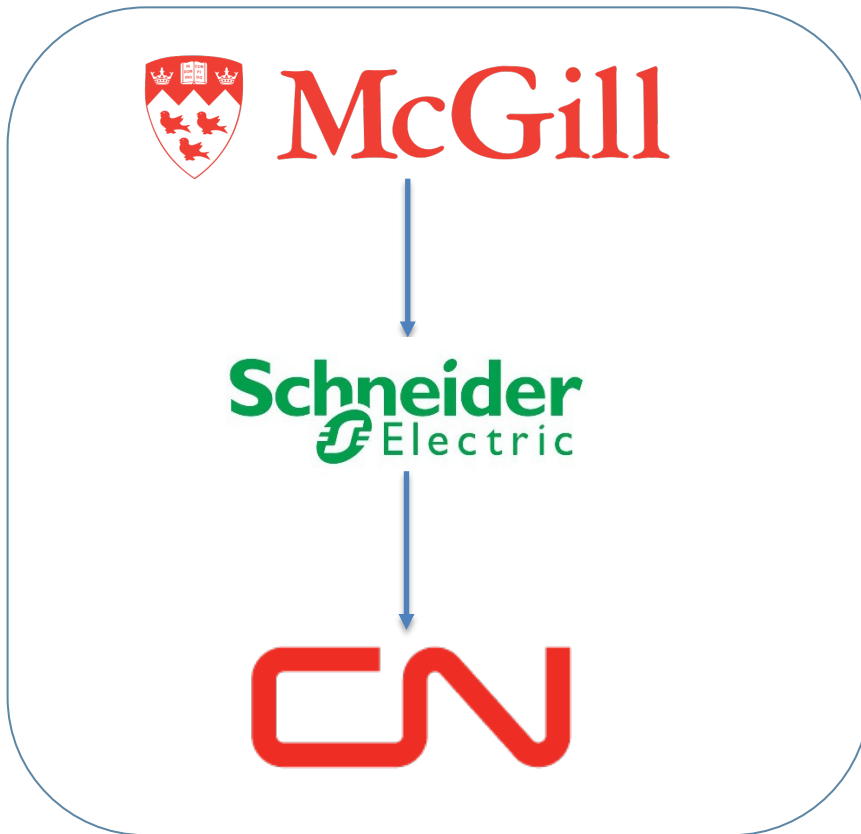


An aerial photograph of a long freight train traveling through a lush, green forested valley. The train, led by a red and black CN locomotive, stretches across the frame from the bottom right towards the top left. The landscape is dominated by dense evergreen forests, with a large, rounded hill in the background. A small clearing with a few buildings is visible near the center of the valley. The sky is blue with scattered white clouds.

The Power of an Energy Management system

Ali Omran

Asset Management Manager- CN



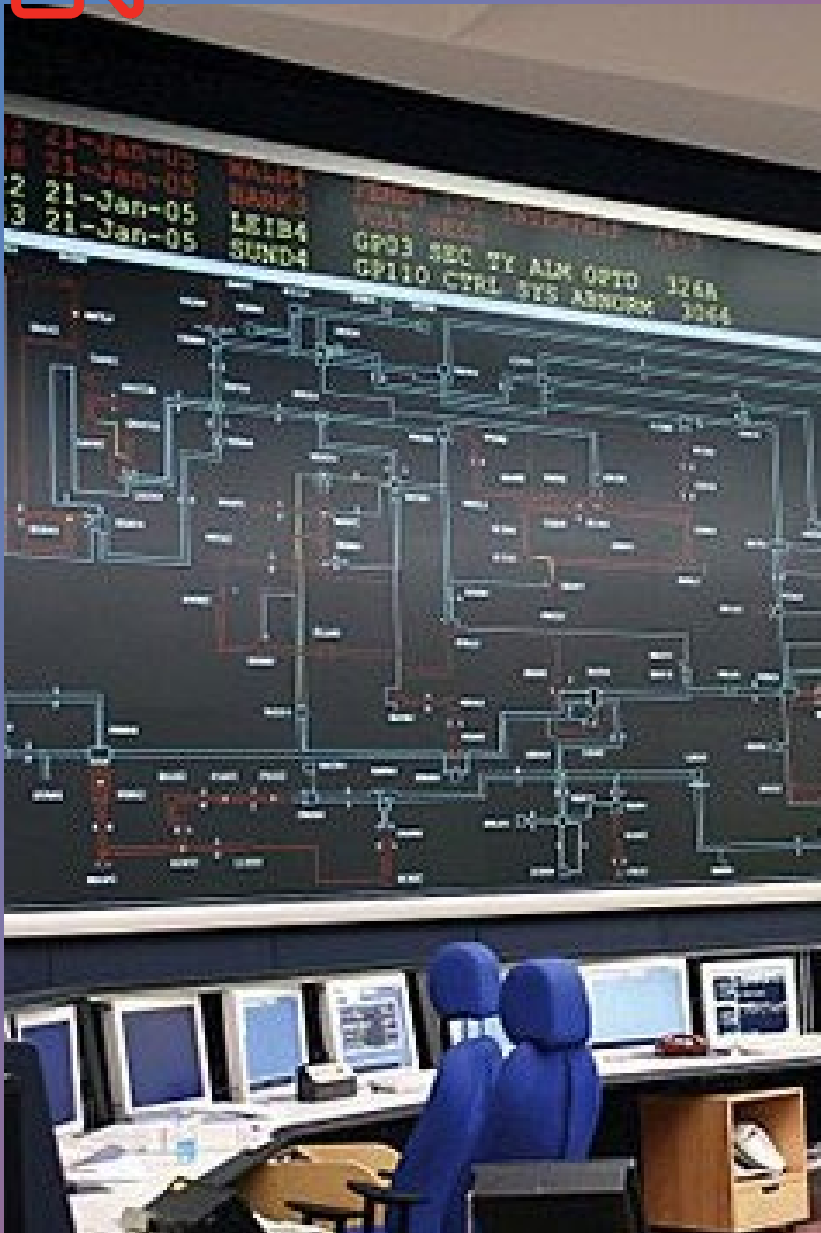
Mcgill University B.Eng
Electrical Engineering 2014



Schneider Electric Advanced
Technical Support. 2014-
2017



- Joined CN Energy Management team 2017
- Leading CN Facilities Asset Management efforts since 2021



Agenda

- Benefits of real-time data to field staff
- Integration of EMIS data with enterprise BI tools
- Non-Energy benefits of EMIS systems
- Lessons learned from large developments



- ❖ 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

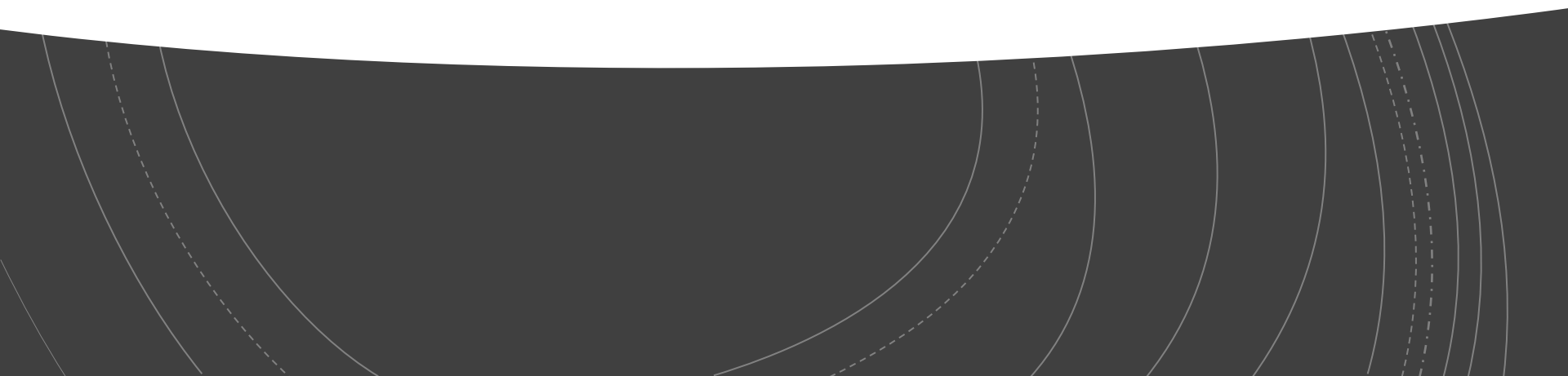
- 25 Major Yard Monitored across North America
- Monitored Yearly Electrical Energy: 100 GWh (~ 9300 homes or YVR)
- Facilities: 2600 buildings and shops across CN network. Various equipment including: Compressors, switch heaters, Communications.
- Monitored Peak demand : 30 MW



A Typical Large Yard



Monitoring Infrastructure



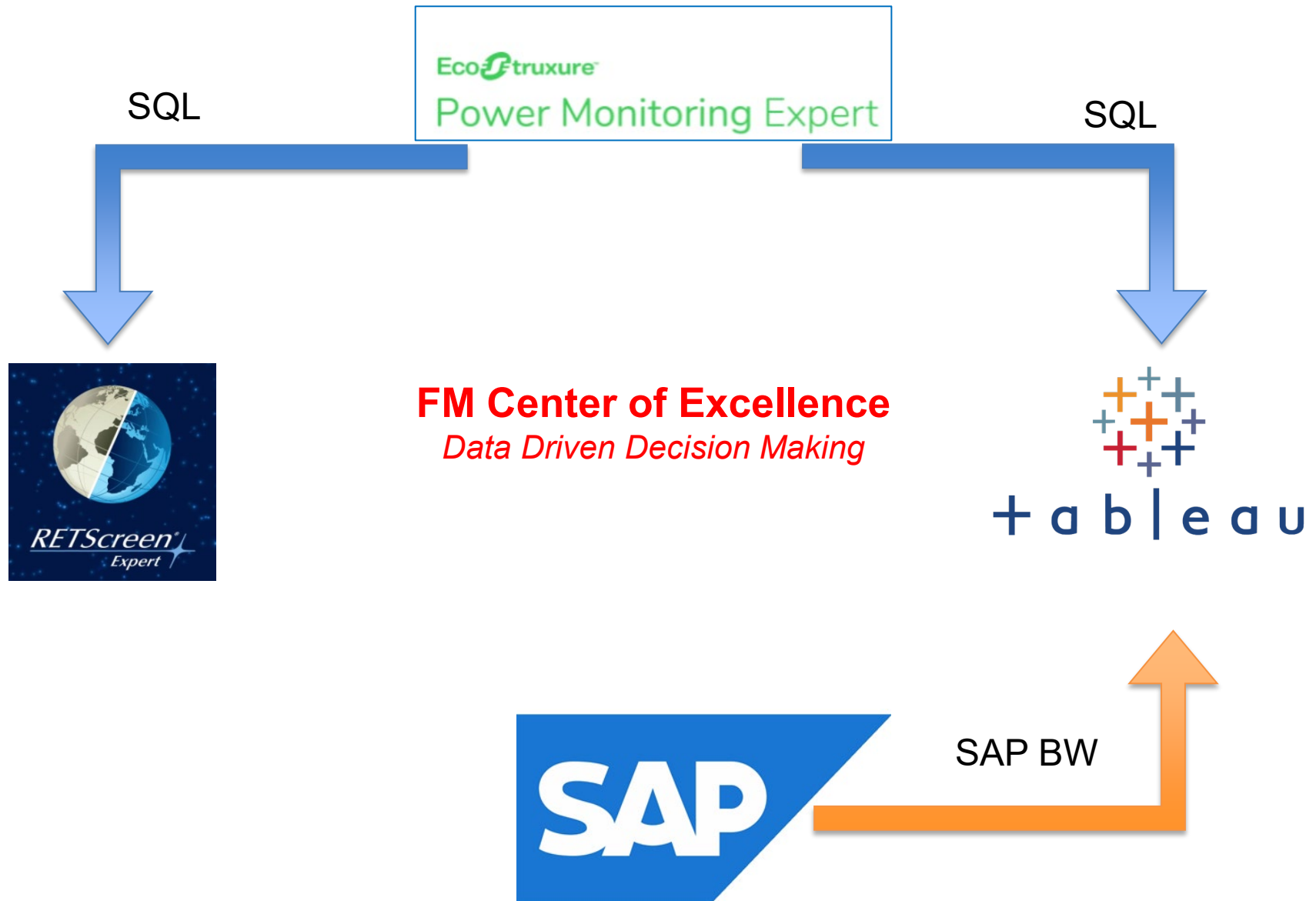
Monitoring Infrastructure- Field Devices

1- Developed a Monitoring standard to streamline installations on existing infrastructure as well as new installations

2- The focus is on critical assets that can help the team from both the maintenance and energy management aspect .



Monitoring Infrastructure- Software Layers





Select Year
2020

Date Comparison
Current vs. Prior Year

Yard Name
All

Color Legend
-5.0% 5.0%

Top N Sites
10

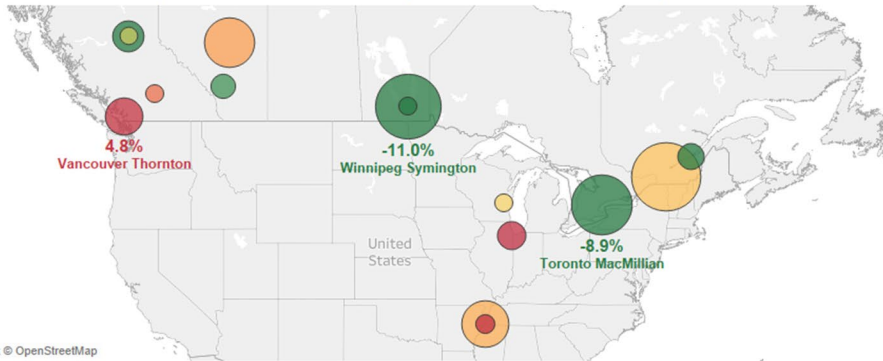
Last Update
December 1, 2021

Energy This Year **99,811 MWh** Change: -13.5%

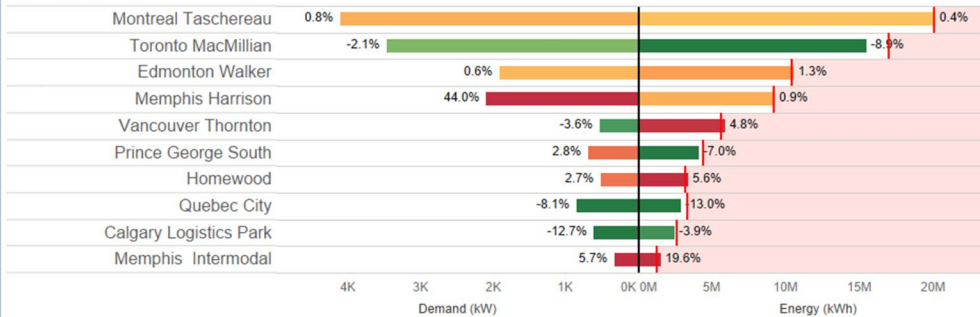
Demand This Year **21,732 kW** Change: -11.4%

Energy Savings **-\$1,265,317** YTD:

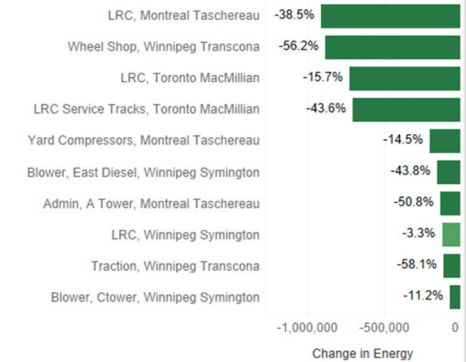
GHG Savings **-448,840** YTD:



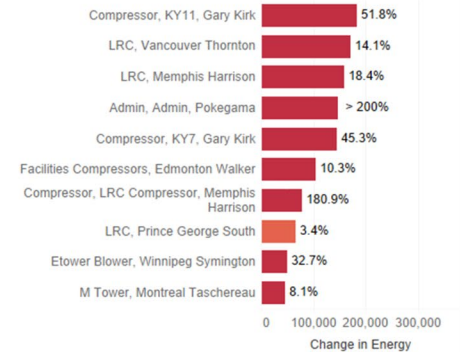
Energy and Demand Top 10



Top 10 Buildings & Equipment



Worst 10 Buildings & Equipment



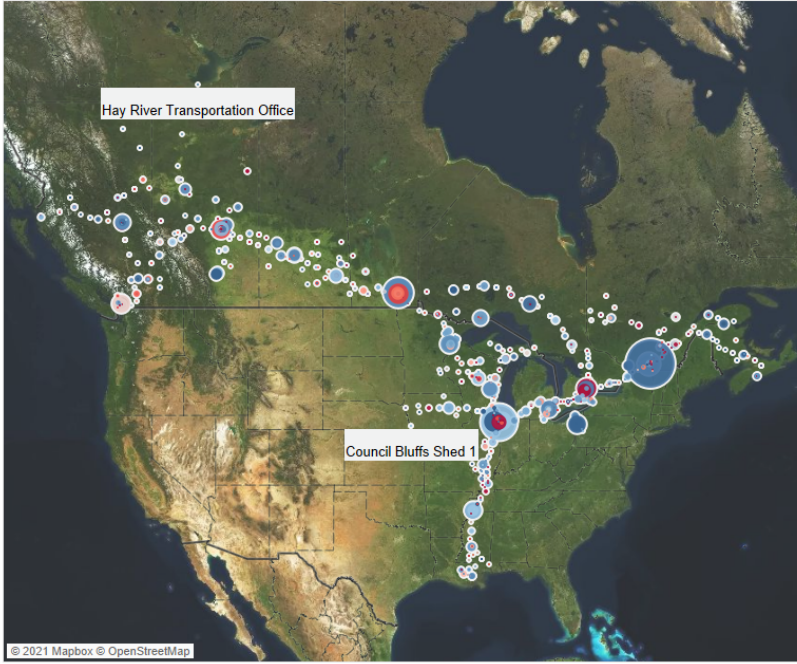
Integration- Tableau based
Energy dashboards



FM Asset Management

Building Level Cost Analysis: **Multiple Cities Selected**

Total Sqft: 8,784,453	\$Janitorial/Sqft: \$1.58	Average FCI: 0.27	Building Count: 1,323
Total Cost: \$56.34M	\$Utilities/Sqft: \$1.94	FCI <0.3: 749	CRV: \$1,760.2M
\$/Sqft: \$6.41	\$R&M/Sqft: \$2.89	FCI >0.3: 572	DM: \$483.3M



\$/Sq.ft \$0.0 \$14.0

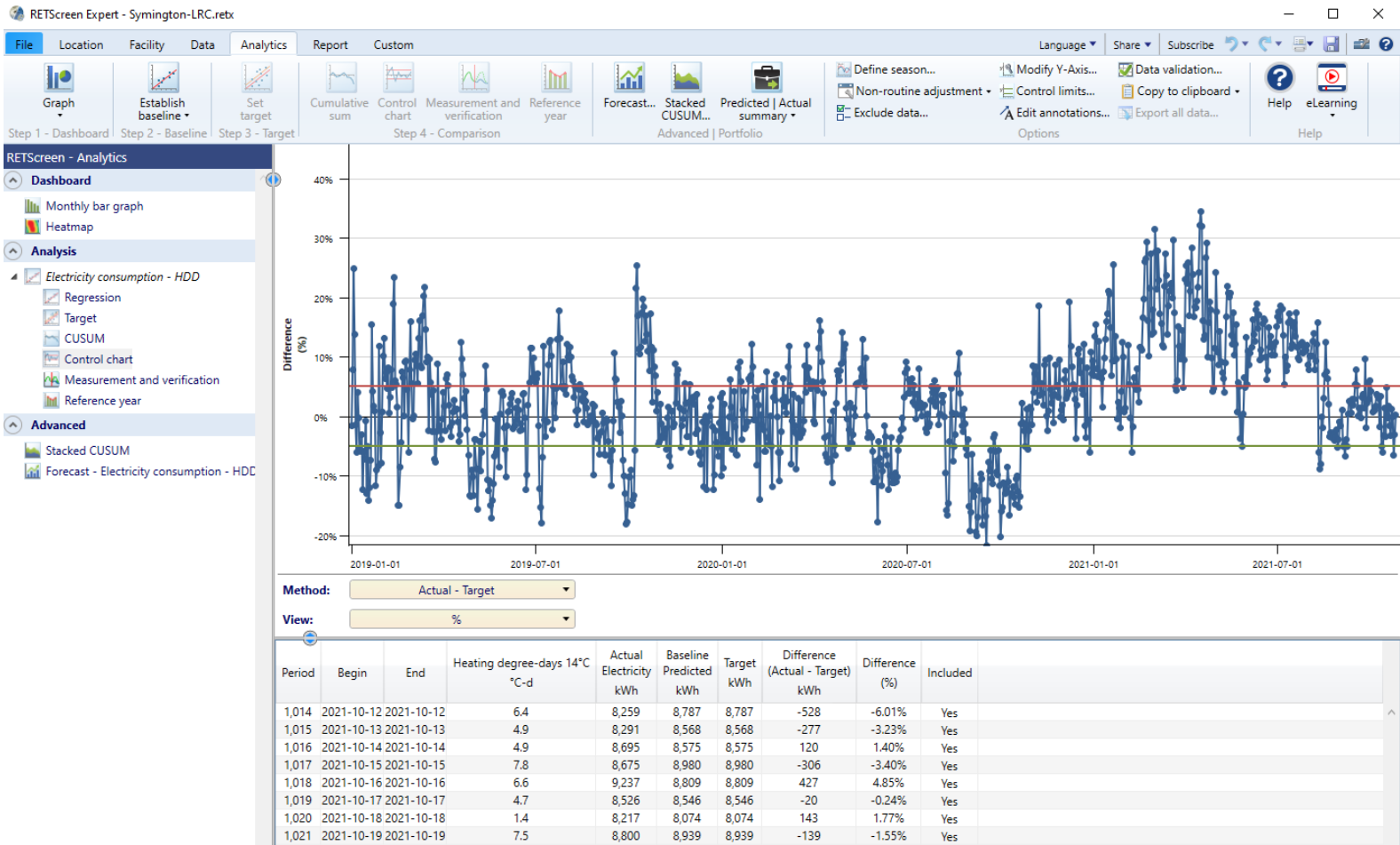
Country All	City All	Building Type All	Sorting Method Utility	City Level	List View
State/Prov All	FCI Value All	Building Status All	Graph Value Sorted Field		

Utility of Building Sorted By Utility | Click on a building to see survey

WOO-LRC	Woodcrest LRC	Homewood, IL	FM_LRC	
MAC-LRC	Macmillan LRC	Vaughan, ON	FM_LRC	
EDM-LRC	Walker - LRC	Edmonton, AB	FM_LRC	528,000
BRA-055	Brampton 55 Devon Road	Brampton, ON	FM_Office	422,800
PRI-LRC-RMO	Prince George SY Mechanical LRC	Prince George, BC	FM_LRC	414,000
HOM-ADM	Homewood Administration Bldg	Homewood, IL	FM_Office	300,000
EDM-OPS	Walker Operations Building - A Building	Edmonton, AB	FM_Office	290,000
SAS-MEC	Saskatoon Mechanical Shop	Saskatoon, SK	FM_CarShop	270,000
SYM-LRC	Symington LRC	Winnipeg, MB	FM_LRC	252,350
TRA-POW	Transcona Power Plant	Winnipeg, MB	FM_Shed	246,398
MAC-ADB	Macmillan Administration B Building	Vaughan, ON	FM_Office	242,297
TRA-CAM	Transcona CN Campus	Winnipeg, MB	FM_Campus	221,240
FON-MEC	Building A	North Fond Du Lac, WI	FM_LRC	208,617
EDM-OPB	Walker Operations Building - B Building	Edmonton, AB	FM_Office	200,000
MEL-MEC	Melville Car Shop	Melville, SK	FM_CarShop	196,000
FDL-FBS	B - Shop (Car Repair)	North Fond Du Lac, WI	FM_CarShop	193,485
TRA-WHE	Transcona wheel shop	Winnipeg, MB	FM_Shop	185,800
TRA-MOT	Transcona Motive Power Shop	Winnipeg, MB	FM_Shop	179,610
MEM-LRC	Memphis LRC	Memphis, TN	FM_LRC	171,600
MEM-CAR	Memphis car shop	Memphis, TN	FM_CarShop	167,700
TAS-COM	Taschereau LRC Atelier Diesel	Montreal, QC	FM_LRC	163,182
TRA-CAR	Transcona Car Shop	Winnipeg, MB	FM_CarShop	156,228
EDM-HRC-CAR	Edmonton Walker HRC Car Shop Bldg	Edmonton, AB	FM_Shop	150,000
EDM-FMS	Edmonton Walker Facility Maintenance Shop	Edmonton, AB	FM_Shop	140,000
MAC-ADM	Macmillan Administration A Building	Vaughan, ON	FM_BunkHouse	136,481

0K 500K Sort by Total

Integration- Energy +Asset Management



Integration- RETSCREEN

Example System: Compressed Air

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

Vista Screens, Trends, Historical Gadgets



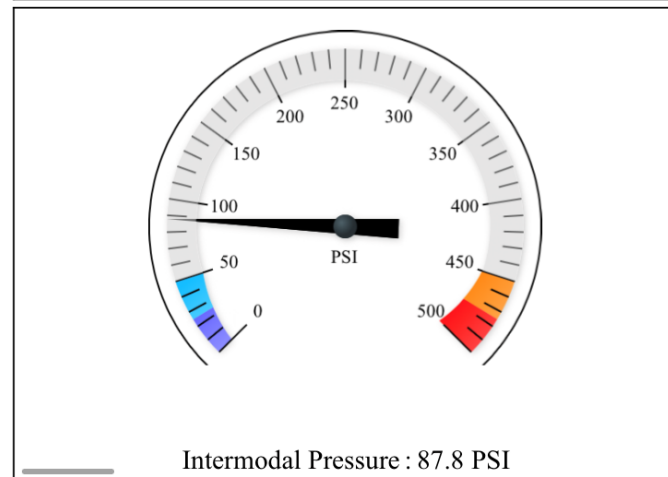
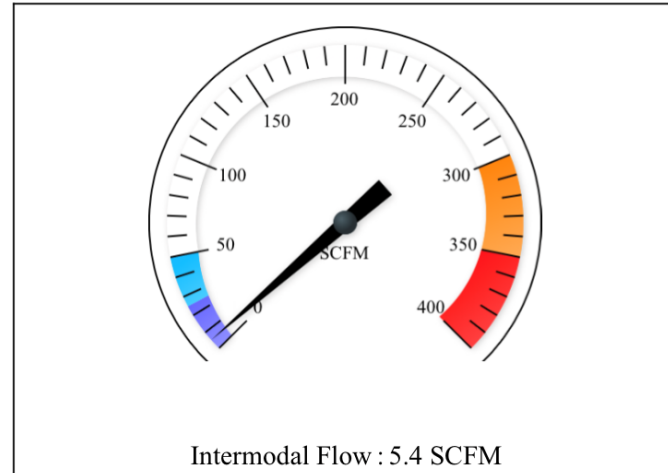
Demand Monitoring

Detect Abnormalities

Ease of accessibility

1- Union staff have mobile access to monitor Compressors

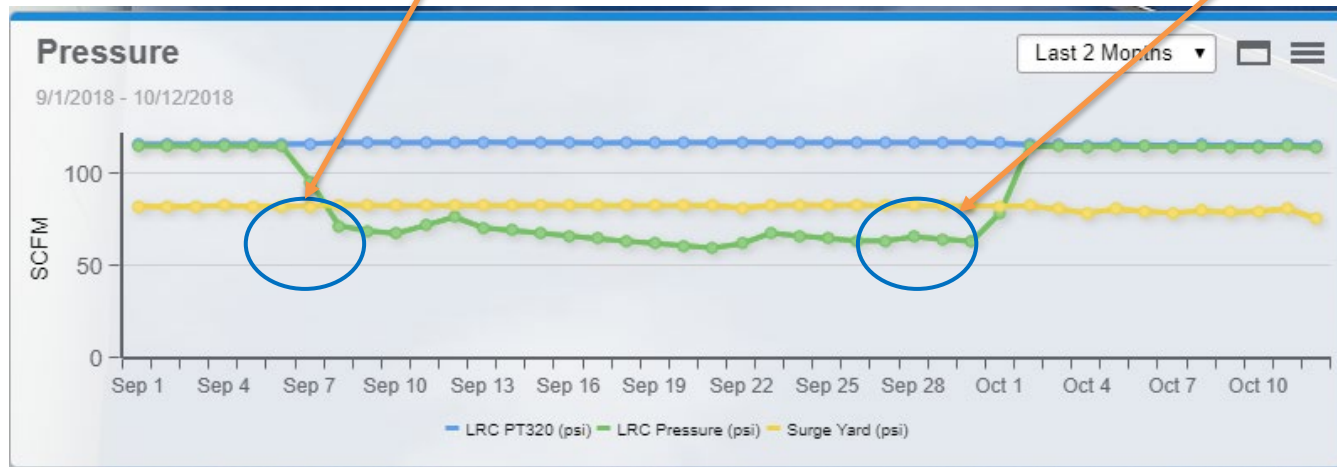
Edmonton Intermodal



Compressor Incident- Vancouver

Sudden Unexplained pressure drop

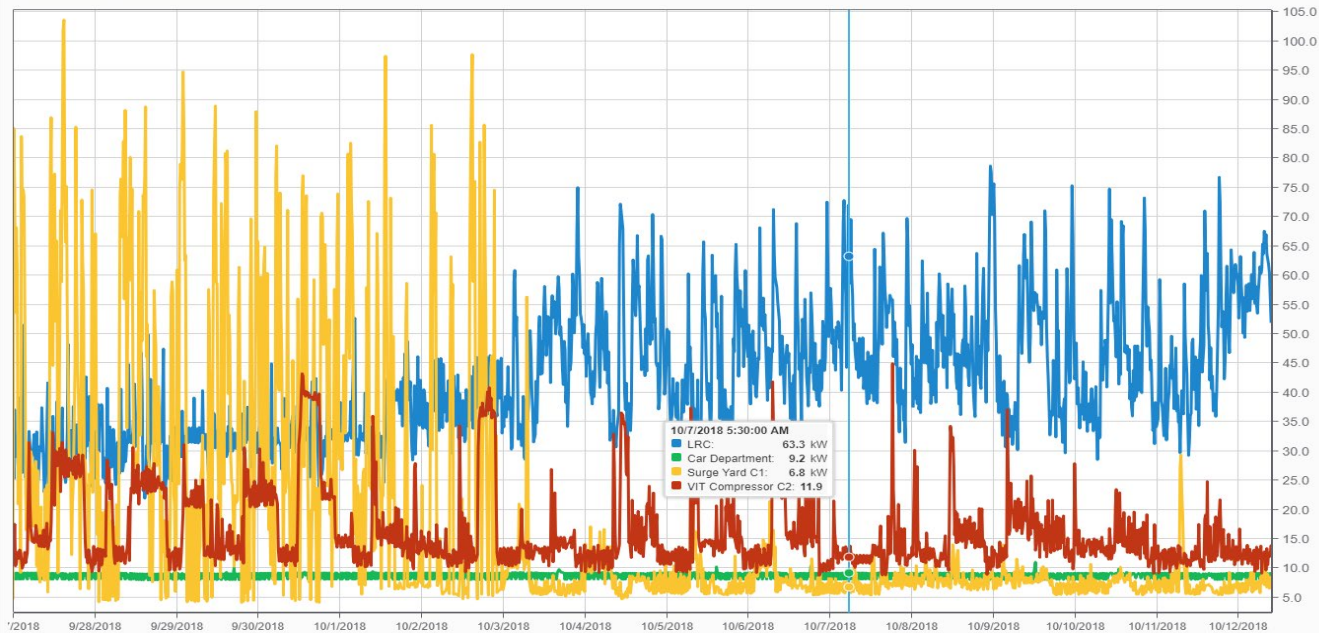
Issue found and valve opened



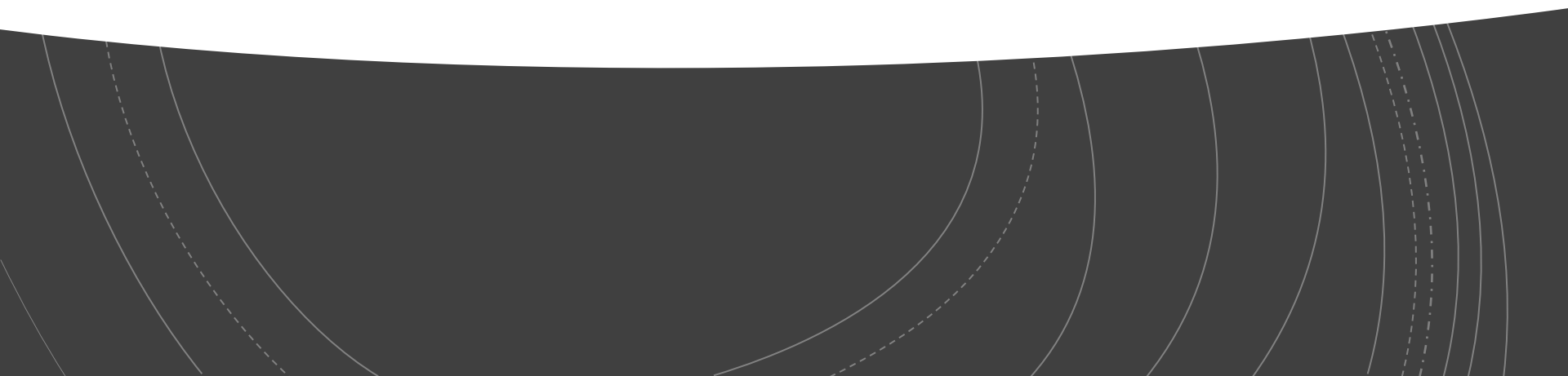
Vancouver Compressors Demand

Vancouver Compressors

Update in 0:06



Example System: Snow Blower System

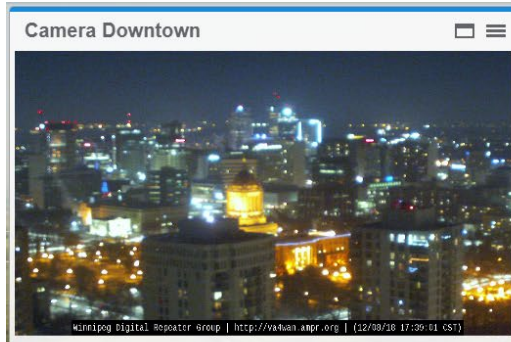


Switch heater Monitoring

- 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.



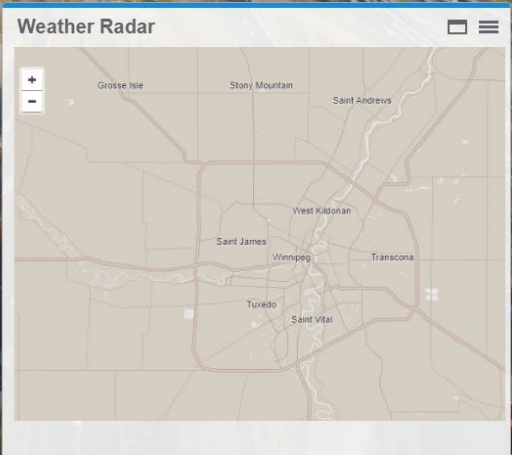
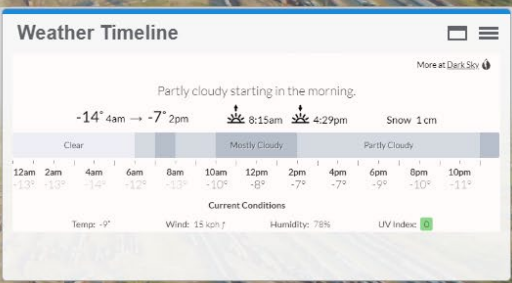
Yard Equipment monitoring (NEBs)



Symington Yard Blower Automation System

Field Temperature **-8.9 C** Field Sensor **No Snow** Snow Drift **No Drift** Field Wind **17.42 km/h**
 Forecast Temperature **-8.6 C** Forecast Snow **No Snow** Criteria **Met** Forecast Wind **20.90 km/h**

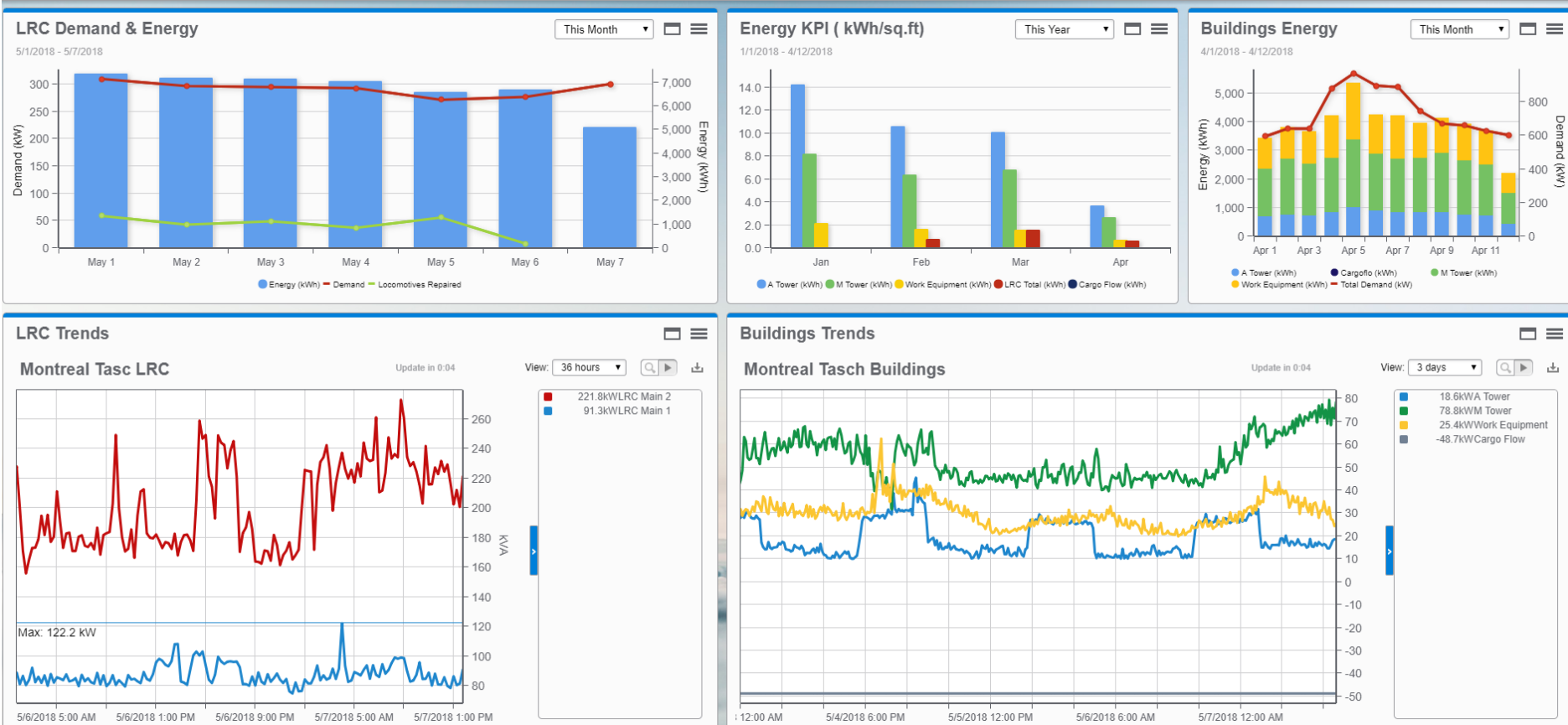
Location	Control Status	Relay Status	Total Amps	Normal Amps	Zone Lockout
Ladder Track North	AUTOMATIC	RELAY ON	0.0 Amps		NORMAL
Ladder Track South	AUTOMATIC	RELAY ON	0.0 Amps		NORMAL
Local Yard	AUTOMATIC	RELAY ON	0.0 Amps		LOCKOUT
Location 9	AUTOMATIC	RELAY ON	42.5 Amps	38.8 Amps	NORMAL
W Tower	AUTOMATIC	RELAY ON	81.2 Amps	111.6 Amps	NORMAL
Sprague South East	AUTOMATIC	RELAY ON	190.5 Amps	164.7 Amps	NORMAL
E Tower	AUTOMATIC	RELAY ON	84.9 Amps	106.6 Amps	NORMAL
Long Points	AUTOMATIC	RELAY ON	57.5 Amps	45.7 Amps	NORMAL
Local Tower A - Central	AUTOMATIC	RELAY ON	76.4 Amps		NORMAL
Local Tower - B 66/20/1	AUTOMATIC	RELAY ON	75.0 Amps		NORMAL
Local Tower C - East	AUTOMATIC	RELAY ON	2.4 Amps		NORMAL
East Diesel Shop	AUTOMATIC	RELAY ON	111.7 Amps	95.6 Amps	NORMAL
C Tower - Hump (1&2)	AUTOMATIC	RELAY ON	120.1 Amps	119.5 Amps	NORMAL
C Tower - Hump (3&4)	AUTOMATIC	RELAY ON	50.5 Amps	52.7 Amps	NORMAL
C Tower - Hump (5&6)	AUTOMATIC	RELAY ON	116.7 Amps	117.2 Amps	NORMAL
S Tower	AUTOMATIC	RELAY ON	116.7 Amps	55.8 Amps	NORMAL
C Tower - Hump (8&9)	AUTOMATIC	RELAY ON	125.9 Amps	126.4 Amps	NORMAL
West LRC (DF)	AUTOMATIC	RELAY ON	122.7 Amps	122.2 Amps	NORMAL
West Fort Rouge	AUTOMATIC	RELAY ON	0.0 Amps		LOCKOUT
Pole 32	AUTOMATIC	RELAY ON	71.6 Amps	76.1 Amps	NORMAL



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

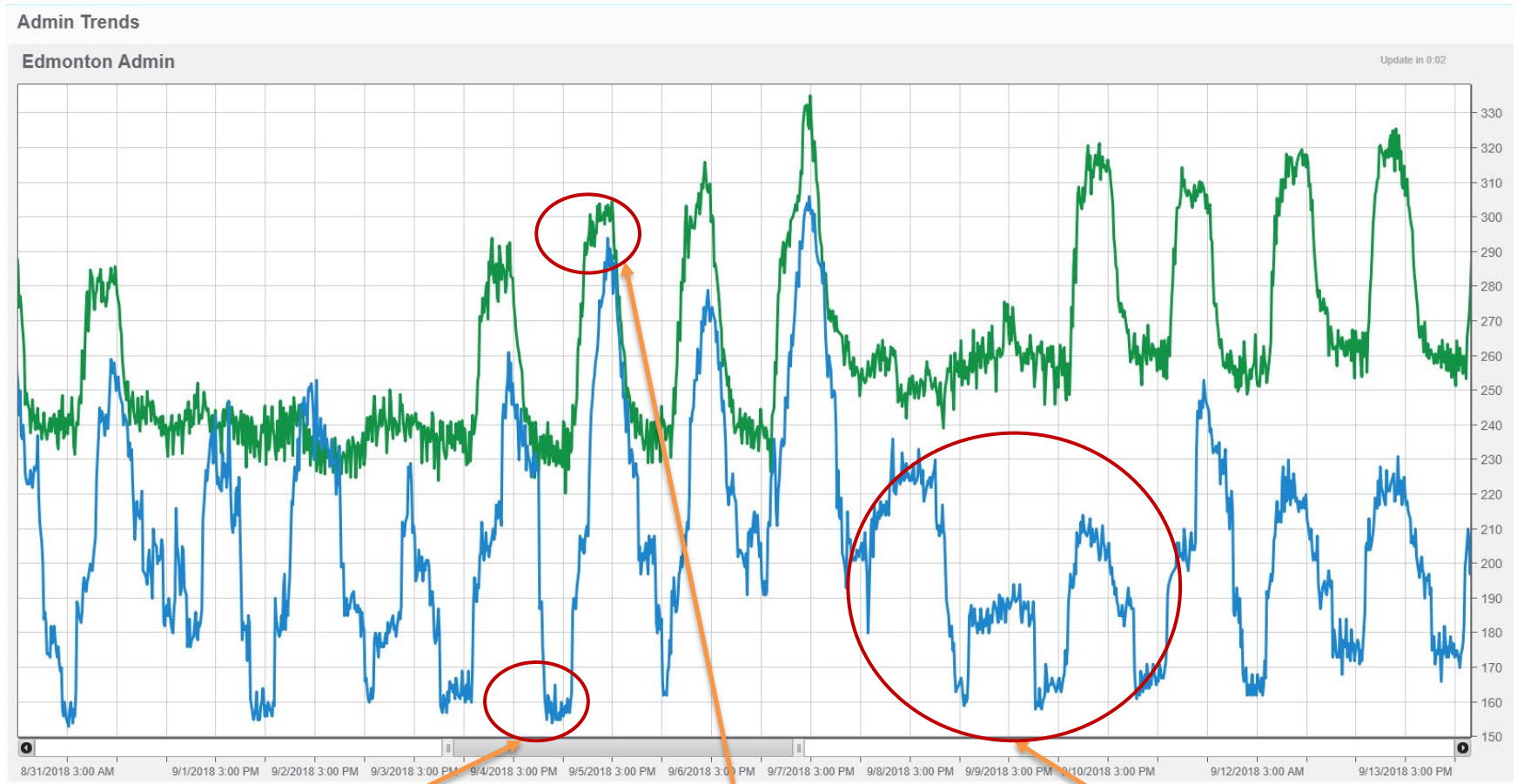
Buildings Monitoring

- 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



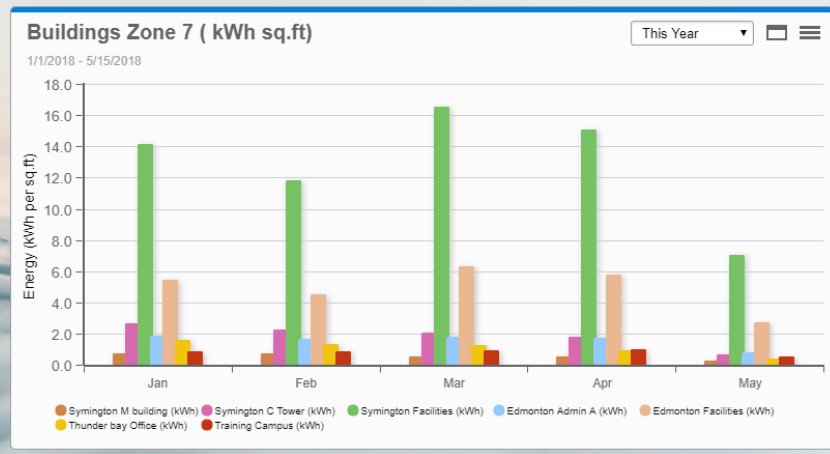
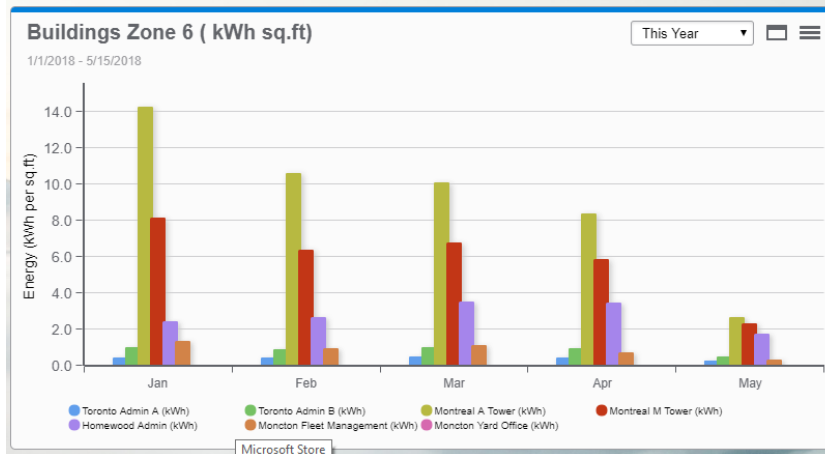
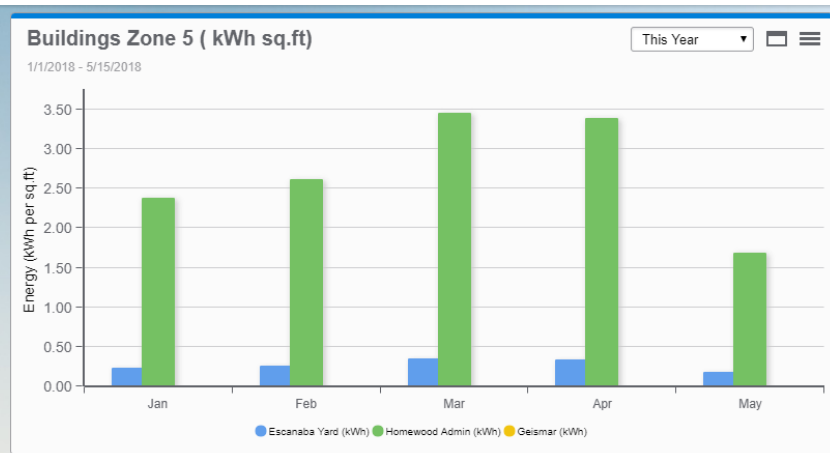
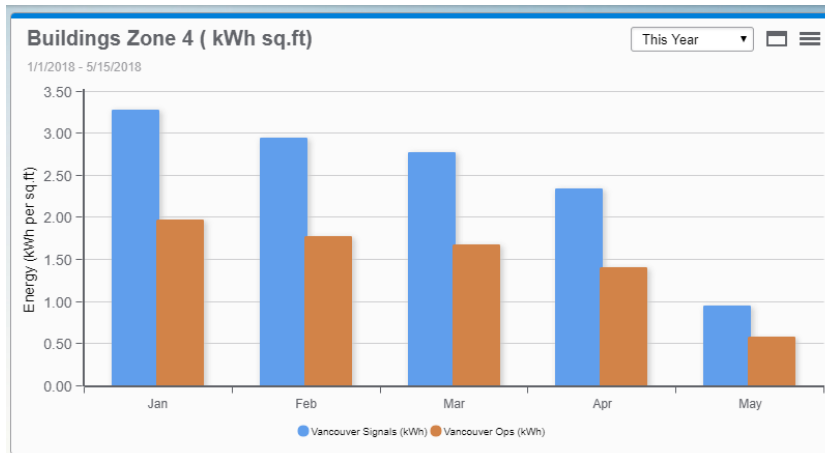
Better night setbacks

Comparable day loads

Weekend shift footprint is lower

Benchmarking

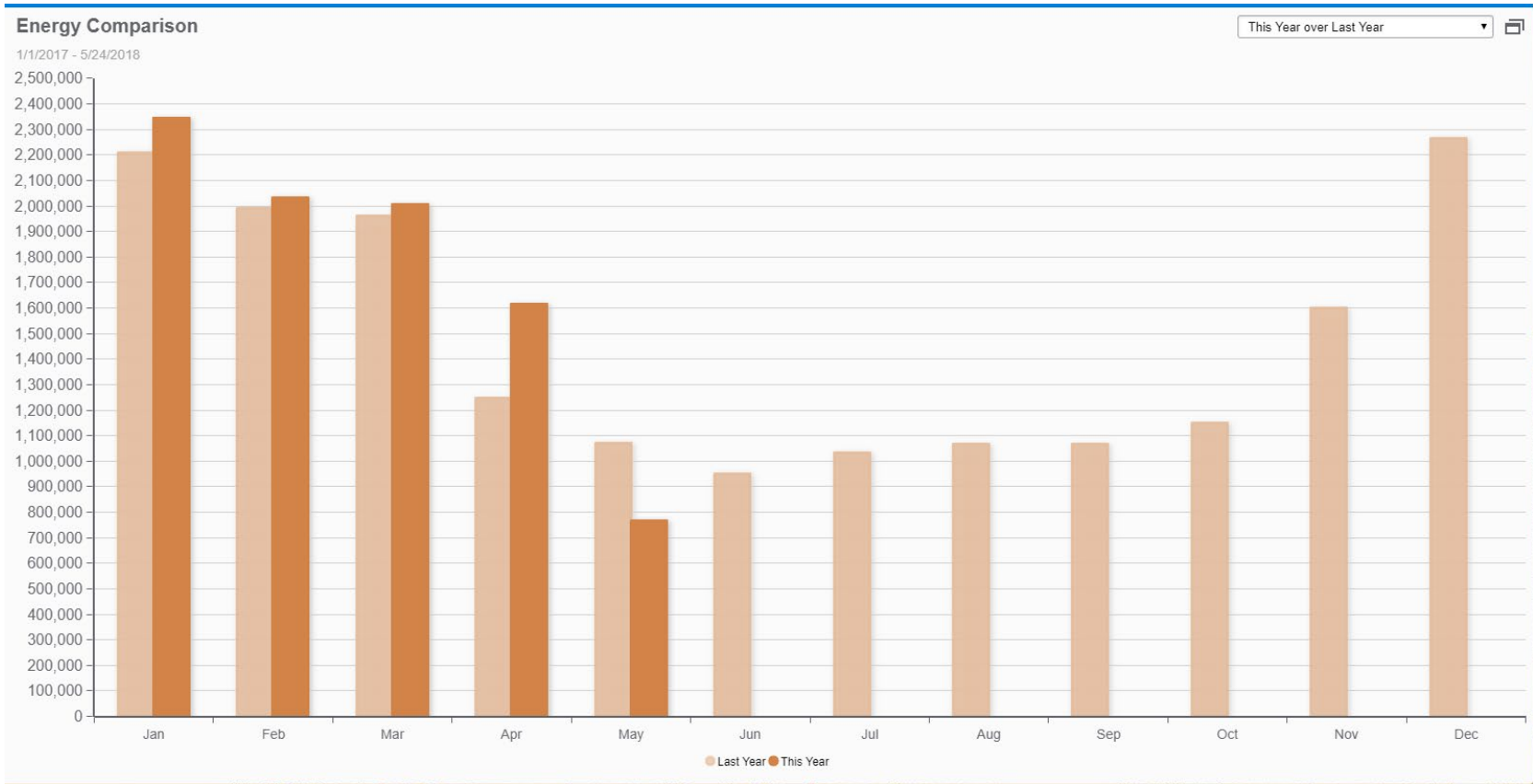
- 1- Group Buildings based on ASHRAE climate zone
- 2- Easy to compare building performance and establish benchmarks



Microsoft Store

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).



Evolution of EMS



How it started

MacMillian Yard System Overview

MacMillian Yard (Total) : 1,565.2 kW	MacMillian Yard (Total) : 1,789.8 kVA
Langstaff Rd (Total) : 0.0 kW	MacMillian Yard (Total) : 1,565.2 kW
Highway 7 (Total) : 1,565.2 kW	MacMillian Yard (Total) : 0.8745 PF
LRC - Diesel Shop (Total) : 565.8 kW	MacMillian Yard (Total)* : 27,338 Volts
Car Shop (Total) : 127.0 kW	Rates : \$/kW Rates : \$/kWh
Administration Bldg (Total) : 324.7 kW	Electrical Costs (Month to Date) \$:
Wheel Shop (Total) : 0.0 kW	Administration Bldg (Total) : 324.7 kW
Maintenance Shop (Total) : 0.0 kW	Building A (Total) : 72.3 kW
UnMetered (Total) : 547.8 kW	Building B (Total) : 252.6 kW
LRC - Diesel Shop (Total) : 565.8 kW	Natural Gas (Bldg) : 0 CuF/Hr
Main 1 (Total) : 324.1 kW	Car Shop (Total) : 127.0 kW
Main 2 (Total) : 240.5 kW	Natural Gas (Bldg) : 0 CuF/Hr
Service Tracks (Total) : 169.3 kW	Compressed Air (Total Yard) : kW
LRC Natural Gas (Bldg) : 0 CuF/Hr	Compressed Air (Total Yard) : SCFM
Nat Gas Costs (Month to Date) \$: 0.00	L Yard - Compressor (Total) : 48.4 kW
Temp : 22.8 Celcius Wind : 25.0 - km/Hr	Compressed Air (Total) : 10 SCFM
Wind Dir : 210 Deg S No Precipitation	Compressed Air (Total) : 127.0 PSIG
	Dryer (Total) : 0 kW
	West Yard - Compressor (Total) : 75.5 kW
	Compressed Air (Total) : 21 SCFM
	Compressed Air (Total) : 138 PSIG
	Dryer (Total) : 0 kW

MacMillian Yard (Total) : 1,568 kW

MacMillian Yard Compressed Air	Brampton Intermodal Compressed Air	MacMillian Yard (Total) : kW
Local Yard - C1 - (Total) : 0.0 kW	North Yard - C1 - (Total) : ... kW	Langstaff Rd (Total) : 0.0 kW
Local Yard - C2 - (Total) : 26.3 kW	North Yard - (Total) : ... SCFM	Highway 7 (Total) : 1,568.0 kW
Local Yard - Dryer - (Total) : 0.0 kW	North Yard - (Total) : ... PSI	LRC - Diesel Shop (Total) : kW
Local Yard - (Total) : 7.7 SCFM	South Yard - C1 - (Total) : ... kW	Car Shop (Total) : 125.9 kW
Local Yard - (Total) : 132.9 PSI	South Yard - (Total) : ... SCFM	Administration Bldg (Total) : kW
West Yard - C1 - (Total) : 51.4 kW	South Yard - (Total) : ... PSI	MacMillian Yard (Total)* : 27,409 Volts
West Yard - C2 - (Total) : 26.1 kW		
West Yard - Dryer - (Total) : 0.0 kW		
West Yard - (Total) : 17.5 SCFM		
West Yard - (Total) : 138.1 PSI		
East Yard - C1 - (Total) : ... kW		
East Yard - C2 - (Total) : ... kW		
East Yard - Dryer - (Total) : ... kW		
East Yard - (Total) : ... SCFM		
East Yard - (Total) : ... PSI		

Brampton Data Center	MacMillian Yard (Total) : kW
Main Incoming - (Total) : ... kW	Brampton Intermodal (Total) : kW
Main Incoming - Vab : ... Volts	Main Incoming 1 (Total) : ... kW
Main Incoming - Vbc : ... Volts	Main Incoming 2 - Refer (Total) : ... kW
Main Incoming - Vca : ... Volts	Maritime Ontario (Total) : 5.8 kW
Main Incoming - Ia : ... Amps	Operations Bldg Vault - VII Avg : ... Volts
Main Incoming - Ib : ... Amps	North Gen Vault - VII Avg : ... Volts
Main Incoming - Ic : ... Amps	Clark Street Vault - VII Avg : ... Volts
	In Gate Vault - VII Avg : ... Volts

C Tower Pressure (PSI_1 Receiver) : 85 PSI	C Tower Pressure (PSI_2 Regulated) : 0 PSI
L Tower Pressure (PSI_1 Receiver) : 91 PSI	L Tower Pressure (PSI_2 Regulated) : 0 PSI
Total Yard Flow (SCFM) : 237 SCFM	
Yard Total kW (C1_C2_C3) : 88 kW	C1 (L Tower) : 35 kW C1 (Hours) : 33,122.4 Hrs Day : 17.2 Hrs
Dryer Amps - L Tower (D1) : 0.00 Amps	C2 (C Tower) : 53 kW C2 (Hours) : 27,281.0 Hrs Day : 23.2 Hrs
L Tower Flow (SCFM) : 42 SCFM	C3 (C Tower) : 0 kW C3 (Hours) : 5,435.6 Hrs Day : 0.3 Hrs
C Tower Flow (SCFM) : 206 SCFM	

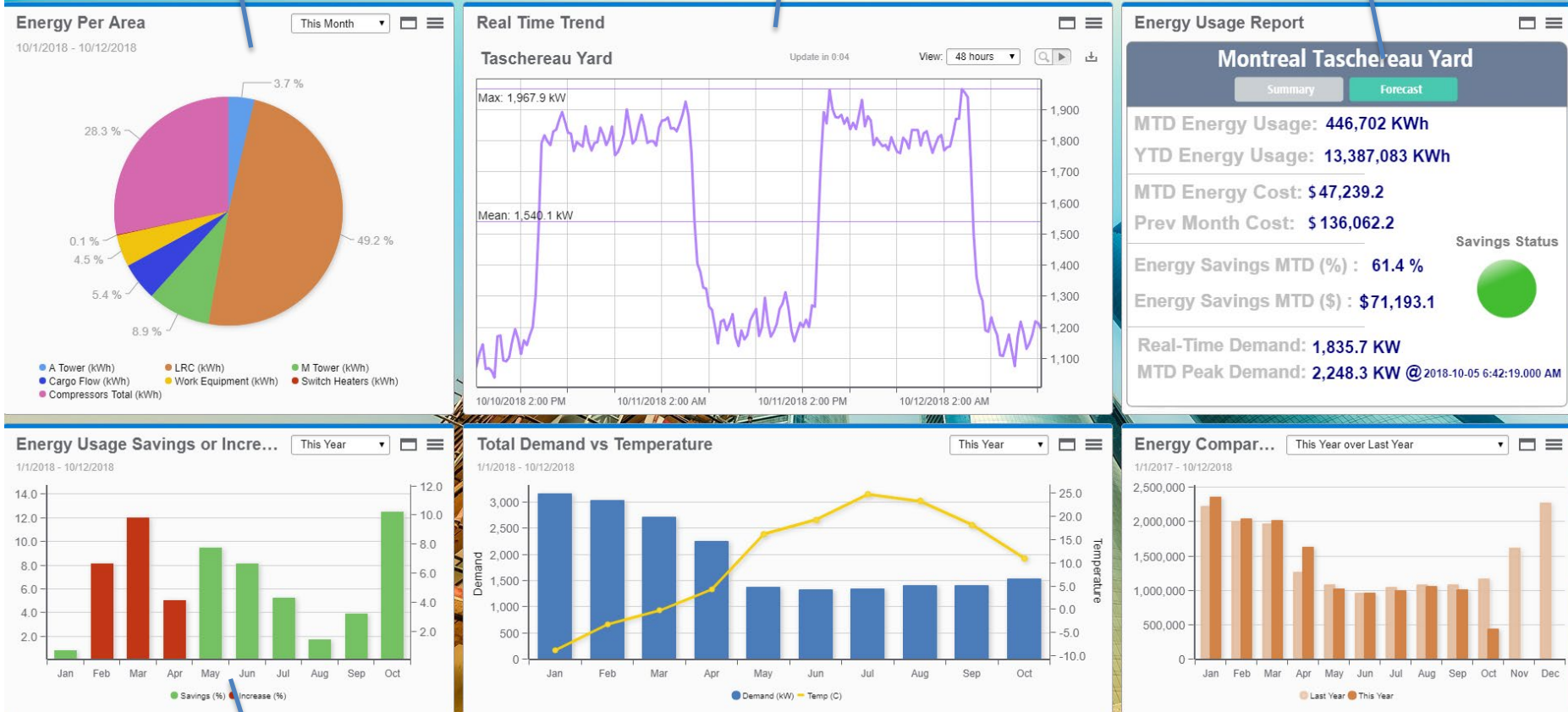
L Tower : 85 %
C Tower : 49 %

The Full story- Easy to read

Sub Metering

Real-Time Trend

Vista Screen



Energy Modeling results

Historical Data



Thank you!