The Power of an Energy Management system

Andrew Muir (on behalf of Ali Omran)

Energy Specialist- CN



- the largest rail network in Canada and the only transcontinental network in North America.
- 19,600 route-miles of track in North America with three coasts Access
- transporting approximately C\$250 billion worth of goods annually:
 - Intermodal
 - Petroleum and chemicals
 - Grain and Fertilisers
 - Forest Products
 - Metals and Minerals
 - Automotive
 - Coal
 - And others

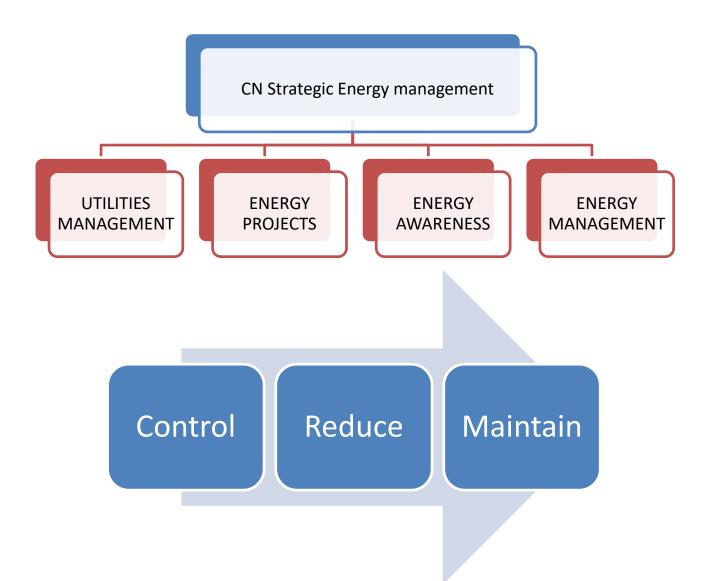


CN Energy in Numbers

- 22 Major Yard Monitored across North America
- Monitored Yearly Electrical Energy: 100 GWh (~ 9300 homes or YVR)
- Facilities: 3600 buildings and shops across CN network. Various equipment including: Compressors, switch heaters, Communications.
- Monitored Peak demand : 25 MW



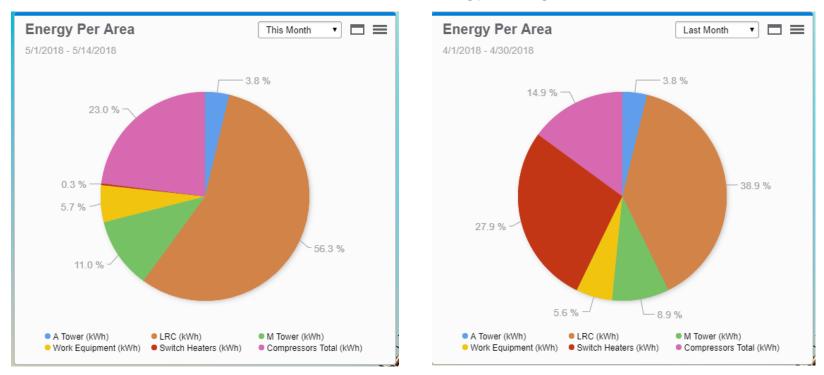
CN Strategic Energy Management Program



A Typical Large Yard

Single Line Diagram $\Box \equiv$ Symington-Single Line щ ₩ ¶ ₩ щ Ĵ 1.0 PF 全 ₹ 594.0 V V 568.8 V 36.0 A А 403.3 A MH Line 1: kW 167.0 kW \$ 310.0 kW ш SS 23,899.3 V 572.1 V 575.9 V 0.0 V 571.4 V [対] S Tower 52.6 A 41.6 A 45.5 A 28.8 A 0.5 A Cap Bank Status Cap Bank 2 LRC Fueling Station 30.3 kW 0.0 kW 32.9 kW 573.8 V 0.2 kW Status **↑** - ⁄-N.O 13.2 A 88 ш ωu m m m 11.3 kW 2018-10-11 11:01:32.566 AM East Diesel 1 600.7 V 206.4 V 562.2 V 203.3 V 601.8 V 🛓 Ĵ Ê 19.6 A 覺 32.9 A 36.6 A 79.1 A 😎 12.2 kW 6.7 kW 22.9 kW 1.1 kW **Building 29** 114.9 kW L1&L2 Total: 88 Car Shop L Tower 1 L Tower Car Shop W Tower UPS 2 UPS 1 M Building Compressor Compressor 1,980.6 kW 552.3 V 112.6 A щ щ щ щ щ -50.9 kVAR 598.2 V 601.1 V 207.5 V 📩 1,981.3 kVA ١ 601.1 V 129.6 A 👮 65.8 A 12.5 A 😾 85.4 kW 58.6 kW 4.3 kW 98.1 kW 88 565.2 V 206.4 V SS 88 589.1 V 4.1 A 覺 60.2 A 👮 25.6 A 覺 SpragueSE Pole 32 C Tower Blower 1 49.8 kW 4.0 kW 8.7 kW WIT UPS C Tower Air C Tower Hump C Tower UPS Click For Lagacy View

Sources of Energy Usage



Spring/Summer

3,000

2,500

2,000 E 1,500 D

1,000

500

0

Jun

Jul

Aug

Sep

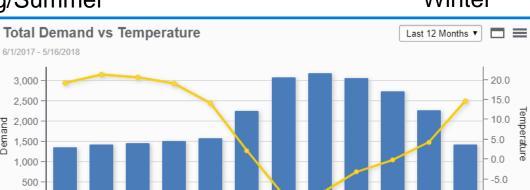
Oct

Nov

Demand (kW) - Temp (C)

Dec

6/1/2017 - 5/16/2018



Jan

Feb

Mar

Apr

May

Winter

-10.0

Compressor Monitoring

Why is it important to monitor?

- Compressors consume between 15-30% of our electrical energy.
- Compressors are used to charge train cars and operate equipment and the system functionality is crucial for CN operations.
- Pressure must be maintained at a certain level.
- Avoid Excessive Airflow from the compressors.
- Verify compressor system work sequence



Compressor Monitoring

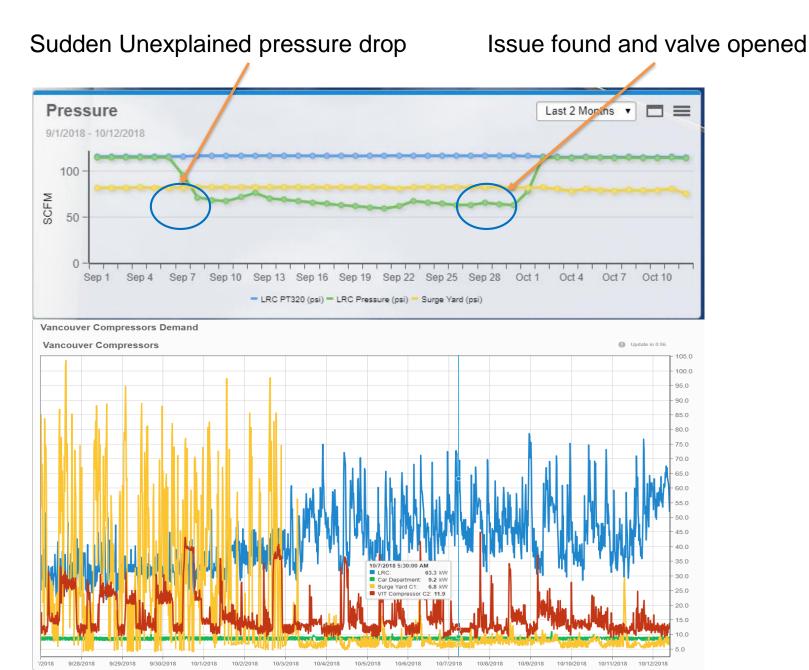
Monitor Pressure

Detect Leakage and high airflow

Detect Abnormalities



Compressor Incident- Vancouver



Switch heater Monitoring

- Switch Heaters/Blowers are crucial for Track operations in winter season
- They account for up to 40% of our winter demand
- A good candidate for automation and control given their weather dependability.





Yard Equipment monitoring

lower Status							
adder Track North.		Ladder Track South	BLOWERS OFF	Local Yard		Location 9	BLOWERS OF
Control Status		Control Status AUTOMATIC		Control Status		Control Status AUTOMATIC	
Relay Status		Relay Status RELAY ON		Relay Status		Relay Status RELAY ON	
Total Amps Amps		Total Amps 0.0 Amps		Total Amps Amps		Total Amps 20.9 Amps	
Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL	
W Tower	BLOWERS OFF	Sprague South East	BLOWERS ON	E Tower	BLOWERS OFF	Long Points	BLOWERS OF
Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status AUTOMATIC	
Relay Status RELAY ON		Relay Status RELAY ON		Relay Status RELAY ON		Relay Status RELAY ON	
Total Amps 53.8 Amps		Total Amps 130.0 Amps		Total Amps 62.3 Amps		Total Amps 46.7 Amps	
Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL	
ocal Tower A - Central	BLOWERS OFF	Local Tower - B 66/20/1	BLOWERS OFF	Local Tower C - East	BLOWERS OFF	East Diesel Shop	BLOWERS OF
Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status AUTOMATIC	
Relay Status RELAY ON		Relay Status RELAY ON		Relay Status RELAY ON		Relay Status RELAY ON	
Total Amps 41.7 Amps		Total Amps 44.8 Amps		Total Amps 0.0 Amps		Total Amps 0.5 Amps	
Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL	
Tower - Hump (1&2)	BLOWERS ON	C Tower - Hump (3&4)	BLOWERS OFF	C Tower - Hump (5&6)	BLOWERS ON	S tower	
Control Status		Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status	
Relay Status		Relay Status RELAY ON		Relay Status RELAY ON		Relay Status	
Total Amps 113.3 Amps		Total Amps 87.1 Amps		Total Amps 110.7 Amps		Total Amps Amps	
Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL	
Tower - Hump (8&9)	BLOWERS ON	West LRC (DF)	BLOWERS OFF	West Fort Rouge		Pole 32	BLOWERS C
Control Status AUTOMATIC		Control Status AUTOMATIC		Control Status		Control Status AUTOMATIC	
Relay Status RELAY ON		Relay Status RELAY ON		Relay Status		Relay Status RELAY ON	
Total Amps 119.8 Amps		Total Amps 0.5 Amps		Total Amps Amps		Total Amps 65.9 Amps	
Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL		Zone Lockout NORMAL	

• Troubleshoot blower panels by looking at real-time current readings.

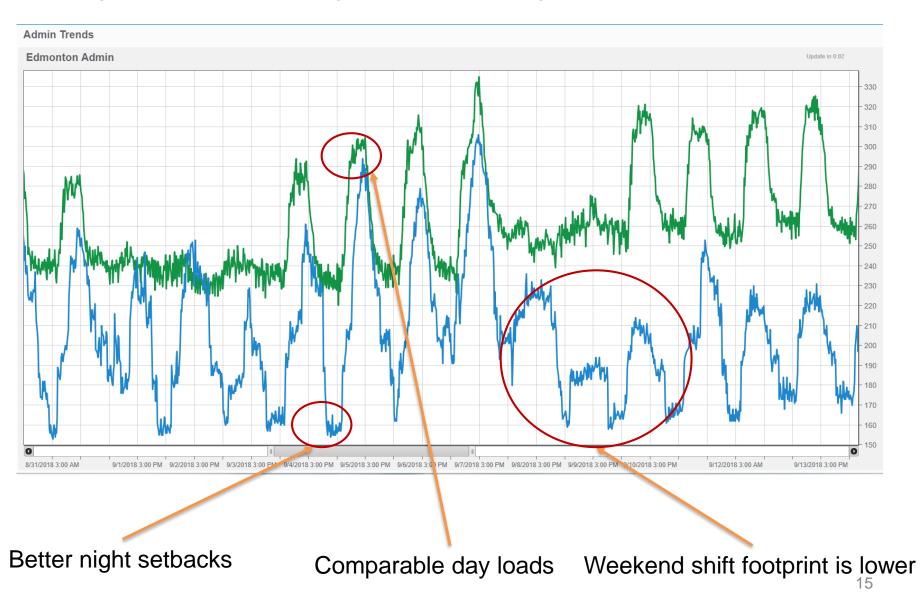
Buildings Monitoring

- Keep Track of Energy Usage and spot abnormalities in real time
- Track the short term demand and compare it to the long term demand.



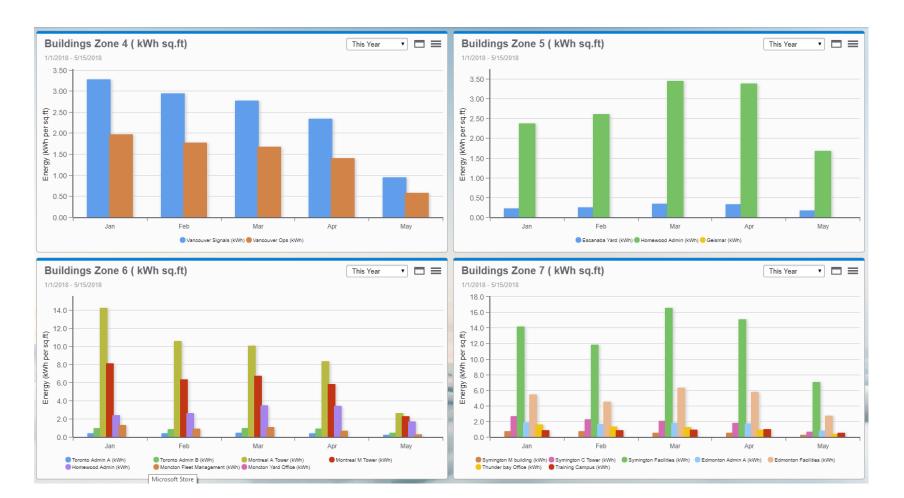
Buildings Monitoring

• Spotting anomalies by comparing similar sized buildings within the same climate zone



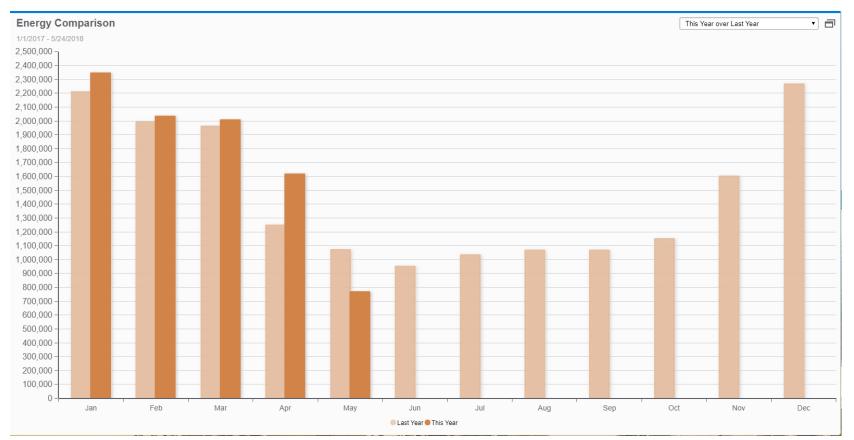
Benchmarking

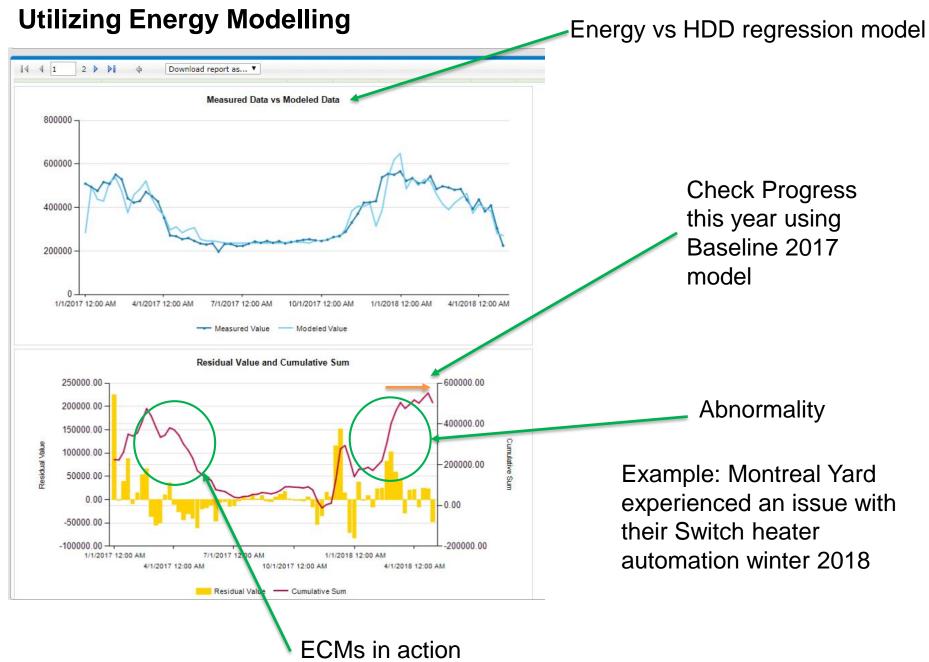
- 1- Group Buildings based on ASHRAE climate zone
- 2- Easy to compare building performance and establish benchmarks



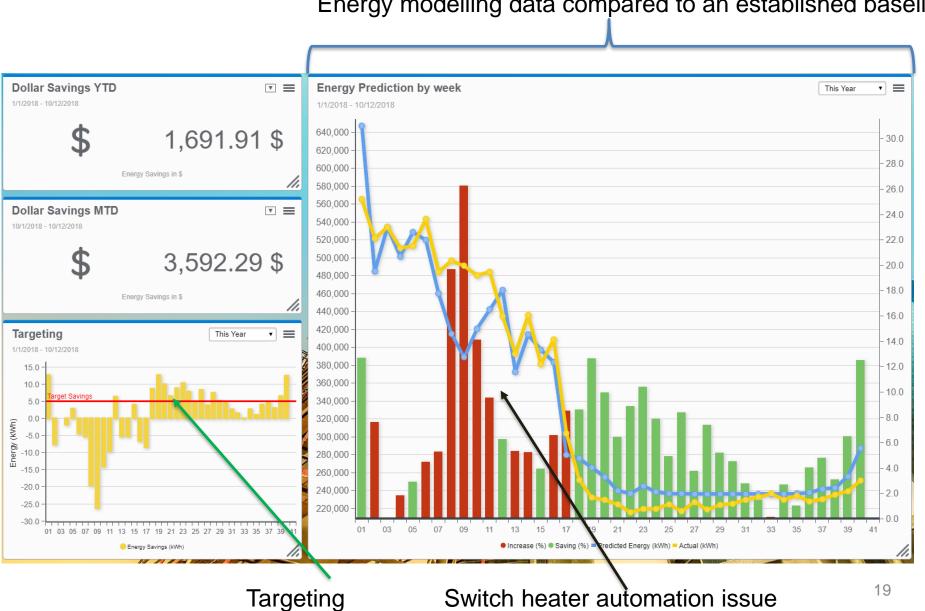
Why do we need an energy model?

- Analyzing raw data can be tricky
- What drives energy usage in a facility?
- Comparisons can be misleading if the conditions are different (eg. colder winters).





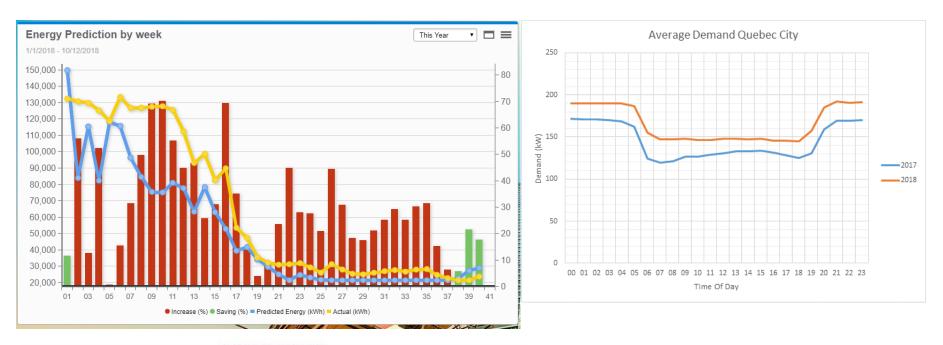
Major Yard Energy Modeling Example

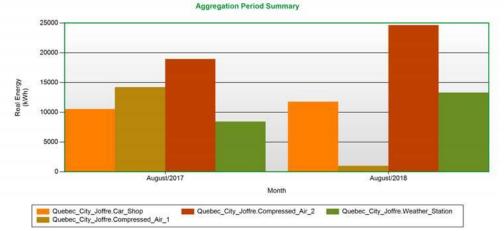


Energy modelling data compared to an established baseline

Quebec city-Success Story

Energy modelling data show green after 38 weeks of red!





1- Used sub metering data to find the source of increase was the compressor.

2- site inspection found multiple air leaks in the pipes and the compressor regulator.

3- Estimated avoided cost \$30,000

Energy Forecasting (still in beta)



Weekly Energy Forecasting:

1- Linear regression formulas from Baseline

2- HDD Weekly Forecast from weather XML service.

3- Compare with Actual Energy Usage

Montreal Taschereau Yard						
Summary	Forecast					
Energy Usage Forecast- This Week						
Forecasted Energy Usage	Monday	Tuesday				
277,362.8 kWh	Forecasted Energy 33,500.9 kWh Actual Energy	Forecasted Energy 38,184.0 kWh Actual Energy				
Actual Energy Usage 79,978.3 kWh	32,706.8 kWh Wednesday Forecasted Energy	32,644.0 kWh Thursday Forecasted Energy				
Savings Achieved	34,281.4 kWh Actual Energy kWh	37,403.5 kWh Actual Energy kWh				
\$19,738.5 71.2 %	Friday	Weekend				
	Forecasted Energy 34,671.7 kWh Actual Energy kWh	Forecasted Energy 69,343.3 kWh Actual Energy kWh				

Evolution of EMS



Pre-Upgrade screens

MacMillian Yard System Overview

MacMillian Yard (Total) : 1,565.2 kW	A			
Langstaff Rd (Total) : 0.0 kW				
Highway 7 (Total) : 1,565.2 kW				
LRC - Diesel Shop (Total) : 565.8 kW				
Car Shop (Total) : 127.0 kW				
Adminstration Bldg (Total) : 324.7 kW				
Wheel Shop (Total) : 0.0 kW				
Maintenance Shop (Total) : 0.0 kW				
UnMetered (Total) : 547.8 kW				
LRC - Diesel Shop (Total) : 565.8 kW				
Main 1 (Total) : 324.1 kW				
Main 2 (Total) : 240.5 kW				
Service Tracks (Total) : 169.3 kW				
LRC Natural Gas (Bldg) : 0 CuFt/Hr				
Nat Gas Costs (Month to Date) \$: 0.00				
Temp : 22.8 Celcius Wind : 25.0 - kM/Hr				
Wind Dir : 210 Deg S No Precipitation				

/		_	
MacMillian Yard (Total) : 1	,789.8 kVA	騗	
MacMillian Yard (Total)	: 1,565.2 kW		
MacMillian Yard (Total)	: 0.8745 PF		
MacMillian Yard (Total)	* : 27,338 Volts		
Rates : \$/kW	Rates : \$/kWh		
Electrical Costs (Month	to Date) \$:		
Administration Bldg (Total) : 324.7 kW		
Building A (Total) : 72.3	kW		
Building B (Total) : 252.	Building B (Total) : 252.6 kW		
Natural Gas (Bldg) : 0 C	CuFt/Hr		
Car Shop (Total) : 127.0 kV	v	嗣	
Natural Gas (Bldg) : 0 C	CuFt/Hr		
Compressed Air (Total Ya	rd):kW	Į.	
Compressed Air (Total	Yard): SCFM		
L Yard - Compressor (Tota	al) : 48.4 kW	桶	
Compressed Air (Total)	: 10 SCFM		
Compressed Air (Total)	: 127.0 PSIG		
Dryer (Total) : 0 kW			
West Yard - Compressor (Total) : 75.5 kW		
West Yard - Compressor (Compressed Air (Total)		44	
_	: 21 SCFM	44	

NW 400 300 200 200 200 200 200 200 200 200 2	MacHillian Yard (Tota); 1,558 k₩	
MacMillian Yard Compressed Air	Brampton Intermodal Compressed Air	00044 120044 1
Local Yard - C1 - (Total) : 0.0 kW	North Yard - C1 - (Total) : kW	MacMillian Yard (Total) : kW
Local Yard - C2 - (Total) : 26.3 kW	North Yard - (Total) : SCFM	Langstaff Rd (Total) : 0.0 kW
Local Yard - Dryer - (Total) : 0.0 kW	North Yard - (Total) : PSI	Highway 7 (Total) : 1,568.0 kW
Local Yard - (Total) : 7.7 SCFM	South Yard - C1 - (Total) : kW	LRC - Diesel Shop (Total) : kW
Local Yard - (Total) : 132.9 PSI	South Yard - (Total) : SCFM	Car Shop (Total) : 125.9 kW
West Yard - C1 - (Total) : 51.4 kW	South Yard - (Total) : PSI	Adminstration Bldg (Total): kW
West Yard - C2 - (Total) : 26.1 kW		HacMillian Yard (Total)* : 27,409 Volts
West Yard - Dryer - (Total) : 0.0 kW		
West Yard - (Total) : 17.5 SCFM	Main Incoming - (Total) : kW	Main Incoming 1 (Total) : kW
West Yard - (Total) : 138.1 PSI		
East Yard - C1 - (Total) : kW		
East Yard - C2 - (Total) : kW	Main Incoming - Vca : Volts	Operations Bldg Vault - VII Avg : Volts
East Yard - Dryer - (Total) : kW	Main Incoming - Ia : Amps	North Gen Vault - VII Avg : Volts
East Yard - (Total) : SCFM	Main Incoming - Ib : Amps	Clark Street Vault - VII Avg : Volts
East Yard - (Total) : PSI	Main Incoming - Ic : Amps	In Gate Vault - VII Avg : Volts

PSI 100 80 60 40		1 Receiver) : 85 PSI		PSI 100 80 60		2 Regulated) : () PSI
11:43:55	15:43:55	19:43:55	- i l	11-43-55 1	5 43 55	19:43:55	- i l
PSI 100 80 60 40	· · · · · · ·	1 Receiver) : 91 PSI		PSI 100 80 60 40		2 Regulated) : () PSI
11:43:55	15:43:55	19:43:55	+		5:43:55	19:43:55	+
SCFM 3000 2000 1000				SCFM) : 237 SCFM			
11-43-55	13-43-55	15-43-55	1	7-43-55 19-4	9-55	21-43-55	
kwY	ard Total KW (C1_	C2_C3) : 88 kW		C1 (L Tower) : 35 kW	C1 (Hours): 33,122.4 Hrs) ay : 17.2 Hr
225 150 75	aran an			C2 (C Tower) : 53 kW	C2 (Hours	i) : 27,281.0 Hrs) ay : 23.2 Hr
01	15:43:55	19:43:55		C3 (C Tower) : 0 kW	C3 (Hour	s) : 5,435.6 Hrs	Day: 0.3 Hrs
Amps Dry 7.5 2.5 2.5	er Amps - L Towe	r (D1) : 0.00 Amps		SCFMLTow 600 400 200	er Flow (SC	FM) : 42 SCFM	
11 43 55	15:43:55	19:43:55	<u> </u>	11 43 55	15:43:55	19:43:55	i i i
	L Tower : C Tower :			600 400	er Flow (SCF	FM) : 206 SCFM	
				200	11/11		
				11:43:55	15:43:55	19:43:55	

The Full story- Easy to read



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Thank you!

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