Rate (cents)	Savings
Monthly kWh (ON)	74339	5380	0.1315	$707.47
Monthly kWh (Off)	79719			

Utility Bill Savings Analysis - Demand					
	Peak kVA	90% of Peak	Charge	Cost	Difference
Peak kVA (ON)	218	196	$13.43	$2,634.16	$483.58
Peak kVA (Off)	258	232	$13.43	$3,117.73	

.2 Charlottetown Center

Reading	On	Off
Total Number of Readings	8064	8076
Power		
Average KW (Active Power)	85	86
Average KVA (Apparent Power)	91	102
Average KVAR (Reactive Power)	22	54
Peak Average KW	189	186
Peak Average KVA	194	213
Energy		
KWhr Total	56890	57842
KVAhr Total	60673	68612
Average KWhr	7	7
Average KVA Hours	8	8
Average Power Factor	0.91	0.84

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Working Energy (KWhr) - Extrapolated					
Per Hour		Per Day		Per Month (31 days)	
On	Off	On	Off	On	Off
85	86	2032	2063	62985	63944
Difference				959	
Percentage				1.50%	

Apparent Energy (KVAhr) - Extrapolated					
Per Hour		Per Day		Per Month (31 days)	
On	Off	On	Off	On	Off
90	102	2167	2447	67174	75851
Difference				8677	
Percentage				11.4%	

Utility Bill Savings Analysis - Consumption				
	kWh	Difference	Rate (cents)	Savings
Monthly kWh (ON)	62985	959	0.1315	$126.14
Monthly kWh (Off)	63944			

Utility Bill Savings Analysis - Demand					
	Peak kVA	90% of Peak	Charge	Cost	Difference
Peak kVA (ON)	194	175	$13.43	$2,348.90	$225.14
Peak kVA (Off)	213	192	$13.43	$2,574.05	

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.3 Summerside Waterfront Campus

Reading	On	Off
Total Number of Readings	8064	8020
Power		
Average KW (Active Power)	93	94
Average KVA (Apparent Power)	115	132
Average KVAR (Reactive Power)	63	92
Peak Average KW	237	245
Peak Average KVA	287	312
Energy		
KWhr Total	62648	62990
KVAhr Total	75826	88168
Average KWhr	8	8
Average KVA Hours	9	11
Average Power Factor	0.83	0.69

Working Energy (KWhr) - Extrapolated					
Per Hour		**Per Day**		**Per Month (31 days)**	
On	**Off**	**On**	**Off**	**On**	**Off**
93	94	2237	2262	69360	70121
Difference				761	
Percentage				1.08%	

KVAhr (Apparent Energy) - Extrapolated					
Per Hour		**Per Day**		**Per Month (31 days)**	
On	**Off**	**On**	**Off**	**On**	**Off**
113	132	2708	3166	83950	98151
Difference				14200	
Percentage				14.5%	

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Utility Bill Savings Analysis - Consumption				
	kWh	Difference	Rate (cents)	Savings
Monthly kWh (ON)	69360	761	0.1315	$100.04
Monthly kWh (Off)	70121			

Utility Bill Savings Analysis – KW Demand				
	Peak kW	Charge	Cost	Difference
Peak kW (ON)	237	$13.43	$3,182.91	$107.44
Peak kW (Off)	245	$13.43	$3,290.35	

Utility Bill Savings Analysis – kva Demand					
	Peak kVA	90% of Peak	Charge	Cost	Difference
Peak kVA (ON)	287	258	$13.43	$3,465.31	$306.60
Peak kVA (Off)	312	281	$13.43	$3,771.91	

.4 Atlantic Police Academy

Reading	On	Off
Total Number of Readings	9784	10351
Power		
Average KW (Active Power)	51	53
Average KVA (Apparent Power)	57	66
Average KVAR (Reactive Power)	25	38
Peak Average KW	131	130
Peak Average KVA	153	162
Energy		
KWhr Total	41556	46064
KVAhr Total	46504	56747
Average KWhr	4	4
Average KVA Hours	5	5
Average Power Factor	0.91	0.80

Working Energy (KWhr) - Extrapolated					
Per Hour		Per Day		Per Month (31 days)	
On	Off	On	Off	On	Off
51	53	1223	1282	37920	39731
Difference				1811	
Percentage				4.56%	

Apparent Energy (KVAhr) - Extrapolated					
Per Hour		Per Day		Per Month (31 days)	
On	Off	On	Off	On	Off
57	66	1369	1579	42435	48946
Difference				6511	
Percentage				13.3%	

Utility Bill Savings Analysis - Consumption				
	kWh	Difference	Rate (cents)	Savings
Monthly kWh (ON)	37920	1811	0.1315	$238.15
Monthly kWh (Off)	39731			

Utility Bill Savings Analysis - Demand					
	Peak kVA	90% of Peak	Charge	Cost	Difference
Peak kVA (ON)	153	138	$13.43	$1,852.21	$109.07
Peak kVA (Off)	162	146	$13.43	$1,961.28	

6 INTERPRETATION AND ANALYSIS

.1 Working Energy Consumption

The table below summarizes the comparison of the monthly Working Energy Consumption, with the phase angle technology turned on vs. the phase angle technology turned off at each of the four sites:

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Working Energy (kWh) - Extrapolated			
	Monthly kWh		
Site	On	Off	Difference
ATHI	74,339	79,719	-5380
			6.75%
CC	62,985	63,944	-959
			1.50%
SWFC	69,360	70,121	-761
			1.08%
APA	37,920	39,731	-1811
			4.56%

.2 Apparent Energy Consumption

The table below summarizes the comparison of the monthly Apparent Energy Consumption, with the phase angle technology turned on vs. the phase angle technology turned off at each of the four sites:

Apparent Energy (kVAh) - Extrapolated			
	Monthly kVAh		
Site	On	Off	Difference
ATHI	76,976	94,614	-17,639
			18.6%
CC	67,174	75,851	-8677
			11.4%
SWFC	83,950	98,151	-14,200
			14.5%
APA	42,435	48,946	-6511
			13.3%

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.3 Peak Demand

The table below summarizes the comparison of the monthly Peak Demand for both KW and KVA, with the phase angle technology turned on vs. the phase angle technology turned off.

Peak kW			
Site	**On**	**Off**	**Difference**
ATHI	202	226	-24
CC	189	186	-3
SWFC	237	245	-8
APA	131	130	+1

Peak kVA			
Site	**On**	**Off**	**Difference**
ATHI	218	258	-40
CC	194	213	-19
SWFC	287	312	-17
APA	153	162	-9

.4 Potential Utility Bill Savings

The table below summarizes the potential monthly utility bill savings with the phase angle technology turned on. Note, for the purposes of these calculations we made the following assumptions:

1. Working energy savings is calculated using second block energy rates.

2. Although Maritime Electrics fee structure indicates that they charge the demand as follows – *"$13.43 per kW in excess of 20kW or 90% of the maximum kva demand – whichever is larger."*, Holland College has come to learn that they only charge 90% of the maximum kva demand and do not take in to account kW. These calculations are based on 90% of kva.

3. Summerside Electric only charges demand for peak KW.

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Utility Bill Savings Analysis (Monthly)				
Site	kWh	Peak kVA	Peak kW	Total Savings
ATHI	$707.47	$483.48	NA	$1190.95
CC	$126.11	$229.65	NA	$355.76
SWFC	$100.07	NA	$96.70	$196.77
APA	$238.15	NA	$0	$238.15
				$1981.63

Based on the total monthly spending of $49,300. The savings were approximately 4%.

.5 Power Factor

The table below summarizes the comparison of Power Factor, with the phase angle technology turned on vs. the phase angle technology turned off.

Power Factor			
Site	**On**	**Off**	**Difference**
ATHI	0.97	0.84	+0.13
CC	0.91	0.84	+0.07
SWFC	0.83	0.69	+0.14
APA	0.91	0.80	+0.11

7 CONCLUSION

Note that this study did not consider occupied or unoccupied building usage, or weather related conditiosn.

There were reductions in both Working Energy Consumption and Apparent Energy Consumption at all four sites when the phase angle technology was turned "ON". Over the course of the study the total working energy consumption savings were:

- ATHI – 5,380
- CC - 959
- SWFC - 761
- APA – 1,811

8,911

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Maritime Electric calculates their greenhouse gas emission (kg/kWh CO2e) on an annual basis. Based on their calculations (0.163 kg/kWh CO2e), a savings of 8,911 kWh would result in a reduction of 1,452 kg CO2e.

There were also reductions in both the Peak KW and Peak KVA demand with the Phase Angle Technology turned "ON".

The study showed utility bill savings of approximately $1,981.63 per month over the four buildings, with the Phase Angle Technology turned on.

There was also significant improvements in the power factor at all four buildings with the Phase Angle Technology turned on.