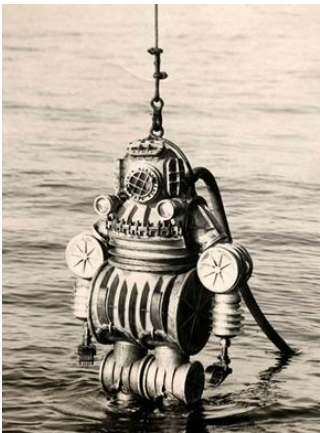




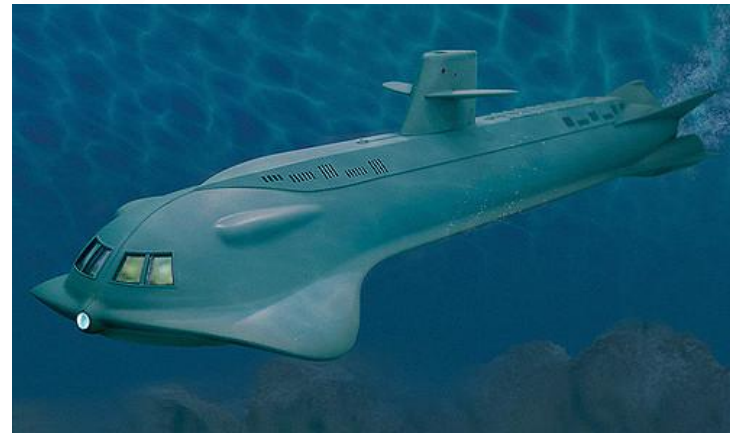
Deep Dive into Transformer Monitoring with PI



Inflatable Diving Suit



Vince Polsoni
Alectra Utilities



Agenda

- Alectra
- Maintenance Methodology
- Intelligent Transformer Maintenance
- Innovation
- Leveraging Integrated/ Interfaced Systems
- PI AF, Notifications, Analysis, Reporting



Where is Alectra?

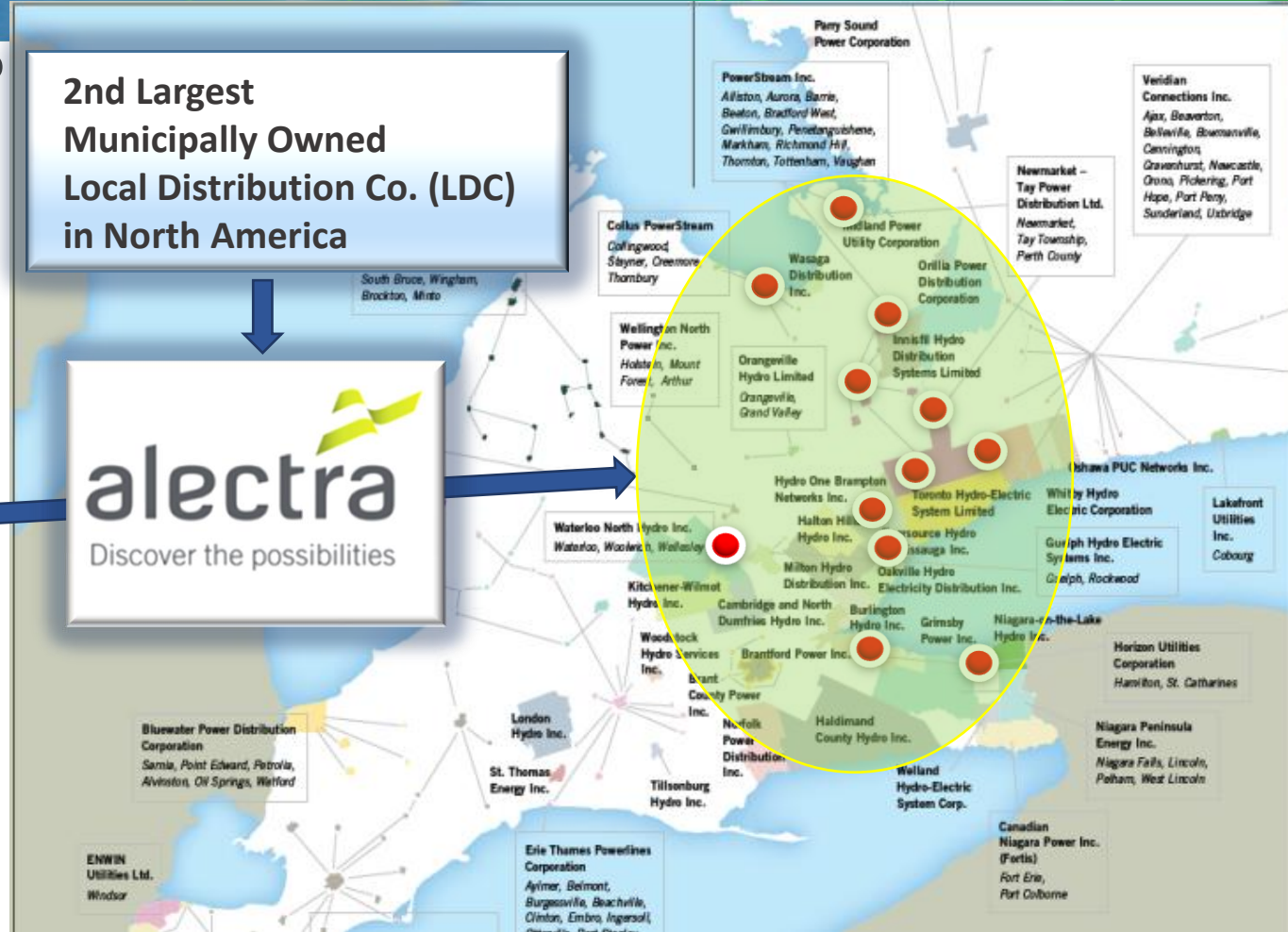


Ontario
1,068,587 km²

Alectra Service Territory

- Located just North and West of Toronto, Ontario, Canada
- 1800 km²
- 15 Communities
- 1 million Customers
- 3.1 million Population
- 4750 MW Peak Demand
- \$3.6 Billion Total Assets

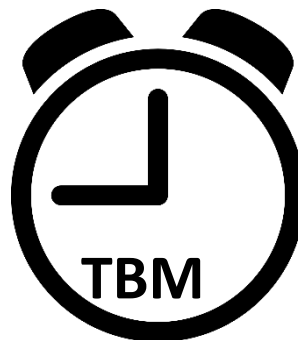
2nd Largest
Municipally Owned
Local Distribution Co. (LDC)
in North America



The Alectra Intelligent Maintenance Plan



RCM3 - ISO55000 Compliant
RCM3 - ISO31000 Compliant



(Time Based Maintenance)

100% of work (PM)
was time based

The Plan

RCM3

(Reliability Centered Maintenance)

RCM3



(Condition Based Maintenance)

- Preventive, Predictive
- On Condition Task
- Failure Finding
- Scheduled Restoration
- Scheduled Discard
- No Scheduled Maintenance

**'Right Work at
the Right Time,
Done the Right Way,
The First time'**

Intelligent Station Maintenance at Alectra

- Leverage integration of PI System and CMMS
- Risk Based - Condition Based Maintenance
- RCM3 methodology incorporated in CMMS
- Situational Awareness - Instant Information 24/7
 - PI Notifications (Real time)
 - Alerts from CMMS System
 - PI System Reports, Dashboards
- Automatic Triggered Maintenance Work Orders
- Analytics in multiple systems
- One source of data
- Keeping it Simple



The Alectra Intelligent Maintenance System

2 Key Components

1. CASCADE CMMS

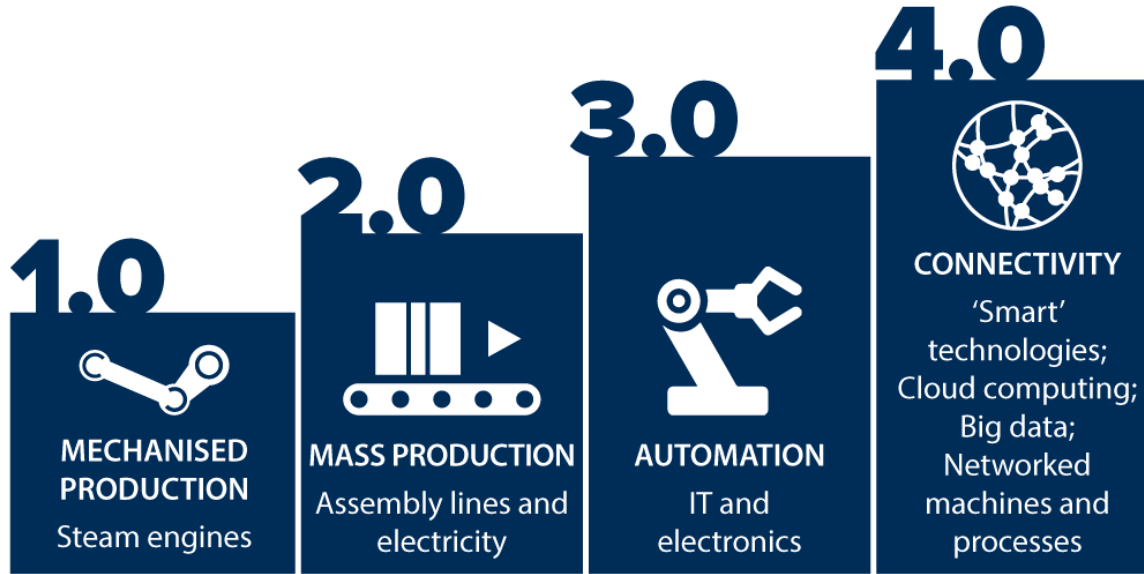
- Tracks assets, Maintenance history, Asset Condition and Costs
- Analytics
- Trigger maintenance tasks based on condition or events
- Interfaces with PI System, test equipment and Oil lab data
- Prioritize maintenance work – Criticality, Health and Risk

2. PI System

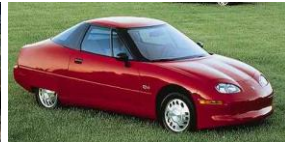
- Data collector, Speed optimized
- Real-time analysis and notifications
- Easy reporting tools, easy interfacing, enabler of IIOT



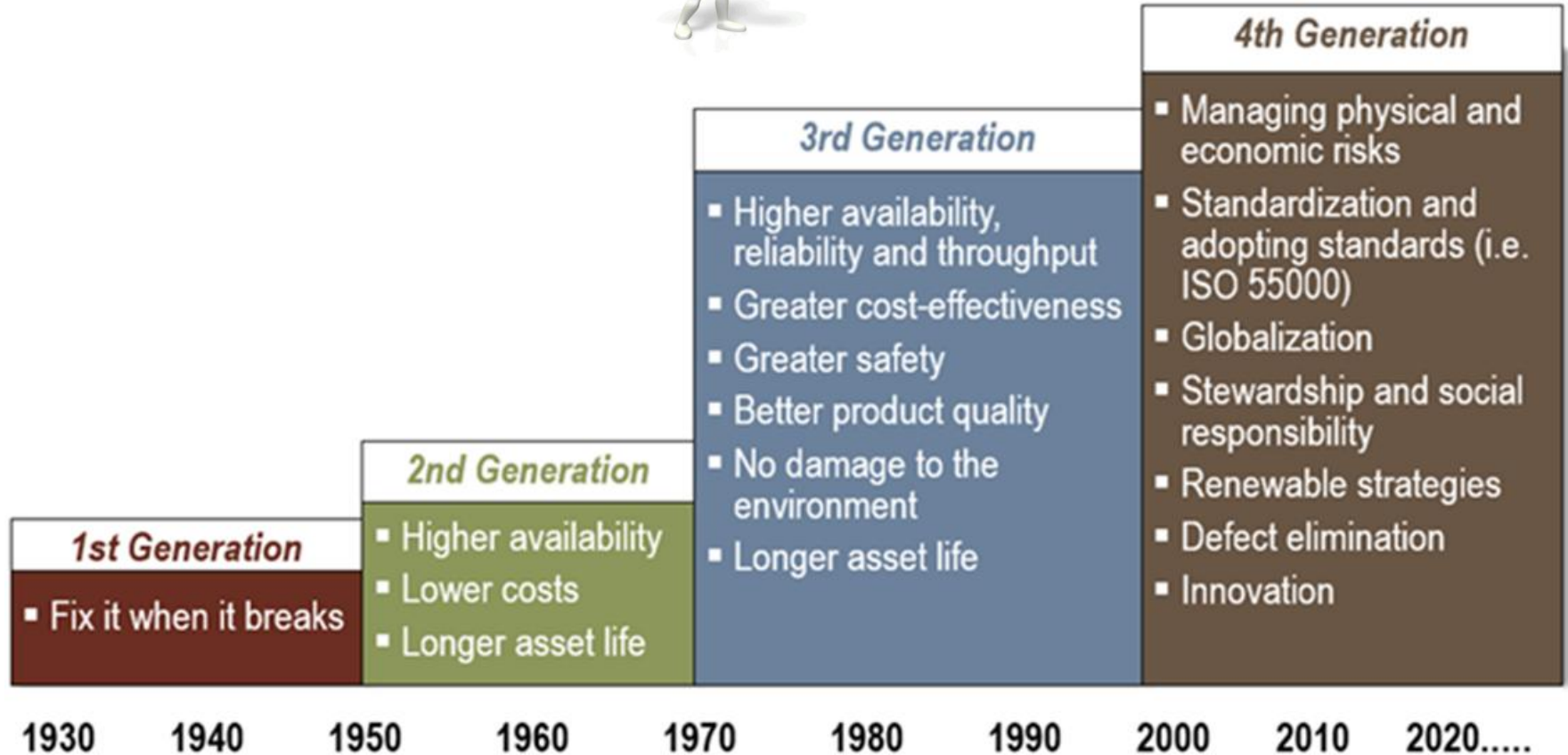
Industrial Development – Industry 1.0 to 4.0



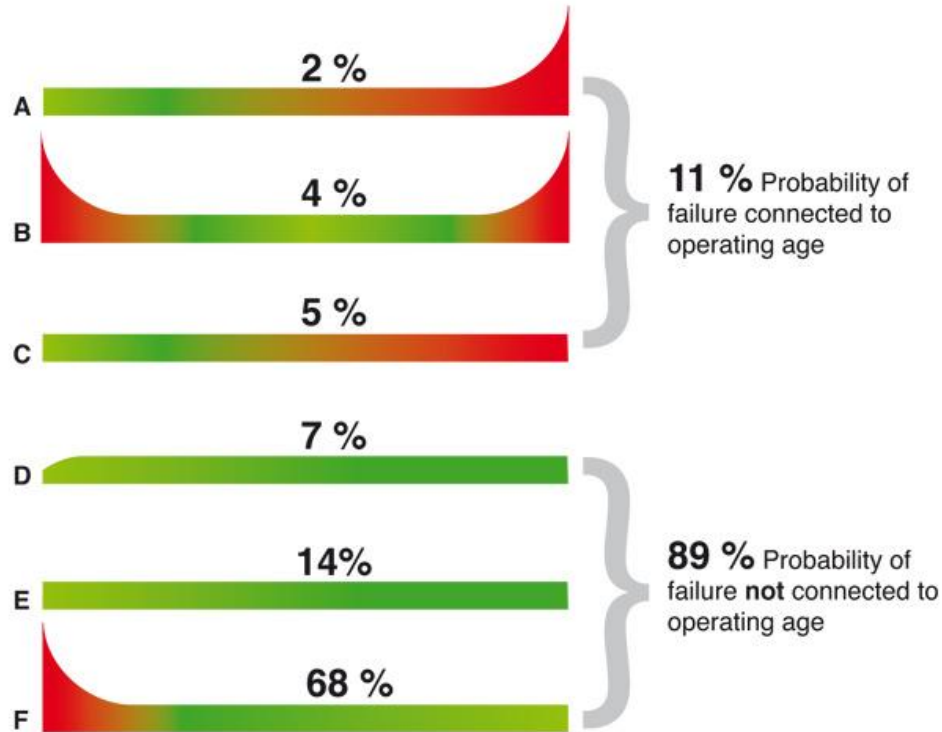
The stages of industrial development



What is RCM3



RCM3 - Understanding Failure Curves

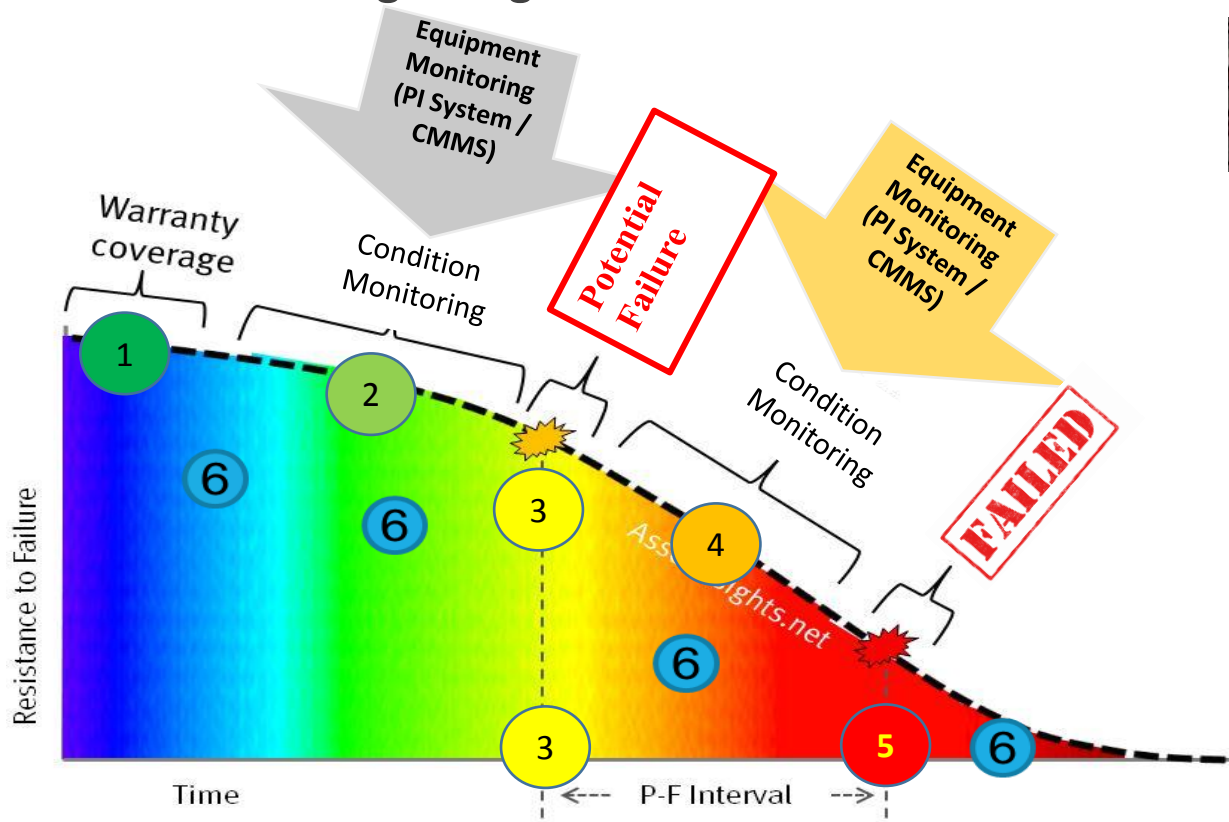


Source: RCM II by John Moubray, Industrial Press Inc, 1992

- Premature random failures
- Often after Human Intervention

RCM3 – On Condition Task

Condition Scoring Using Potential Failure “PF” Curve

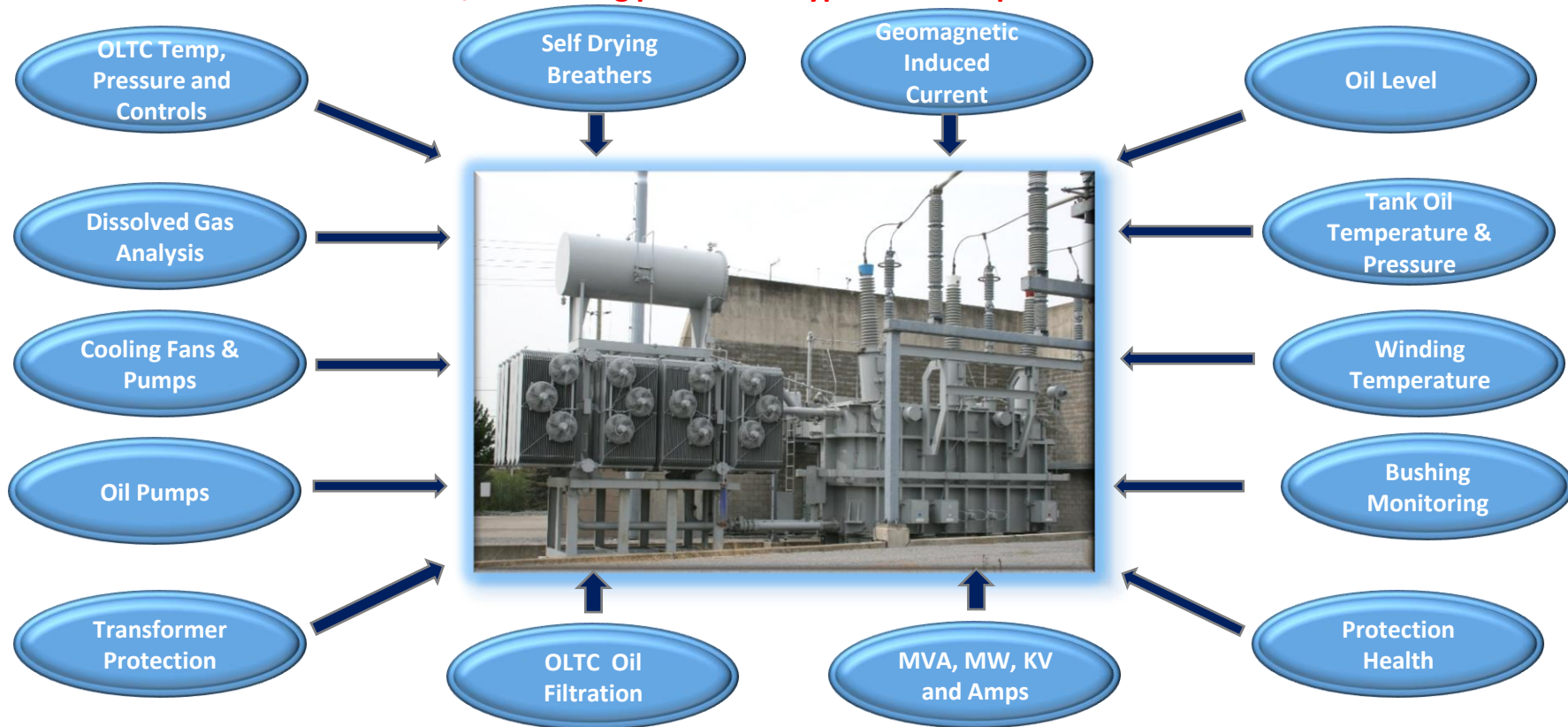


Alectra Condition Scoring Matrix

- 1 New
- 2 Used
- 3 Potential Failure
- 4 Failed – Schedule Repair
- 5 Failed – Emergency Repair
- 6 Failed – Repaired Onsite

Embedded Sensors of a Power Transformer at Alectra

Over 100 sensors/monitoring points on a typical station power transformer



Sensors / Equipment Monitoring – Building block for successful Intelligent Maintenance (CBM)



Transformer Self Drying Breather



Bushing Monitoring Systems



Substation Thermal Camera



Tap Changer Oil Filtration

Sensors / Equipment Monitoring – Key building block for successful Intelligent Maintenance (CBM)



7 Gas Dissolved Gas Analysis
Monitoring Unit

 SAN FRANCISCO 2018



Temperature & Pressure



Transformer Monitoring Relay

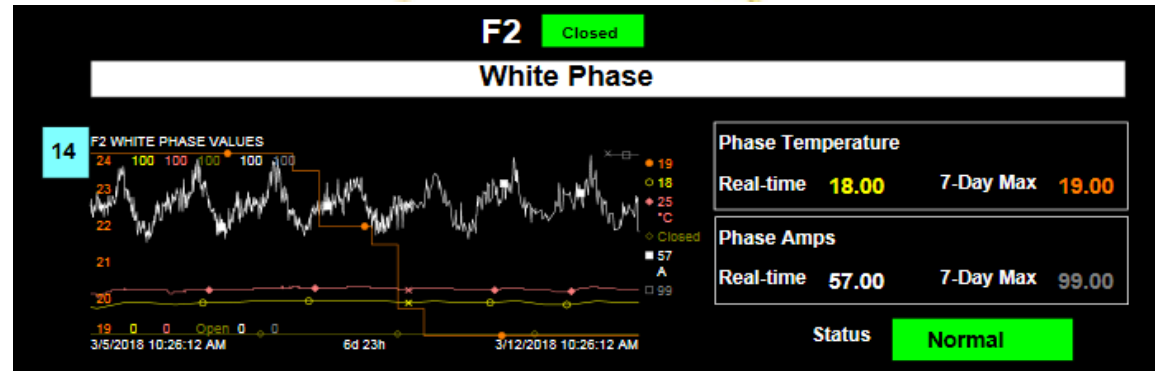
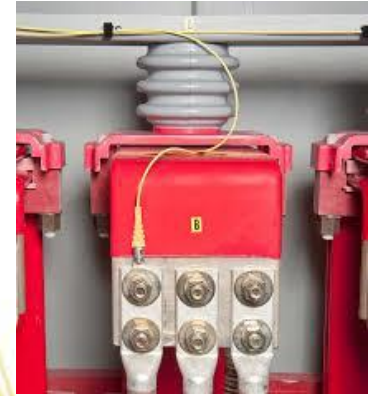


Protection Relay



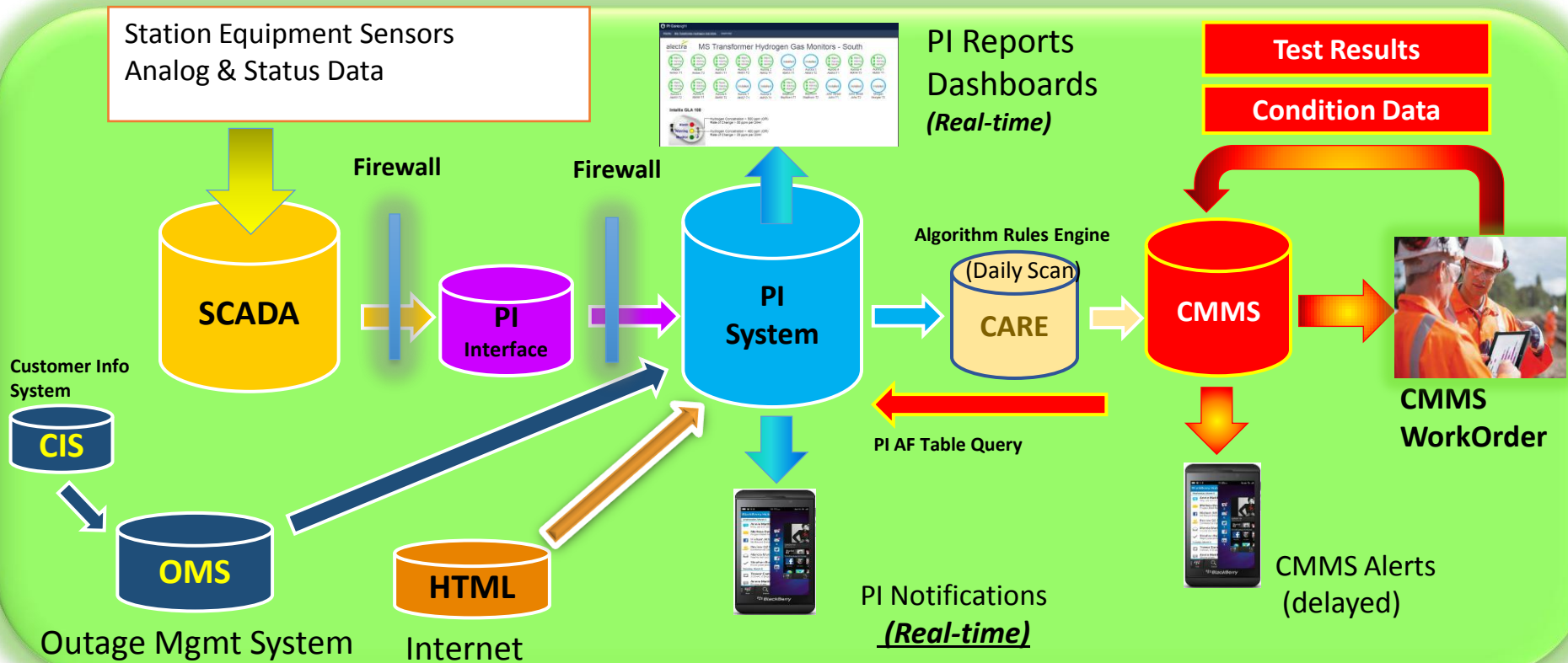
Hydrogen Gas Monitor

Fibre Optic - Temperature Sensor Monitoring



Monitors temperature of terminations, locations where InfraRed scanning is not safe or possible.

Alectra Intelligent Maintenance System Setup



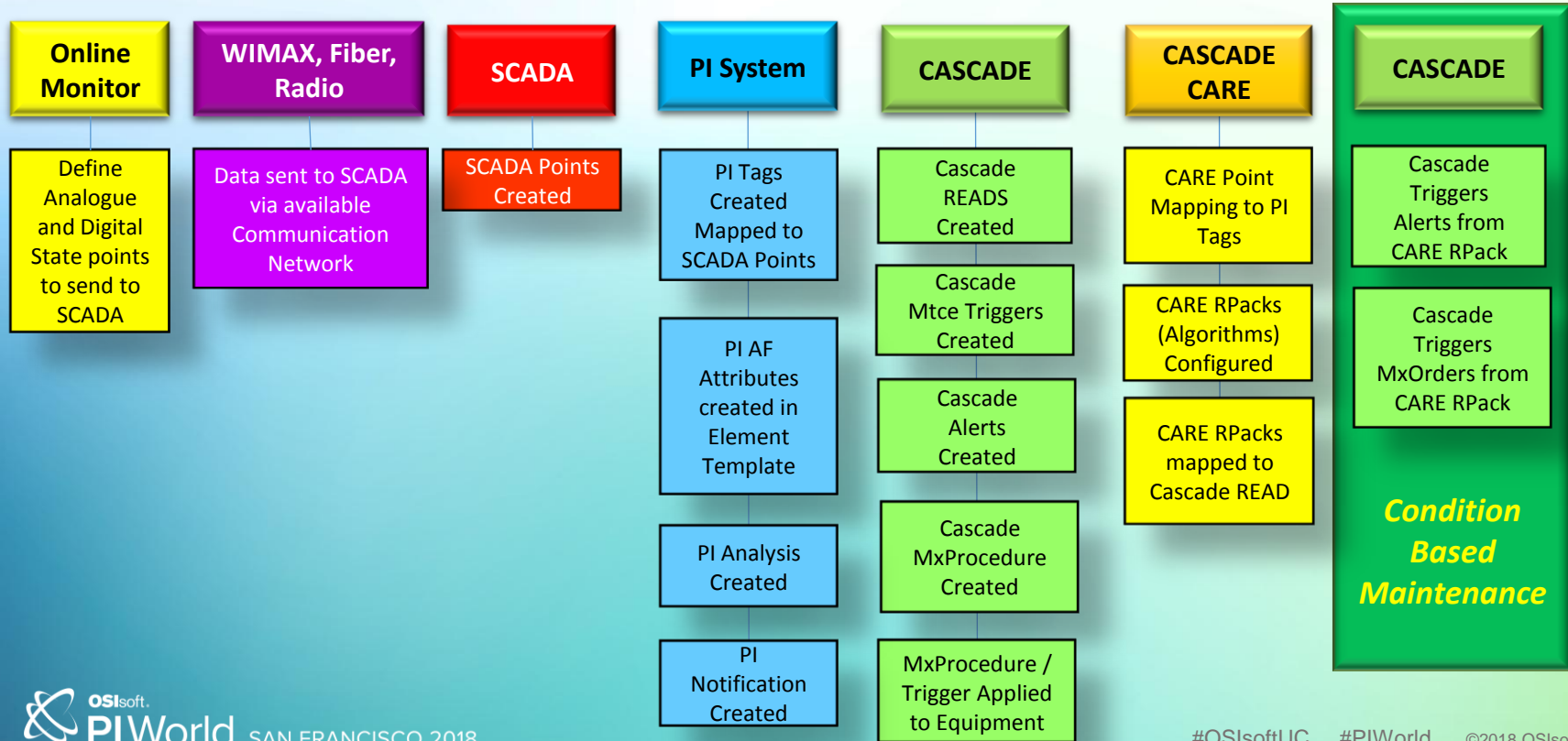
Sensor Data used to Trigger Transformer Maintenance Tasks

- **Transformer:**

- Dissolved Gas and Moisture (Oil Condition)
- Loading, Oil Temperature, Oil Level, Transformer Tank Pressure
- Transformer Cooling Status and Cooling Failure
- Tap Positions (monthly max and min and if passed through neutral)
- Tap Changer Oil temperature vs main Tank Oil Temperature
- Bushing Monitoring Power Factor & Capacitance
- Geomagnetically Induced Currents (GIC)



How Alectra configures Intelligent Transformer CBM using PI System and CMMS



Communication Infrastructure

- Fibre – redundant systems throughout utility territory
 - Leased and owned
- WiMax (Remote stations) to Hubs (Stations) then Fibre to servers throughout utility
- Radio System to Hubs (Stations)

Transformer Monitoring

- Utilize a SEL 2414 Relay
- Inputs:
 - Hydrogen Monitor
 - High, High High, Monitor status (Form C Contact)
 - Winding and Oil temperatures from gauges
 - Oil level
 - Pressure Relief Status, Rapid Pressure (Oil movement – Protection Trip)
 - RTD – building temperature (3 wire 100ohm range)
 - Fan controls, amps
 - Know running current. If within operating window ‘Normal’ if outside operating range “Cooling Failure Alarm”
 - Once a week for a 15 min interval fans are exercised automatically.



Example: 7 Gas Transformer Oil Monitor

Product: Morgan Schaffer Calisto 9

- Analyses 7 gasses plus water content
- Monitored Consumables: Carrier gas, Calibration gas
 - PI Report and Notifications on consumables (weeks remaining and pressure)
- Gas data interfaced to TOA4
 - Script run at 3pm daily to upload gas values and have oil analyzed
- Synchronized with CMMS twice a day
- PI Notifications if gasses exceed IEEE standard thresholds
- CMMS triggers alerts and auto generates work order if DGA or Moisture condition codes show oil is in poor condition
- Data stored in PI as tags and stored in AF structure



Integrated Expert Systems – Intelligent Transformer Oil Monitoring



Transformer Dissolved Gas Analysis Monitor Report



PI Notification-Transformer DGA Levels Exceeding Thresholds

MTS3E:D.H. Cockburn Expansion:T4 DGA Gas Values Change - Message (HTML)

File Message Tell me what you want to do...

PI-Notifications@powerstream.ca Vince Polsoni 9:33 PM

MTS3E:D.H. Cockburn Expansion:T4 DGA Gas Values Change

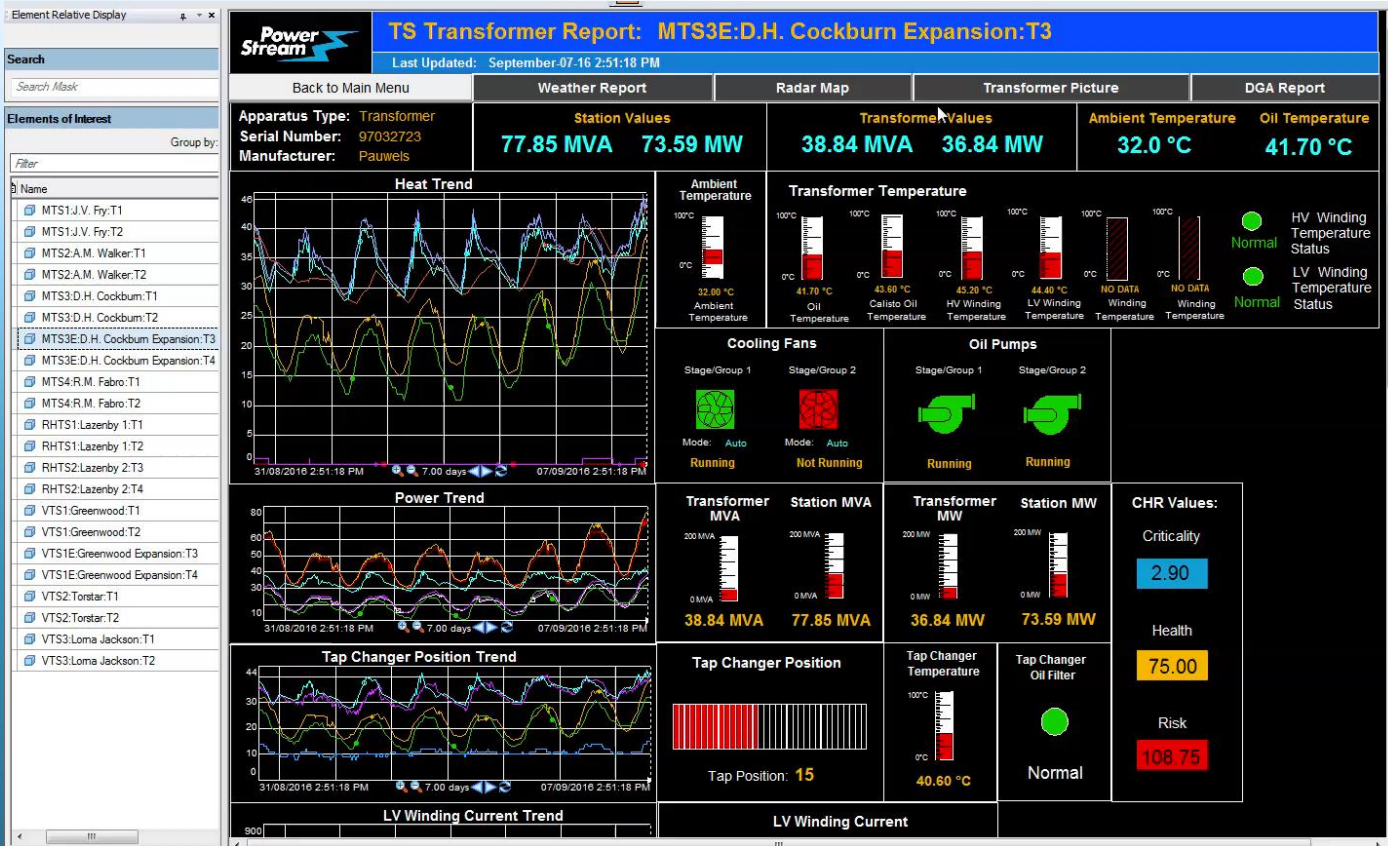
Hi,

As of **4/21/2018 9:32:23 PM Eastern Daylight Time (GMT-04:00:00)** Gas values have reached one or more IEEE thresholds:

	Current Value	Low Alert (2)	Increase Alert (2)	Increase Warning (3)	Increase Alarm (4)	Rate Alert (2)	Rate Warning (3)	Rate Alarm (4)
Hydrogen (h2)	2	NA	101	701	1801	0.33	3.33	6.66
Oxygen (o2)	21300	NA	8000	NA	NA	NA	NA	NA
Methane (ch4)	5.2	NA	121	401	1001	0.4	4	8
Carbon Dioxide (co2)	635	NA	NA	NA	NA	NA	NA	NA
Carbon Monoxide (co)	222	NA	351	571	1401	1.2	12	24
Ethylene (c2h4)	3.6	NA	51	101	201	0.17	1.67	3.33
Ethane (c2h6)	0.4	NA	66	101	151	0.22	2.2	4.4
Acetylene	0.2	NA	3	15	30	0.12	1.2	2.4
Water	0	NA	25	NA	NA	NA	NA	NA
Rel saturation	0	NA	30	NA	NA	NA	NA	NA
co2/co	2.86036	3	10	NA	NA	NA	NA	NA

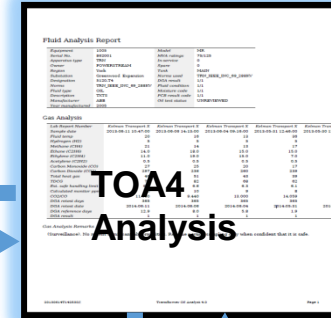
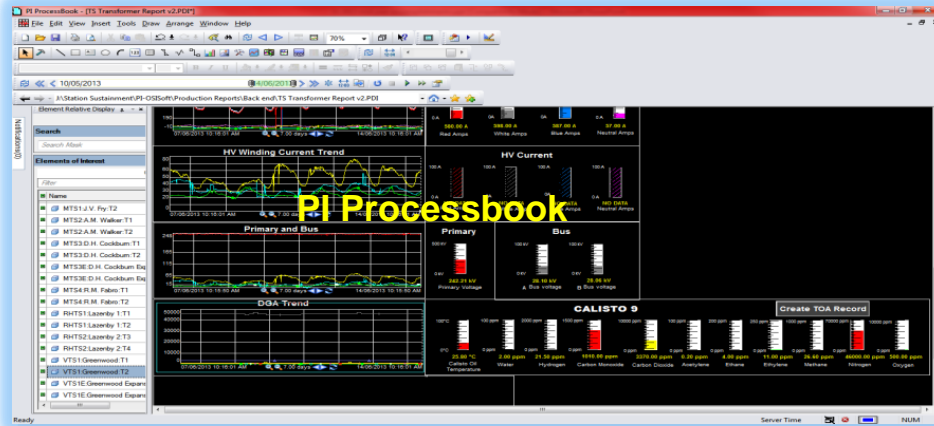
Thanks,
Operations Technology

Real-Time Transformer Oil Analysis



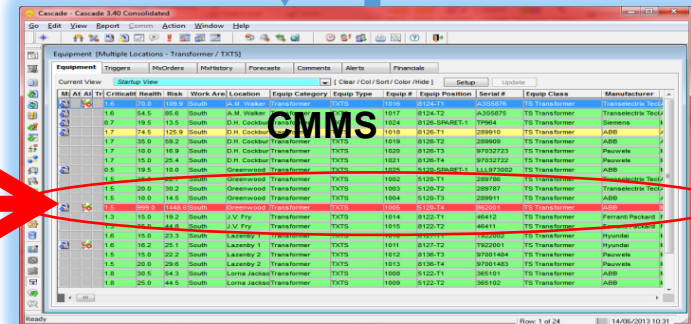
Intelligent Maintenance Example

Dissolved Gas Analysis in Transformer



Daily Synch
or On Demand

Daily synch



Transformer Problem Identified

- (Health and Risk Increase)
- PI Notification, CMMS Alert
- Auto Generated CM Work Order

TS Transformer Oil Condition Report

PI Coresight

Power Stream

Richmond Hill

RHTS1:Lazenby 1

RHTS2:Lazenby 2

TS Transformer DGA Report_v2

TOA4 Daily Load - Message (HTML)

File Message Tell me what you want to do...

Fri 12/1/2017 3:01 PM

PiDashTV

TOA4 Daily Load

To Vince Polsoni

Cc Yrsguli Kairaden

Hi

22 out of 22 TS Transformers' sample data have been uploaded at 01/12/2017 3:00:48 PM by TOA4 Daily Upload

T4	LTC	2		5/10/2016 12:00:00 AM	1	5/10/2016 12:00:00 AM
	TRN	1	1	6/29/2016 3:03:00 PM	1	7/21/2015 12:00:00 AM
	LTC	1		5/10/2016 12:00:00 AM	1	5/10/2016 12:00:00 AM

VT54	T2	TRN	1	1	6/29/2016 3:06:00 PM	1	7/21/2015 12:00:00 AM
	LTC	2		5/6/2016 12:00:00 AM	1	5/6/2016 12:00:00 AM	
VT54	T1	TRN					
	T2	TRN					

Ad Hoc Display

6/30/2016 12:44:06 AM

8h

Now

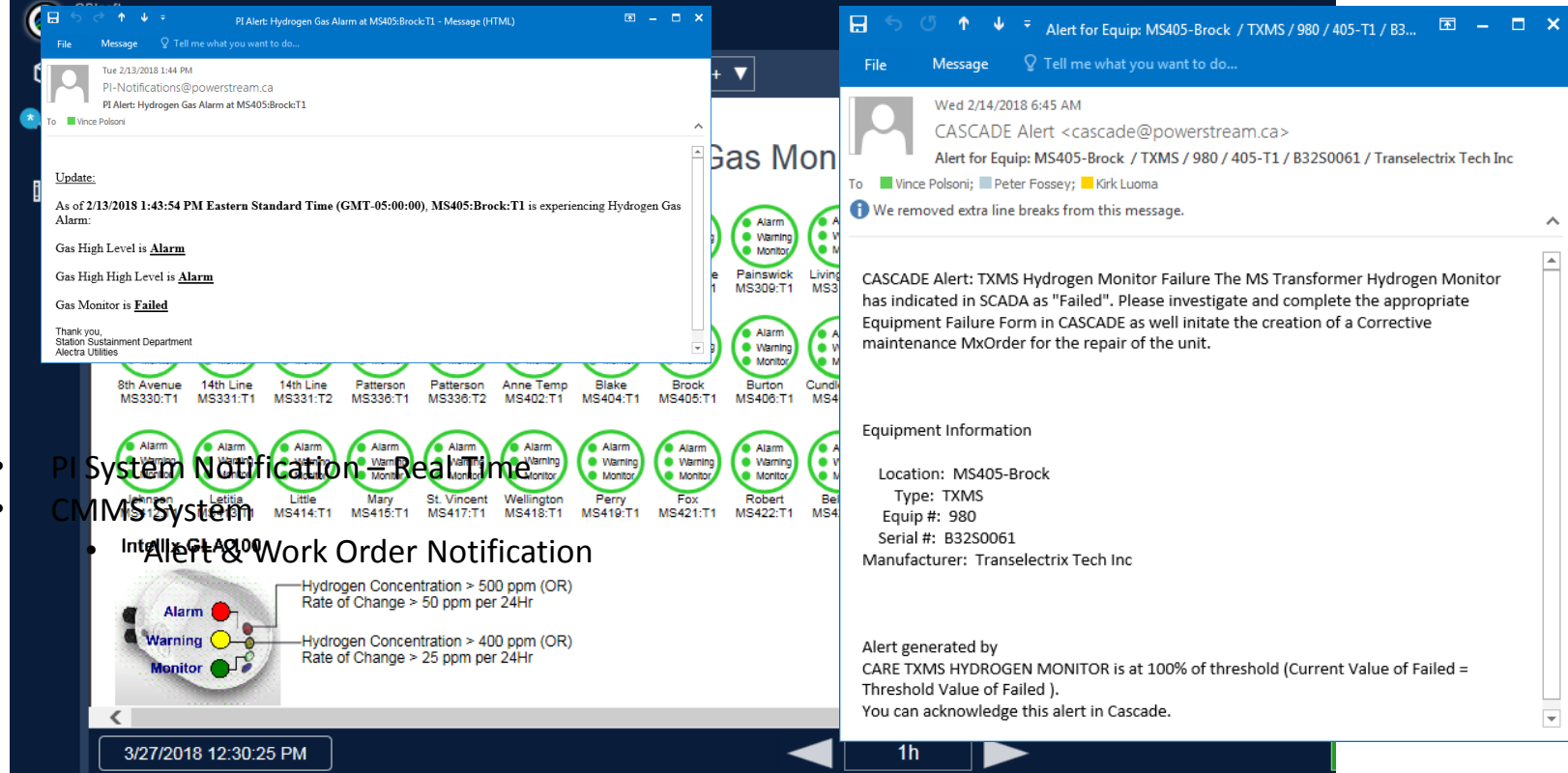
6/30/2016 8:44:06 AM



OLTC - DGA yearly

Transformer Hydrogen Gas Alarm Report

- PI System Notification - Real Time
- CMMS System
 - Alert & Work Order Notification



The image displays two email notifications side-by-side. The left email is a 'PI Alert: Hydrogen Gas Alarm at MS405:Brock:T1' received on Tue 2/13/2018 at 1:44 PM from PI-Notifications@powerstream.ca. It states that the transformer is experiencing a Hydrogen Gas Alarm, with Gas High Level, Gas High High Level, and Gas Monitor all in 'Alarm' or 'Failed' states. The right email is a 'CASCADE Alert' received on Wed 2/14/2018 at 6:45 AM from cascade@powerstream.ca. It informs that the TXMS Hydrogen Monitor has failed and provides detailed equipment information: Location MS405-Brock, Type TXMS, Equip # 980, Serial # B32S0061, and Manufacturer Transelectrix Tech Inc. It also includes the alert generation logic and instructions to acknowledge the alert in Cascade.

PI Alert: Hydrogen Gas Alarm at MS405:Brock:T1 - Message (HTML)

Tue 2/13/2018 1:44 PM
PI-Notifications@powerstream.ca
PI Alert: Hydrogen Gas Alarm at MS405:Brock:T1

To: Vince Polsoni

Update:

As of 2/13/2018 1:43:54 PM Eastern Standard Time (GMT-05:00:00), MS405:Brock:T1 is experiencing Hydrogen Gas Alarm:

Gas High Level is **Alarm**

Gas High High Level is **Alarm**

Gas Monitor is **Failed**

Thank you,
Station Sustainment Department
Alterra Utilities

Gas Monitor Status:

Location	Status
8th Avenue MS330:T1	Alarm
14th Line MS331:T1	Alarm
14th Line MS331:T2	Alarm
Patterson MS336:T1	Alarm
Patterson MS336:T2	Alarm
Anne Temp MS402:T1	Alarm
Blake MS404:T1	Alarm
Brook MS405:T1	Alarm
Burton MS406:T1	Alarm
Cundick MS407:T1	Alarm
Little MS414:T1	Alarm
Little MS414:T2	Alarm
Mary MS415:T1	Alarm
St. Vincent MS417:T1	Alarm
Wellington MS418:T1	Alarm
Perry MS419:T1	Alarm
Fox MS421:T1	Alarm
Robert MS422:T1	Alarm
Bellevue MS423:T1	Alarm

Alert & Work Order Notification

Hydrogen Concentration > 500 ppm (OR)
Rate of Change > 50 ppm per 24Hr

Hydrogen Concentration > 400 ppm (OR)
Rate of Change > 25 ppm per 24Hr

3/27/2018 12:30:25 PM

Alert for Equip: MS405-Brock / TXMS / 980 / 405-T1 / B3...

Wed 2/14/2018 6:45 AM
CASCADE Alert <cascade@powerstream.ca>
Alert for Equip: MS405-Brock / TXMS / 980 / 405-T1 / B32S0061 / Transelectrix Tech Inc

To: Vince Polsoni; Peter Fossey; Kirk Luoma

We removed extra line breaks from this message.

CASCADE Alert: TXMS Hydrogen Monitor Failure The MS Transformer Hydrogen Monitor has indicated in SCADA as "Failed". Please investigate and complete the appropriate Equipment Failure Form in CASCADE as well initiate the creation of a Corrective maintenance MxOrder for the repair of the unit.

Equipment Information

Location: MS405-Brock
Type: TXMS
Equip #: 980
Serial #: B32S0061
Manufacturer: Transelectrix Tech Inc

Alert generated by
CARE TXMS HYDROGEN MONITOR is at 100% of threshold (Current Value of Failed = Threshold Value of Failed).
You can acknowledge this alert in Cascade.

Detailed Transformer Report



Example: Transformer Bushing Monitor

Product: Doble IDD/Doble Prime

- Each unit can monitor up to 12 bushings
- Connected to SCADA via DNP3
- Local connection and web page reporting
- Raw data from IDD into PI System
- Leverage PI Reporting and PI Notifications



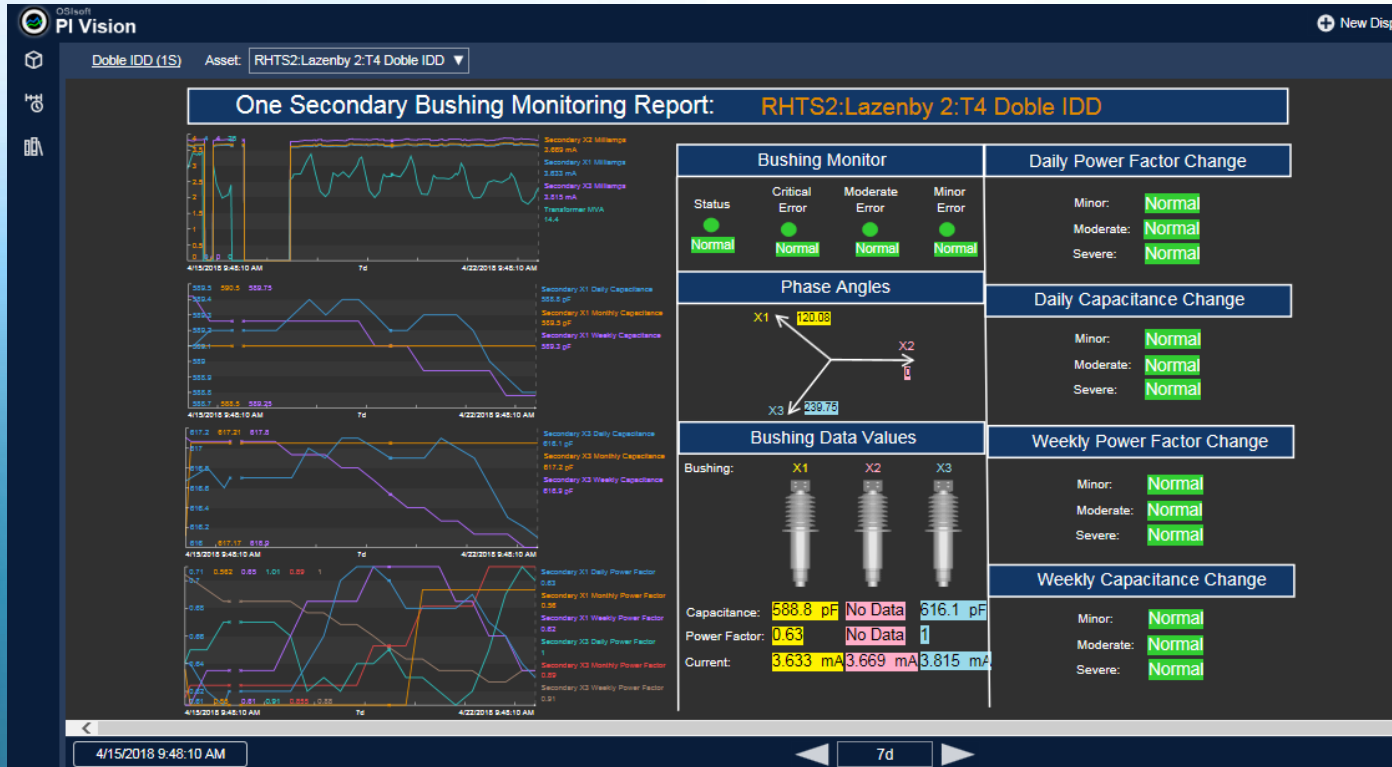
Bushing Monitor



Integrated Expert Systems – Bushing Monitoring Transforming our World



Bushing Monitoring – 1 set Secondary Windings



Bushing Monitor



Bushing Monitoring – 2 sets Secondary Windings



Bushing Monitor



PI AF – Transformer Management

- PI AF Templates
- PI AF Transformer Attributes
- PI Analysis
- PI Notifications
 - Configuration – Analysis
 - Configuration - Notification
 - Email
- PI Table
 - Data extracted from CMMS and OMS systems

PI Asset Framework – Transformer Attributes

The screenshot displays the PI System Explorer (Administrator) window. The left pane shows a tree view of elements, including 'Transformer List'. The main pane shows the 'Transformer List' details, including a table with columns 'Name' and 'Value'. The table contains one entry: 'YTD Deficiencies Count' with a value of '52'. The right pane shows the 'Attributes' tab for the selected element, displaying various properties such as 'Name', 'Description', 'Properties', 'Categories', 'Default UOM', 'Value Type', 'Value', 'Data Reference', and 'Settings...'. The 'Value' field is set to '52'. The 'Data Reference' field contains a SQL query:
`SELECT Count([trfx_val]) FROM [Cascade Equipment Deficiencies] WHERE [equiptype_id] = '149' or [equiptype_id] = '150' or [equiptype_id] = '152';RWM=0;RWN=0`

Transformer List Modified: 07/04/2017 12:31:20 PM. Version: 01/01/1970 12:00:00 AM, Revision 7

Analysis Template – Tap Changer Oil Level

The screenshot displays the OSIsoft PowerStream - PI System Explorer (Administrator) interface. The 'Analysis Templates' tab is selected, and the 'Tap Changer Low Oil Level' template is highlighted in the list. The template configuration is shown on the right, including the name, description, categories, and analysis type. The 'Event Frame Template' is set to 'Migrated Notifications Event Frame Template'. The 'Start triggers' section shows a trigger for 'Tap Changer|TAPCHANGER OIL LEVEL' = 'Low'. The 'End trigger' section is empty. The 'Scheduling' is set to 'Event-Triggered' and the 'Trigger on' is set to 'Any Input'.

Library

- North MS Charger
- RTU
- SharePoint Template
- South MS Battery
- South MS Charger
- Sustained Outages
- Transformer Station
- TS Battery
- TS Bus Template
- TS Bus Tie Breaker
- TS Calisto
- TS Cap Bank Breaker
- TS Charger
- TS Circuit Breaker Template
- TS Feeder Breaker
- TS Inverter
- TS Primary Switch
- TS PRIMAX Charger
- TS Secondary Breaker
- TS Tapchanger
- TS Transformers Bermondsey
- TS Transformers Jones
- TS UPS
- WO by Equipment Type
- WO Total
- WO YTD
- Event Frame Templates

Elements

- Event Frames
- Library
- Unit of Measure
- Contacts
- Management

TS Transformers Bermondsey

General | Attribute Templates | **Ports** | Analysis Templates | Notification Rule Templates

Name: Tap Changer Low Oil Level

Description:

Categories:

Analysis Type: ☐ Expression ☐ Rollup ☒ Event Frame Generation ☐ SQC

☒ Start analyses when created from template

[Create a new notification rule template for Tap Changer Low Oil Level](#)

Example Element: [PowerStream\South Service Area\Richmond Hill\Richmond Hill Transformer Stations\RHTS1-Lazenby 1\Transformers\RHTS1-Lazenby 1:1](#)

Event Frame Template: Migrated Notifications Event Frame Template

Name	Expression	True for	Severity	Value at Evaluation	Value at Last Trigg
Start triggers					
StartTrigger1	'Tap Changer TAPCHANGER OIL LEVEL' = "Low"	Set (optional)	None		
End trigger					
EndTrigger	Type an expression (optional)				

[Add a new variable](#) [Add a new start trigger](#)

[Advanced Event Frame Settings...](#)

Scheduling: ☒ Event-Triggered ☐ Periodic

Trigger on: Any Input

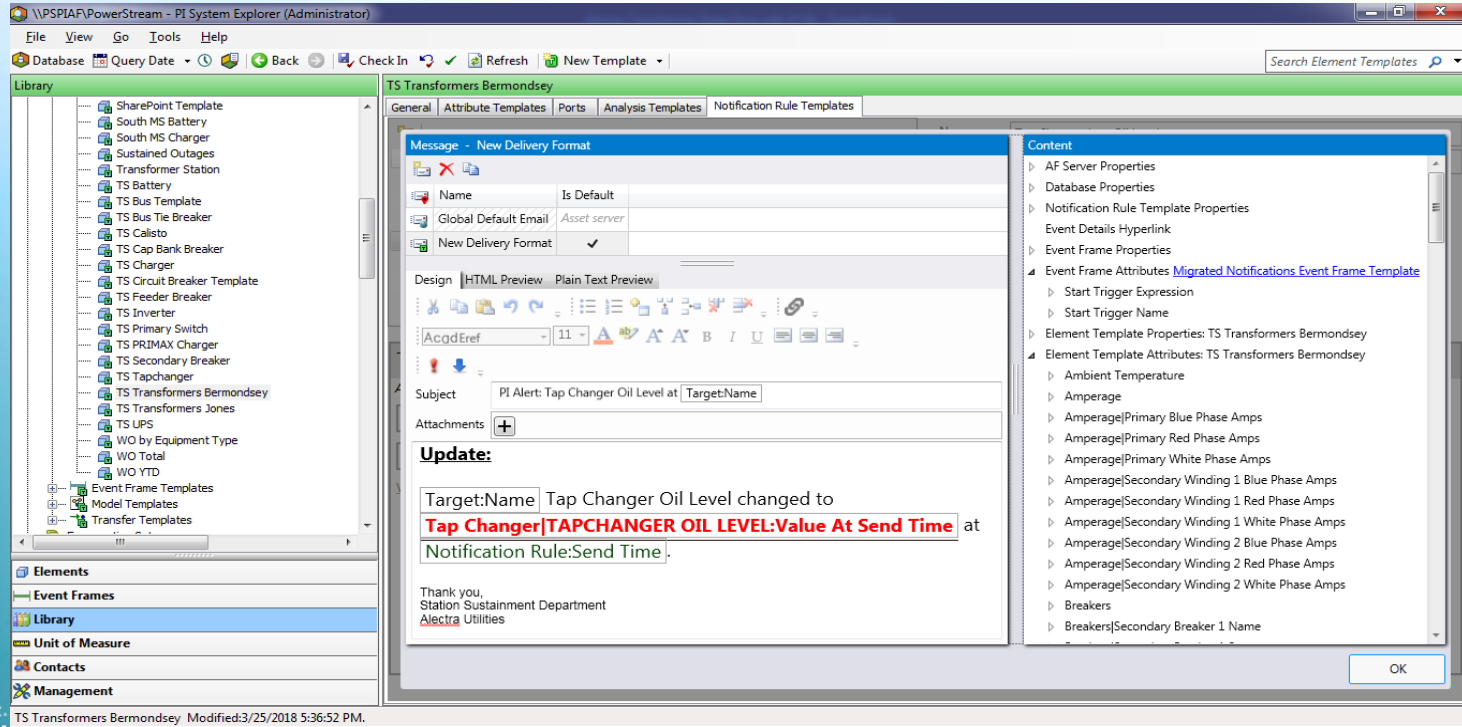
TS Transformers Bermondsey Modified: 3/25/2018 5:36:52 PM.

Notification Rule – Tap Changer Oil Level

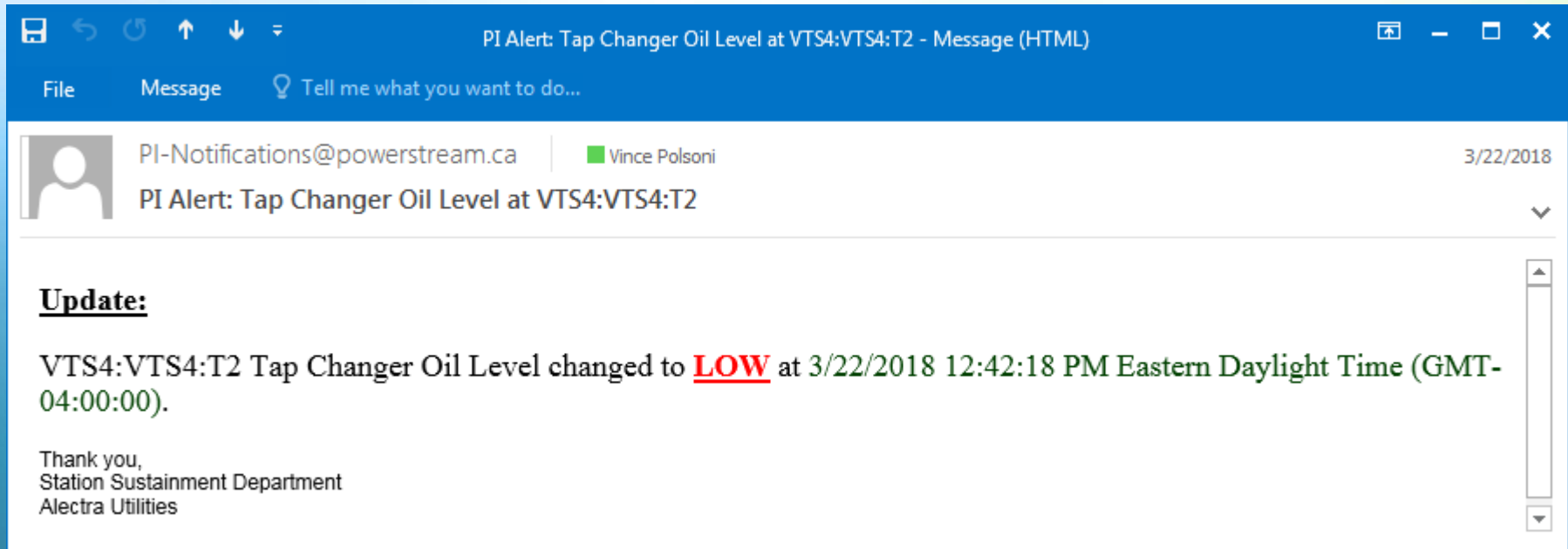
The screenshot displays the 'TS Transformers Bermondsey' configuration window in the 'Notification Rule Templates' tab. The 'Name' field is set to 'Tap Changer Low Oil Level' and the 'Description' is 'Notifies when Tap Changer oil is low'. The 'Categories' dropdown is empty. In the 'Criteria' table, the entry 'Tap Changer Low Oil Level' is selected, with its 'Analysis Template' set to 'Tap...'. The 'Trigger' section states: 'A notification will be triggered when an **event frame** is created that satisfies all of these criteria.' It lists two criteria: 'Referenced Element Template = TS Transformers Bermondsey' and 'Analysis Template = Tap Changer Low Oil Level'. The 'Subscriptions' section indicates there are currently 3 subscribers and provides links for 'View/Edit Subscriptions' and 'Manage Formats'. The bottom status bar shows 'TS Transformers Bermondsey Modified:3/25/2018 5:36:52 PM.'

Name	Criteria
Calisto 9 General Alarm/Error (Bermondsey T...	Analysis Template = Calist...
Main Tank Oil Breather Status Notification	Analysis Template = Main...
Emergency Breaker Status:TS Bermondsey	Analysis Template = Seco...
Tap Changer Low Oil Level	Analysis Template = Tap...
Tap Changer Oil Filter Alarm (Bermondsey TS)	Analysis Template = Tap...
Transformer Differential Protection (Bermon...	Analysis Template = Trans...
TRN Loading (Bermondsey TS)	Analysis Template = TRN...

PI Notification Email Message Template Tap Changer Low Oil



PI Notification – Low Tap Changer Oil



Video Example Table – Transformer and Tap Changer Oil Test Results from CMMS

The screenshot displays the OSiSoft software interface for configuring a table. The left sidebar contains a 'Library' list with various incident and operation categories. The 'Station Location' table is selected. The main panel shows the 'General' tab with fields for Name, Description, Categories, Connection, Query, Time Zone, and Cache Interval. The 'Query' field contains a complex SQL statement. The 'Cache Interval' is set to 0 with a 'Manual Refresh' button. The 'Security' tab is also visible.

Library

- Responder_All DC-Splice Incidents (YTD)
- Responder_Cause Designations
- Responder_Critical Customers
- Responder_Customers Affected by Current Inci
- Responder_Customers by Region
- Responder_Customers per Feeder (Archive)
- Responder_Incidents (Archive)
- Responder_Incidents (in Last 180 Days)
- Responder_Incidents (Momentary 2014)
- Responder_Incidents (Momentary 2015)
- Responder_Incidents (Momentary 2016)
- Responder_Incidents (Momentary)
- Responder_Incidents (Sustained 2014)
- Responder_Incidents (Sustained 2015)
- Responder_Incidents (Sustained 2016)
- Responder_Incidents (Sustained)
- Responder_Operations on DPDs (Last 30 Days)
- Responder_Operations on DPDs (YTD)
- Responder_Origination Designation
- Responder_Region Designations
- Responder_Status Designation
- Responder_Trouble Designation
- Station Location**
- Transformer & LTC Latest DGA & Moisture Result
- Transformer & LTC Latest Oil Test Results
- Transformer Latest Oil Results (Old/Received fro
- TS Asset Condition Assessment Info - Cascade E

Station Location

General | Table | Define Table | Version

Name: Station Location

Description:

Categories:

Connection: Linked - Provider=SQLEDB.1;Password=<PASSWORD>;Persist Security Info=True;User ID=PICASSQL;Initial Catalog=CascadeDB;Data Source=CORPSQL02\CORPSQL02;Use Proce

Query: Linked - Select a.*, b.ASBESTOSPRESNT, b.READING_DT as "ASBESTOS_LAST_READDATE" from (select eq_station.equip_id, a.*,eq_station.criticality_val,eq_station.health_val,eq_sti

Time Zone: <None> ☒ Convert To Local

Cache Interval: 0 Manual Refresh

[Security](#)

Import... Link... Unlink

Elements

- Event Frames
- Library**
- Unit of Measure
- Contacts
- Management

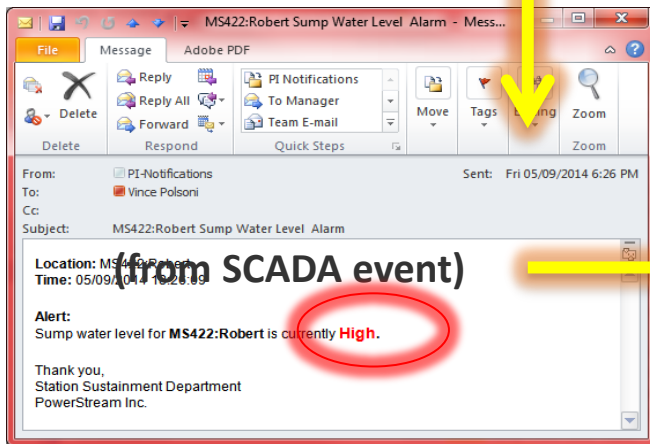
SCADA – PI System – CMMS working as One

PI Report

(High Water Alarm)



PI Notification

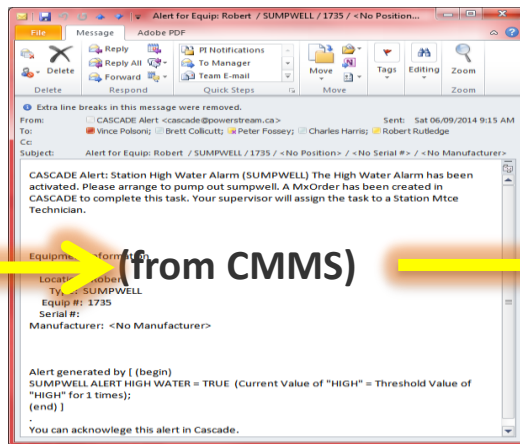


PI Report

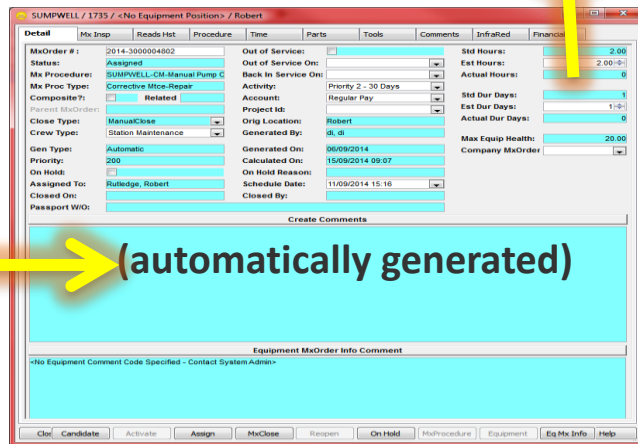
(High Water Alarm Cleared)



CMMS Work Order Alert



CMMS Work Order



PI Notifications – Transformer Conditions



- Transformer Differential
- Transformer Main Tank Breather
- Tap Changer Low Oil
- Tap Changer Oil Filtration Alarm
- Dissolved Gas IEEE Threshold Exceeded
- Dissolved Gas, Moisture and Fluid Quality Condition Code >2
- Calisto 9 Oil Monitor General Alarm

- Transformer Online / Offline
 - Primary Switch Operation
 - Secondary Txmr Breaker Operation
- Transformer Oil Temp/Cooling
- Transformer Bushing Alarm
- Oil Containment Alarm
- Hydrogen Alarm
- Transformer High Winding Temp

SubStation Interconnection – Load Transfer Report



MS309:PainswickT1 High MVA Ratio - Message (...)

File Message Tell me what you want to do...

PI-Notifications@powerstream.ca Vince Polsoni Sat 4:00 PM

MS309:Painswick:T1 High MVA Ratio

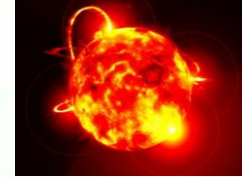
Hi,

MS309:Painswick:T1 Transformer is experiencing a high MVA ratio of **81%**.







Current Load is **4.58MVA**
Current Applied Rate is **20MVA**

	Base Rate	Stage 1	Stage 2
Status	NA	Off	Off
Rating	20MVA	26.6 MVA	33.3 MVA


Thanks,
Operations Technology




Feeder Availability Report - Risk

PI Alert: An update on BARRIE M5 BREAKER Performance - Message (HTML)

File Message  Tell me what you want to do...

 PI-Notifications Vince Polsoni Thu 02/03

PI Alert: An update on BARRIE M5 BREAKER Performance

Update:

One or more thresholds have been exceeded by **BARRIE M5 BREAKER** at 3/2/2017 4:30:25 PM Eastern Standard Time (GMT-05:00:00):

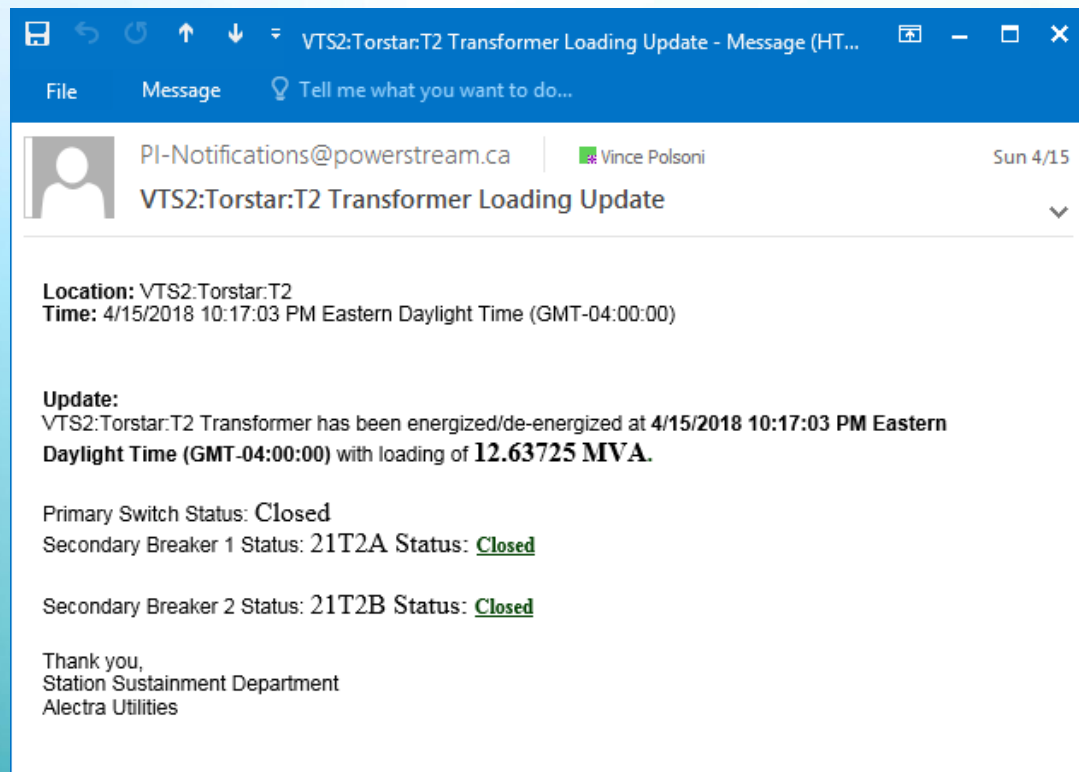
	Number of Incidents	Threshold
Last 30 Days	3	3
Last 60 Days	3	4
Last 90 Days	2	5
YTD	2	N/A

Number of Customers fed by this Feeder is **1354**

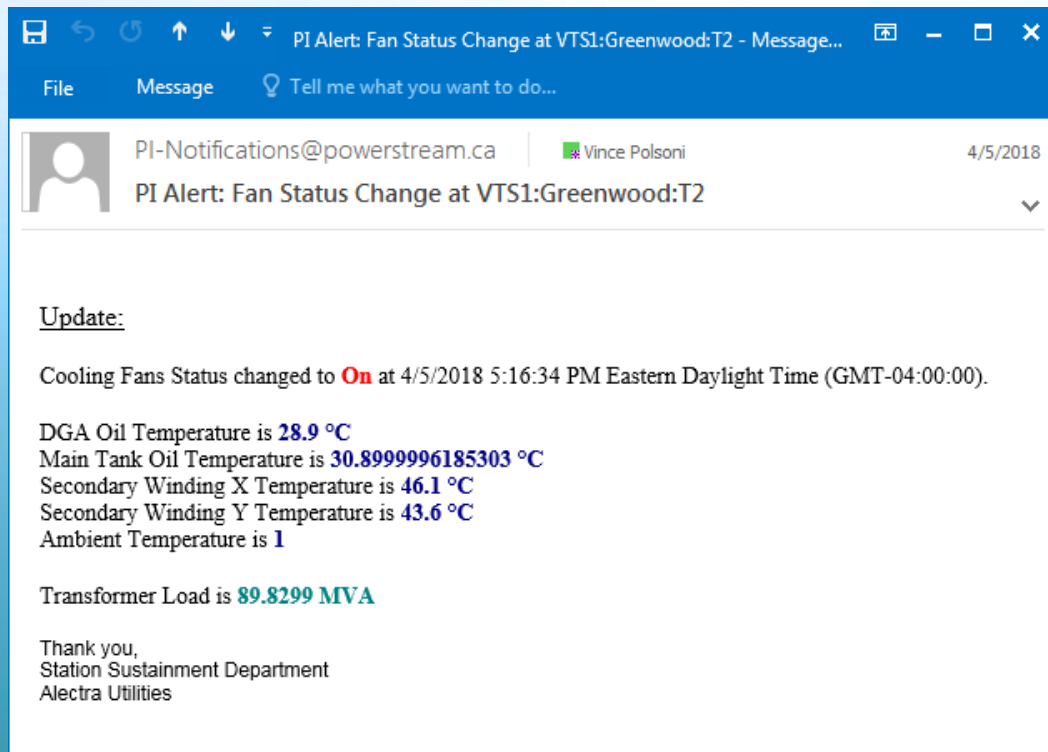
For more information please see [Hydro One TS Feeders Operations on DPDs](#)

Thank you,
Station Sustainment Department
Alectra Utilities

PI Notification – Transformer De-Energized / Energized



PI Notification – Transformer Cooling System On / Off



PI Notification - Transformer Cooling Failure

From: PI-Notifications@powerstream.ca [<mailto:PI-Notifications@powerstream.ca>]

Sent: April-20-18 5:01 PM

To: _____

Subject: MS309:Painswick:T1 Cooling Failure Status Change

Hi,

Cooling Failure Status changed to **Failed** at 4/20/2018 5:00:48 PM Eastern Daylight Time (GMT-04:00:00)

Additional information:

Fan current is **0A**

Oil Level is **Normal**

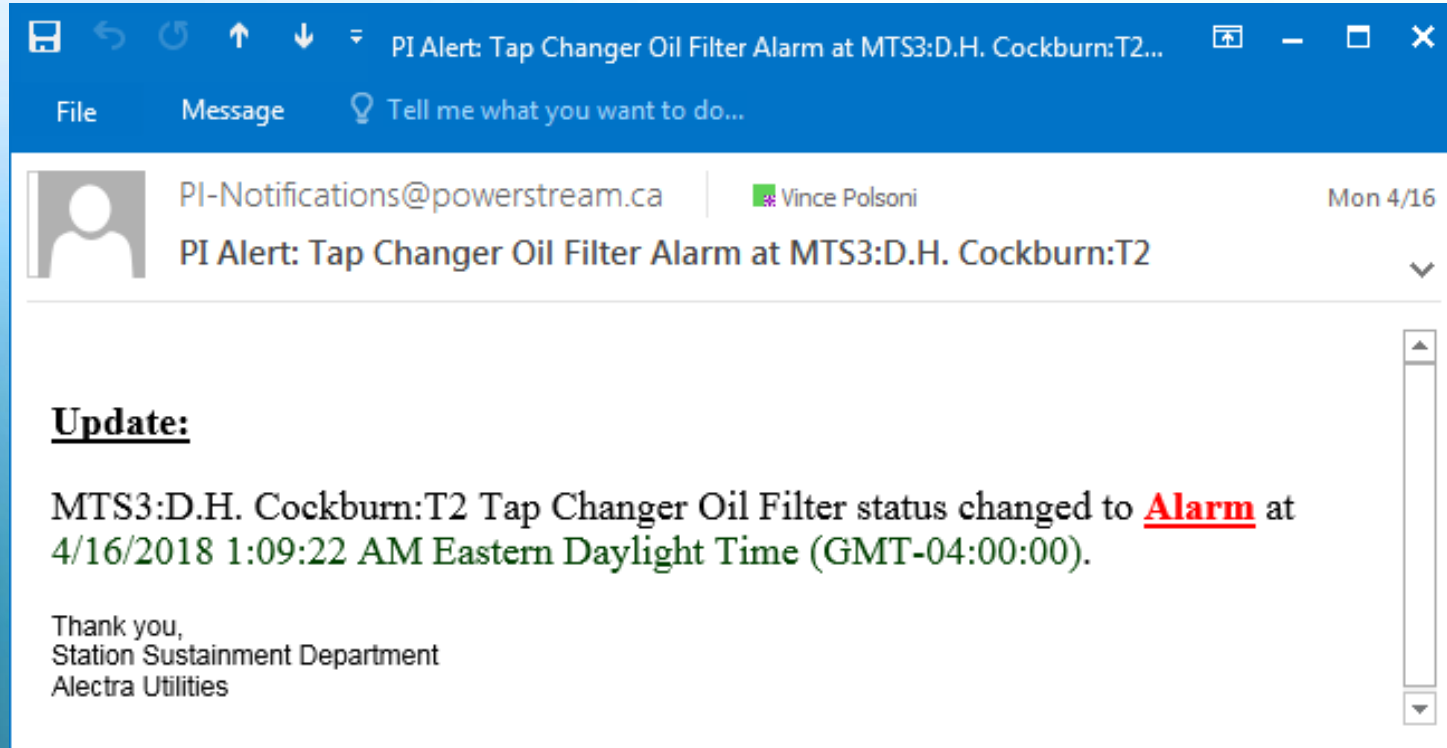
Oil Temperature is **27°C**

Winding Temperature is **25°C**

Transformer Load is **4.44MVA**

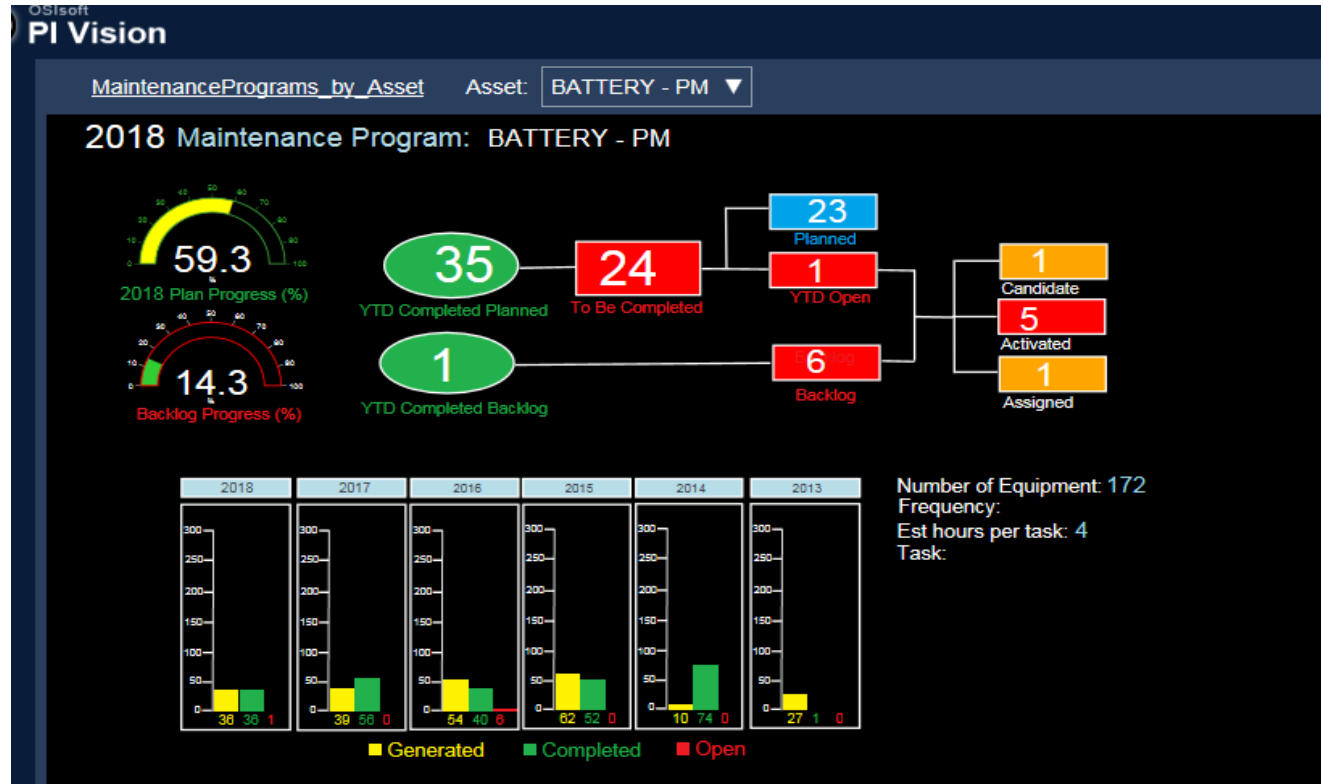
Thanks,
Operations Technology

PI Notification – Tap Changer Oil Filtration Alarm

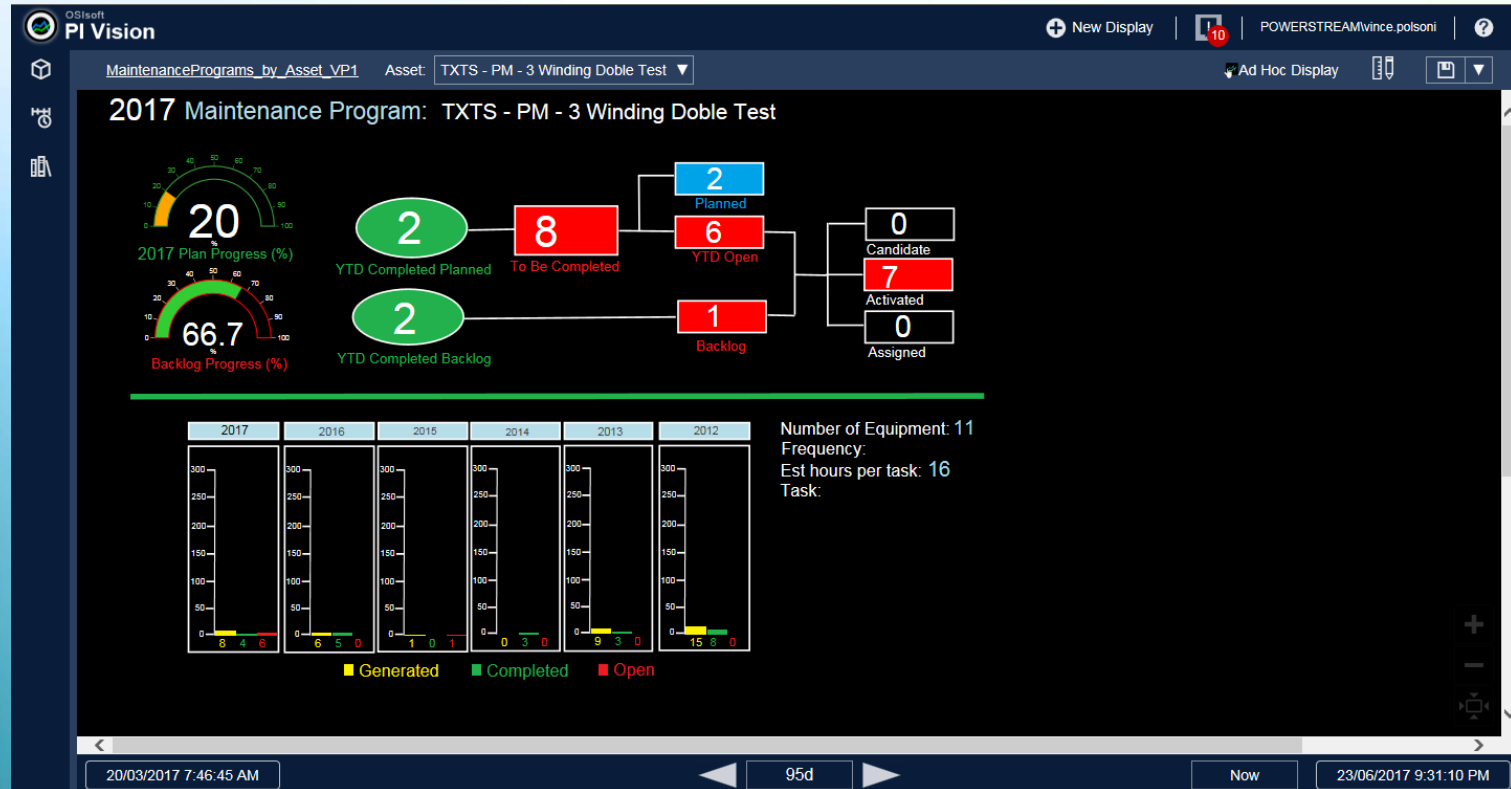


Maintenance Performance Reports

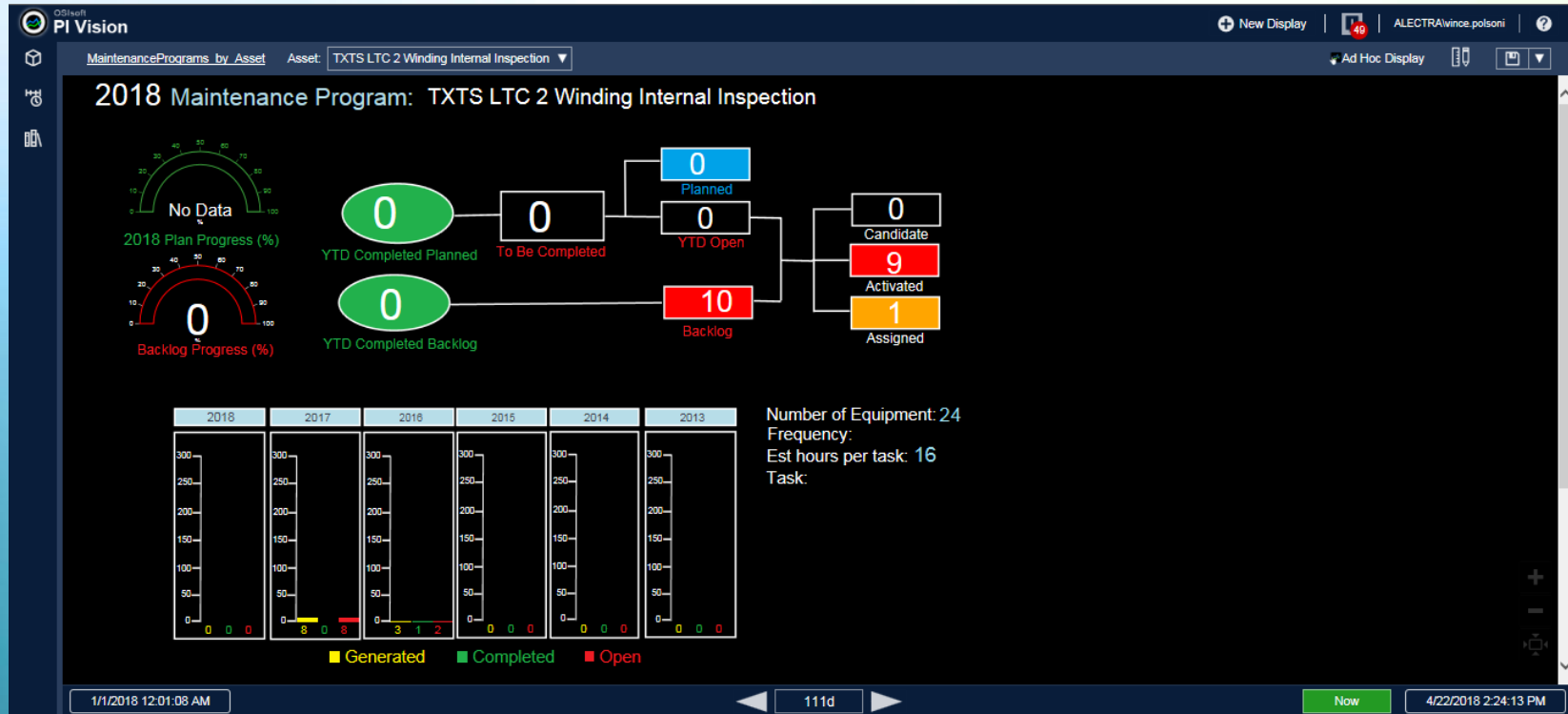
Maintenance Program and Backlog Performance (by Mtce Task)



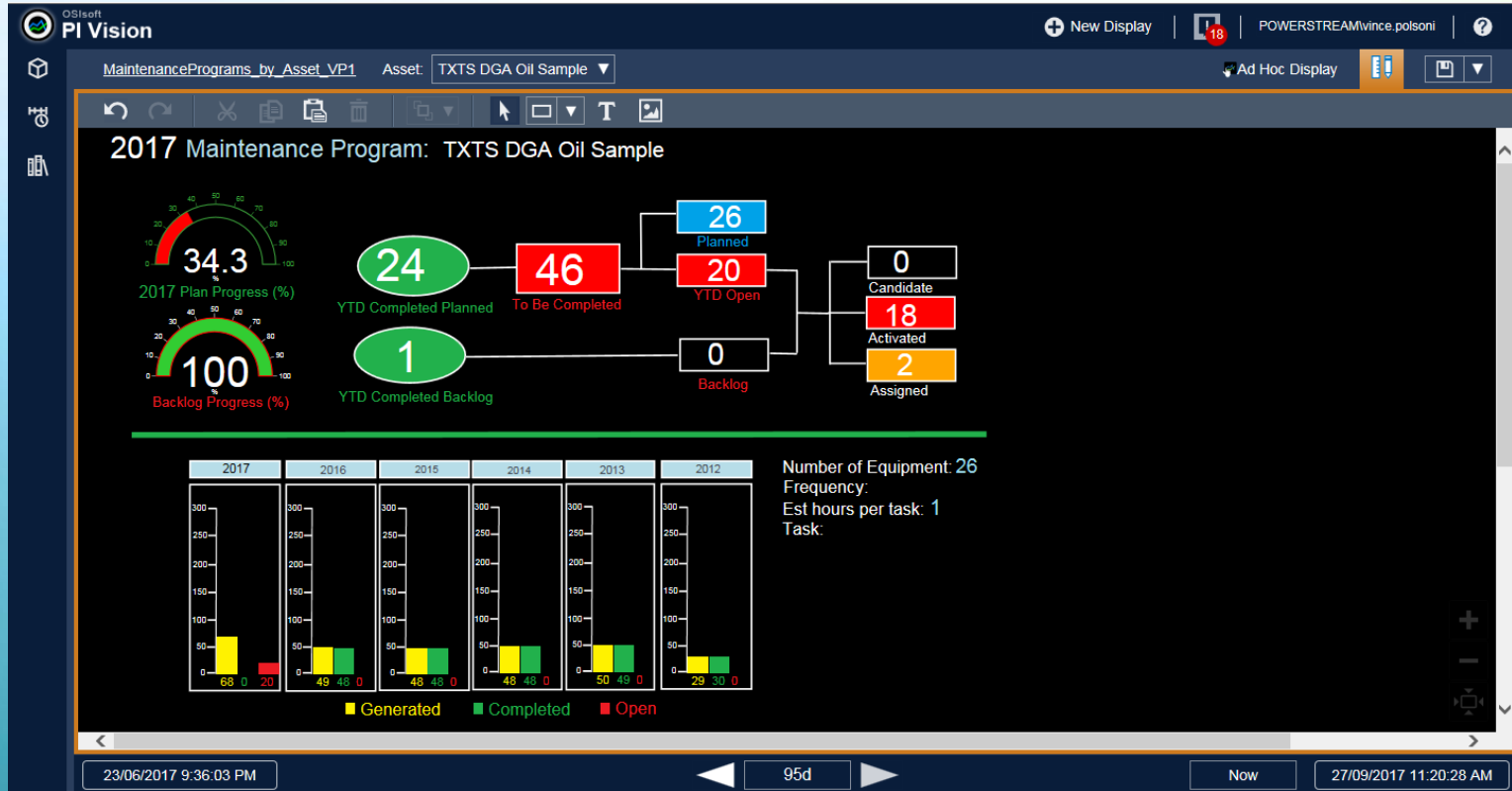
Current Year Transformer 3 Winding Double Test Maintenance Program Completion Report



Current Year Transformer Tap Changer Maintenance Completion Report



Transformer - Annual Oil Samples



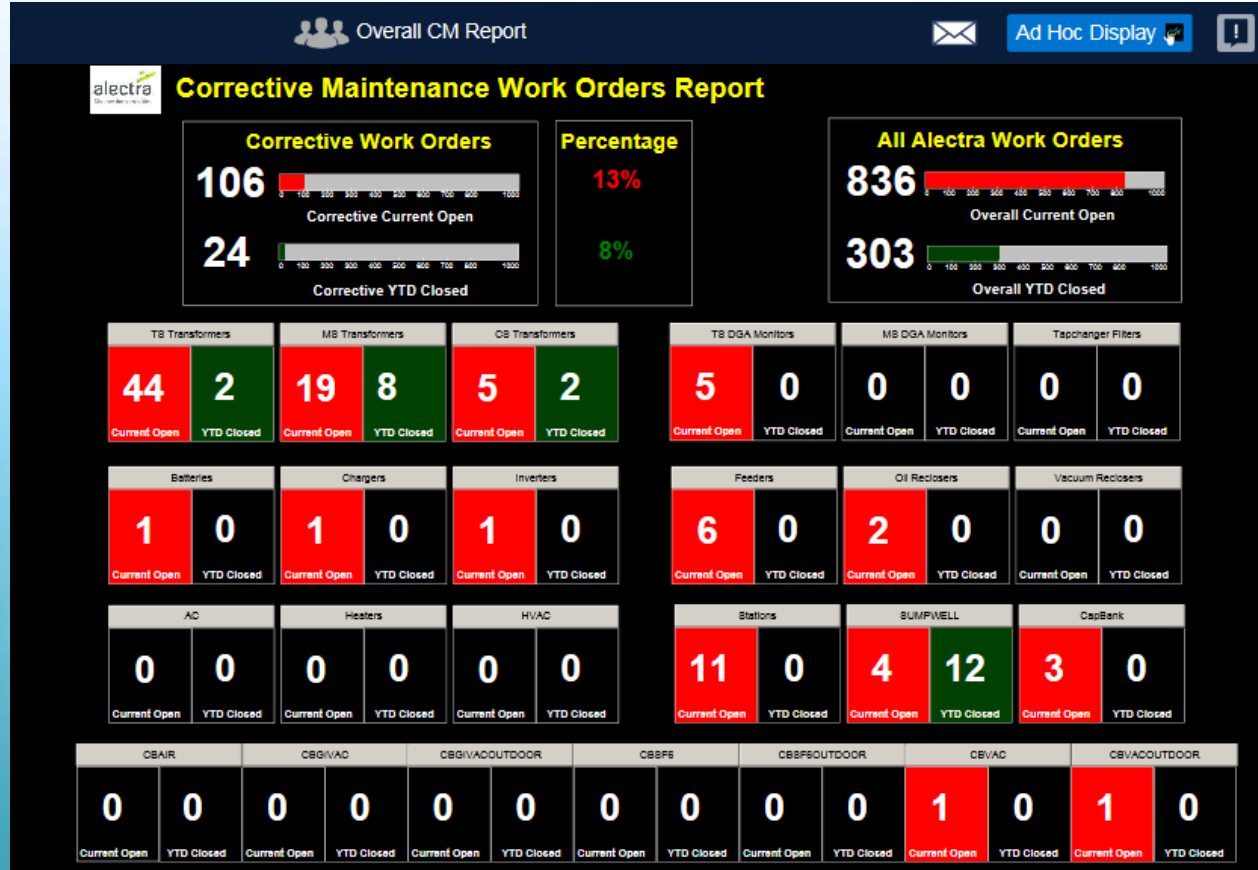
Station Maintenance Program Performance

(by Equipment Type)

Open WO Status



Corrective Maintenance Performance



Visualizing Real-Time Asset Health – CMMS and PI System

Risk

Function of Criticality and Risk

Health

CMMS

Maintenance Program Performance

CMMS and PI / SCADA Data

Equipment Condition (DGA, Moisture, Fluid Quality, Insulation, Capacitance, Bushings, etc.)

Failures, Equipment Status

Number of Customers per Feeder/ Transformer / Station

Number of Open Work Orders

Age

Criticality

No of Transformers at Station (1, 2 or more)

Transfer Capability

Oil Containment

Key Customers

Proximity of Station to Water

Total No of Customers per Station

Transformer - Criticality, Health and Risk

PI Coresight

North MS Transformer CHR_v2

Ad Hoc Display

Vince Polsoni

alectra

Discover the possibilities

North MS Transformer CHR

All North MS Transformers

Criticality

0.89

Barrie	TX #	Criticality	Health	YTD Average	Risk	YTD Average	No. of Open Work Orders							
MS301: Anne North	T1													
MS302: Saunders	T1													
MS303: Ferndale South	T1	1.35	117.50	111.80	158.63	150.94	2							
MS304: Big Bay Point	T1													
MS305: Holly	T1	1.00	28.95	28.85	28.95	28.85	1							
MS306: Little Lake	T1													
MS307: Huronia	T1	1.00	48.95	48.85	48.95	48.85	2							
MS308: Park Place	T1													
MS309: Painswick	T1	1.00	48.95	48.85	48.95	48.85	2							
MS402: Anne Temp	T1													
MS404: Blake	T1	1.25	42.35	41.92	52.94	52.40	1							
MS405: Brock	T1													
MS406: Burton	T1	1.00	77.50	77.50	77.50	77.50	0							
MS407: Cundles East	T1	100.00 %	100.00 %	100.00 %	10 MVA	1.71 MW	1.44 MW	1.47 MW	0.50	110.00	109.07	55.00	54.54	4
MS408: Cundles West	T1	100.00 %	100.00 %	100.00 %	10 MVA	2.78 MW	2.14 MW	2.04 MW	1.00	101.70	58.85	58.95	58.85	1
MS409: Duckworth	T1	100.00 %	100.00 %	100.00 %	5 MVA	2.38 MW	2.19 MW	2.23 MW	1.00	101.70	101.24	101.70	101.24	4
MS410: Ferndale	T1	100.00 %	100.00 %	100.00 %	5/6.6 MVA	1.75 MW	1.46 MW	1.49 MW	0.50	52.50	52.50	26.25	26.25	2
MS411: Innisfil	T1	100.00 %	100.00 %	100.00 %	5 MVA	1.85 MW	1.69 MW	1.73 MW	0.50	22.50	22.50	11.25	11.25	0
MS412: Johnson	T1	100.00 %	100.00 %	100.00 %	5 MVA	1.24 MW	1.32 MW	1.37 MW	1.00	61.70	61.24	61.70	61.24	3
MS413: Letitia	T1	100.00 %	100.00 %	100.00 %	10 MVA	3.02 MW	2.66 MW	2.44 MW	1.00	81.70	81.45	81.70	81.45	4
MS414: Little	T1	100.00 %	100.00 %	100.00 %	5 MVA	1.63 MW	1.46 MW	1.50 MW	0.50	42.50	42.50	21.25	21.25	0

3/10/2017 1:20:06 AM

8h

Now

3/10/2017 9:20:06 AM

Alliston

MS330: 8th Av

MS331: 14th L

MS431: Duffer

MS432: Fitch

Beeton

MS336: Patterson

Bradford

MS321: John

MS322: Melb

MS323: 8th Lin

MS324: Reaga

Penetanguishene

MS421: Fox

MS422: Rober

MS423: Belleb

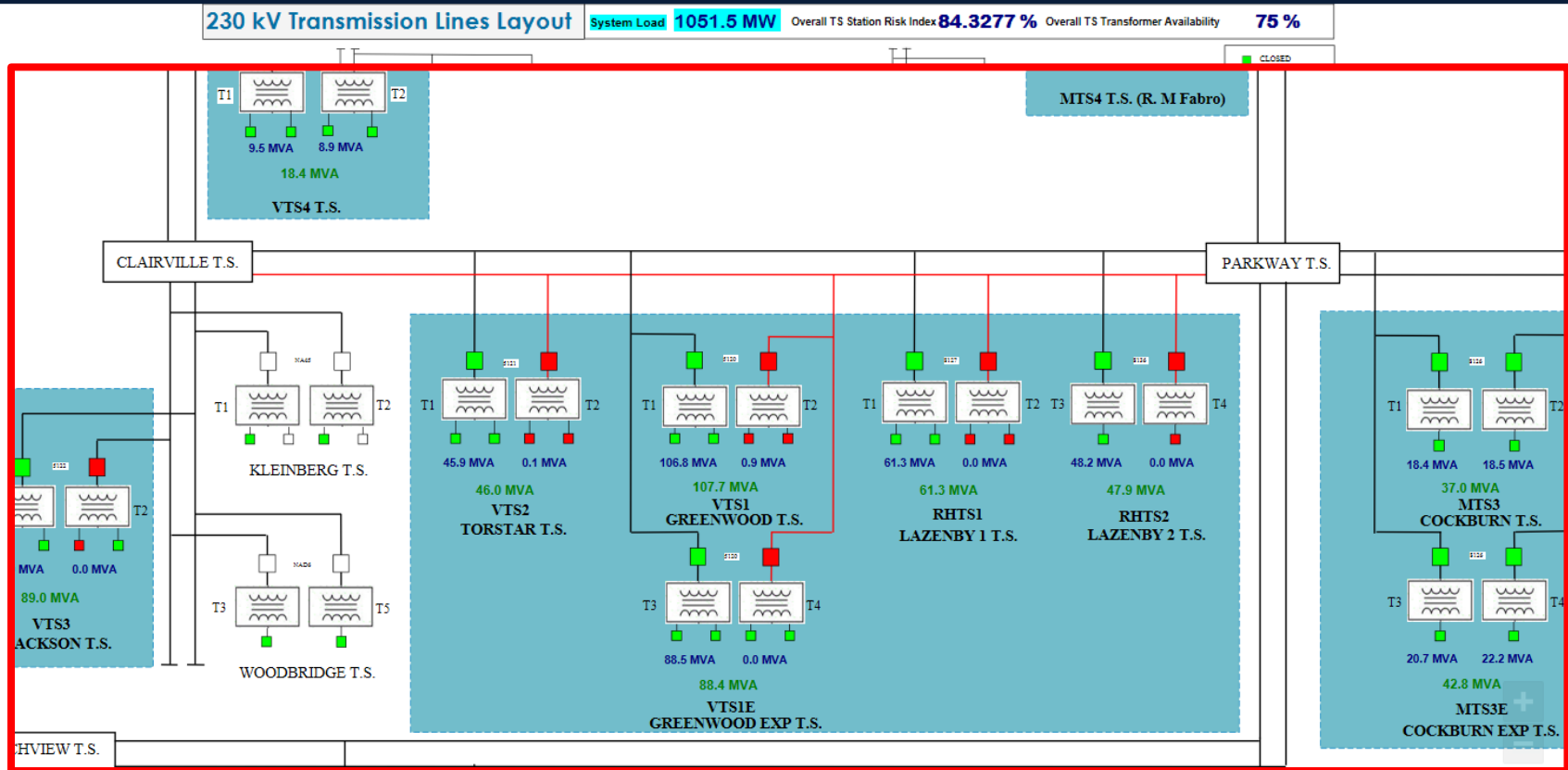
MS424: Cente

Various Operations / Equipment Reports - Alectra

- Transformer Availability
- Transformer Oil Temperature
- Transformer DGA
- Transformer Hydrogen
- Transformer Hydrogen and Moisture
- Transformer Health & Risk
- Transformer Cooling
- Geomagnetic Induced Current
- Transformer Loading

- Transformer Mtce Completion
- Transformer Mtce Forecast
- Transformer Oil Containment
- Transformer Monitoring Equipment
- Transformer Pressure Relief Vent & Gas Accumulation
- Transmission System Supply

230kV Transmission Supply Status Report



Station Performance Metrics (Example)



Overall TS Station Performance

Overall TS Station Risk Index	79.61 %
Overall TS Transformer Availability	72.7273 %
Overall TS Bus Availability	100 %
Feeder TS Breakers "Closed"	92.36 %



Performance
Indicators
(Performance
Equations)



2018

MTS3:D.H. Cockburn

Station Status	On
Station Risk Index	100
Transformer Availability	100
Bus Availability	100
Bus E Availability	LIVE
Bus E Voltage	28.65
Bus Z Availability	LIVE
Bus Z Voltage	28.67
Feeder Breakers Closed (%)	100

RHTS2:Lazenby 2

Station Status	On
Station Risk Index	65.625
Transformer Availability	50
Bus Availability	100
Bus C Availability	LIVE
Bus C Voltage	28.32
Bus D Availability	LIVE
Bus D Voltage	28.28
Feeder Breakers Closed (%)	87.5

MTS1 J.V. Fry	MTS2 A.M. Walker	MTS3 D.H. Cockburn	MTS3E D.H. Cockburn Exp	MTS4 R.M. Fabro
		RHTS1 Lazenby 1	RHTS2 Lazenby 2	
VTS1 Greenwood	VTS1E Greenwood Exp	VTS2 Torstar	VTS3 Lorna Jackson	

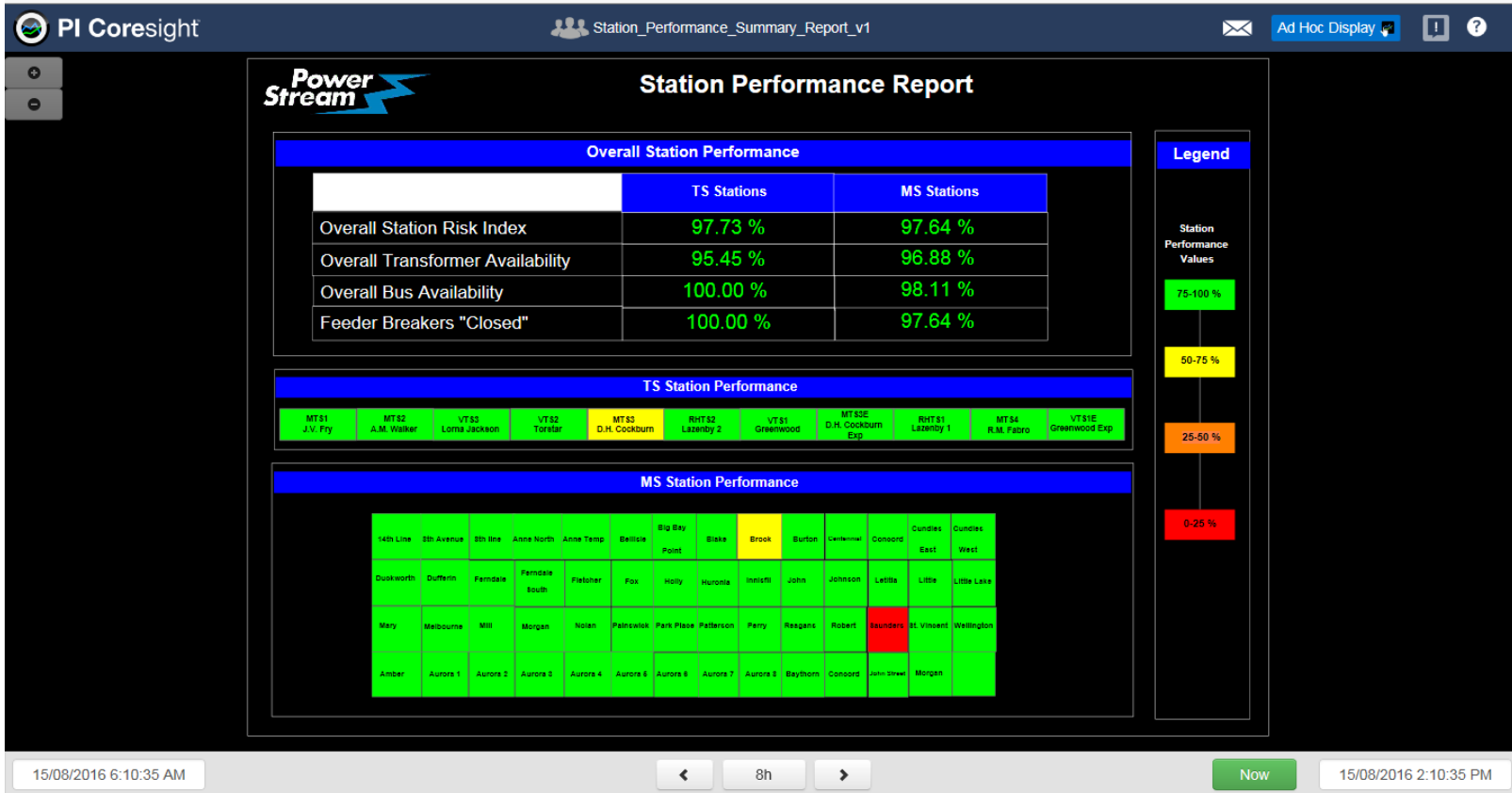


Multi States

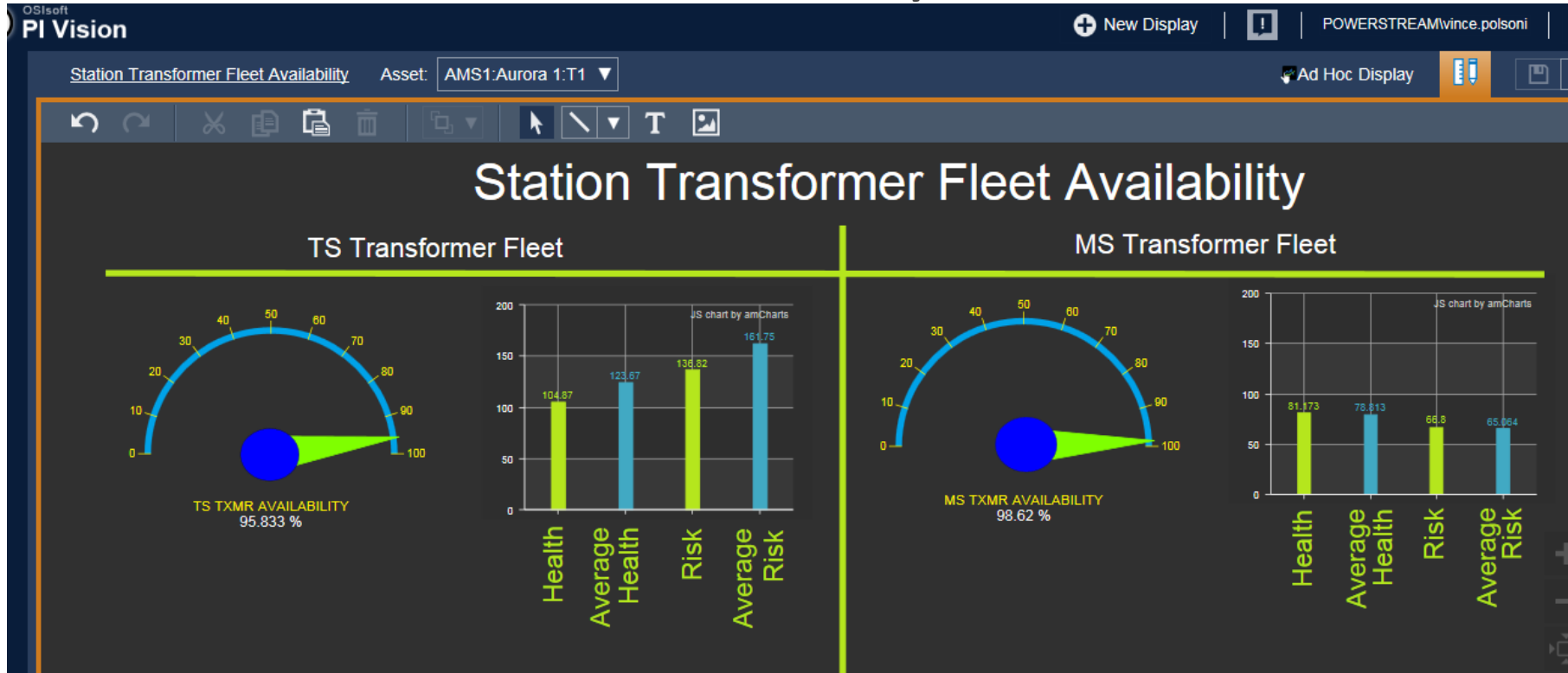


Analytics
(Performance Equations)

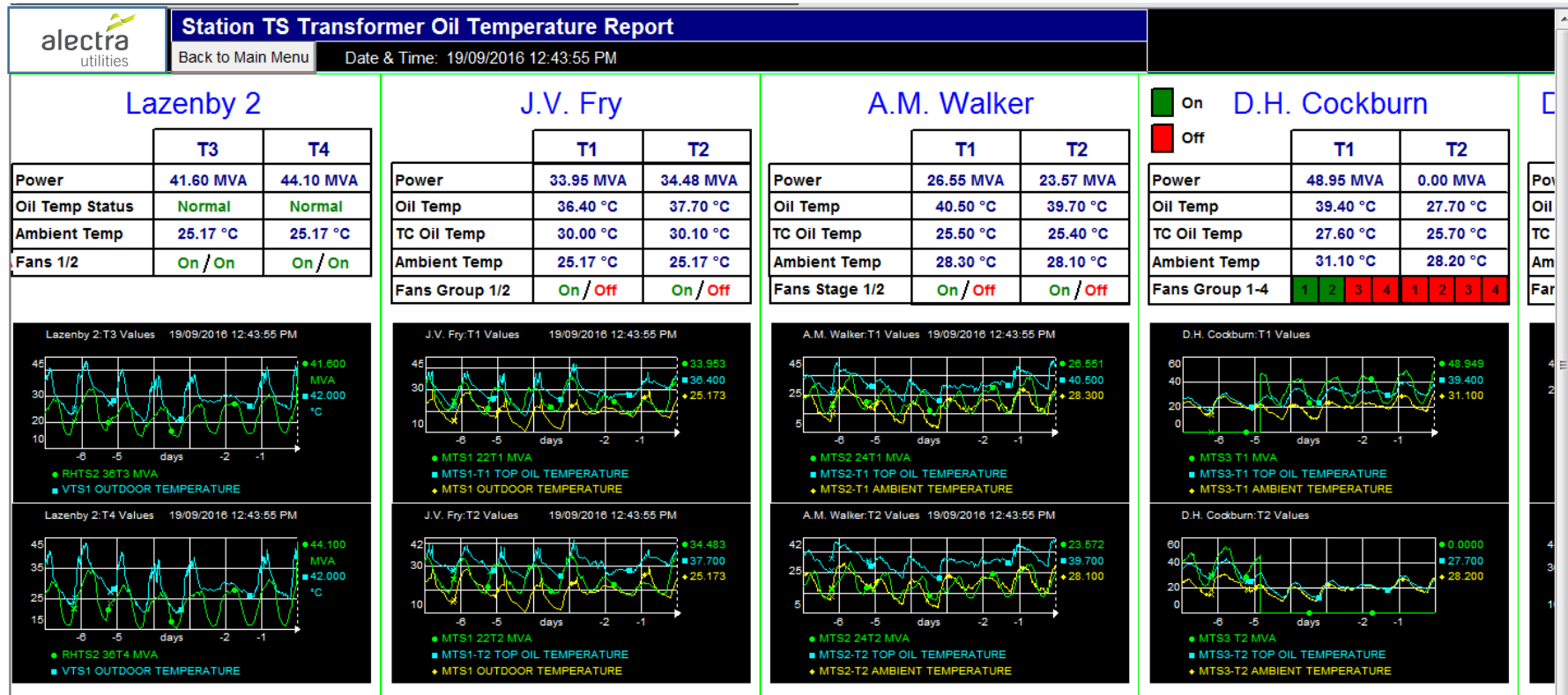
Station Availability (Risk) Report



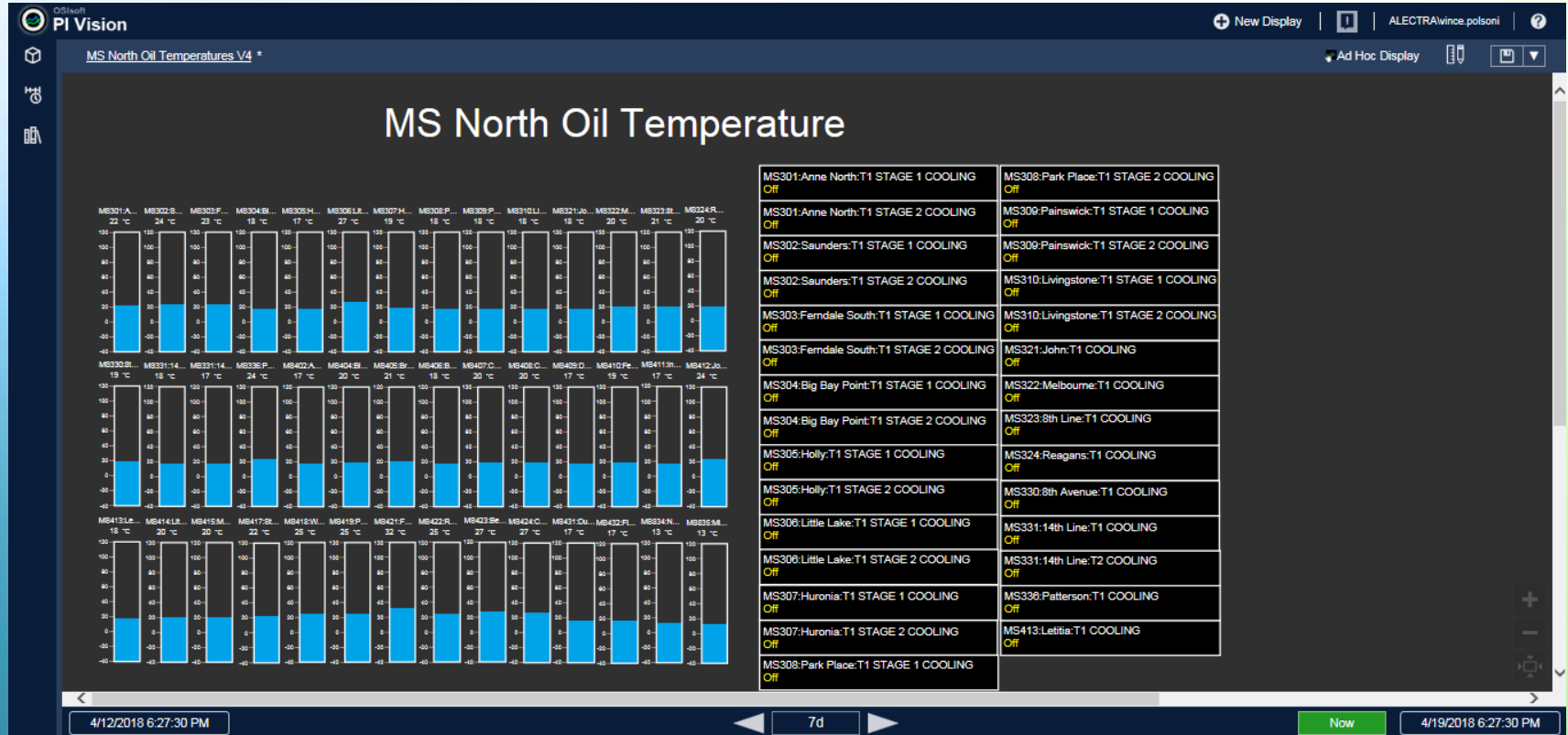
Transformer Fleet Availability



Station Transformer Oil Temperature/Cooling Report

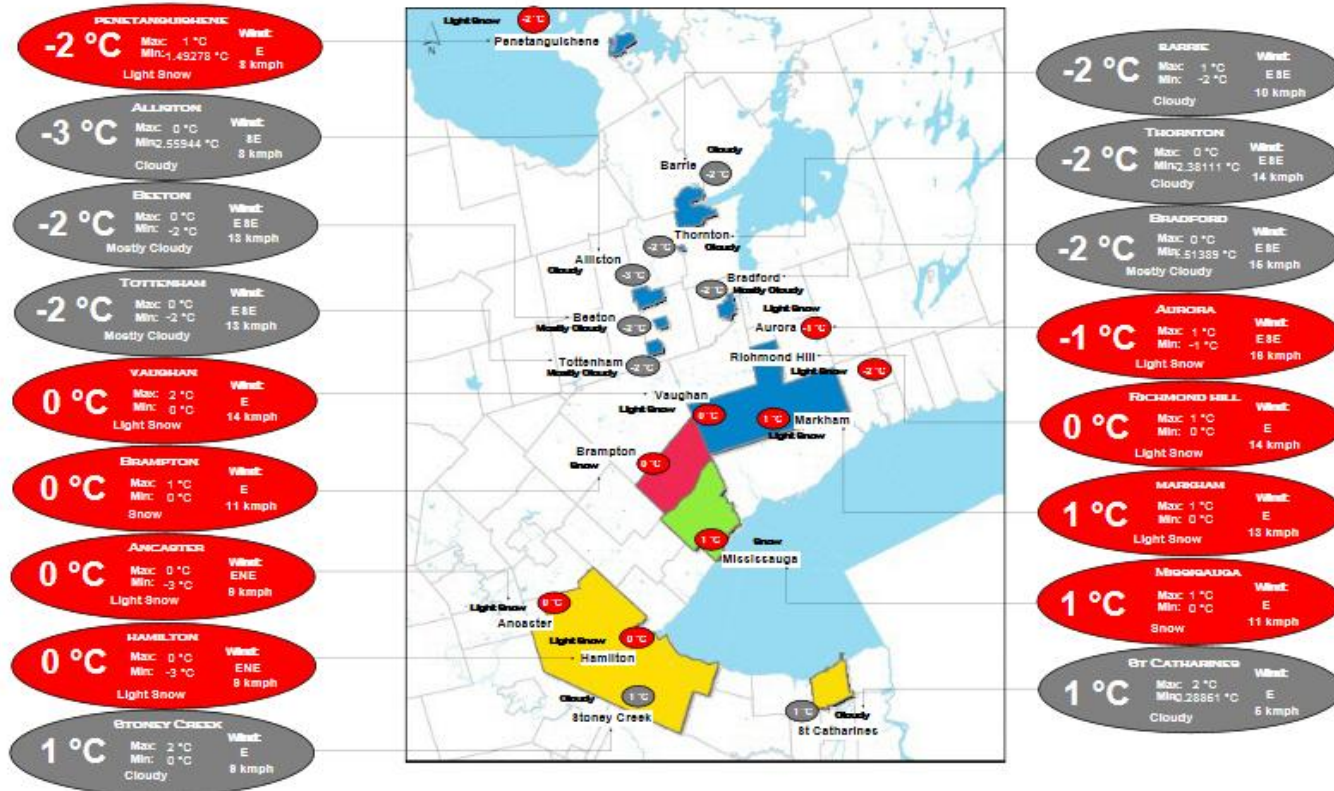


Transformer Oil Temperature Report

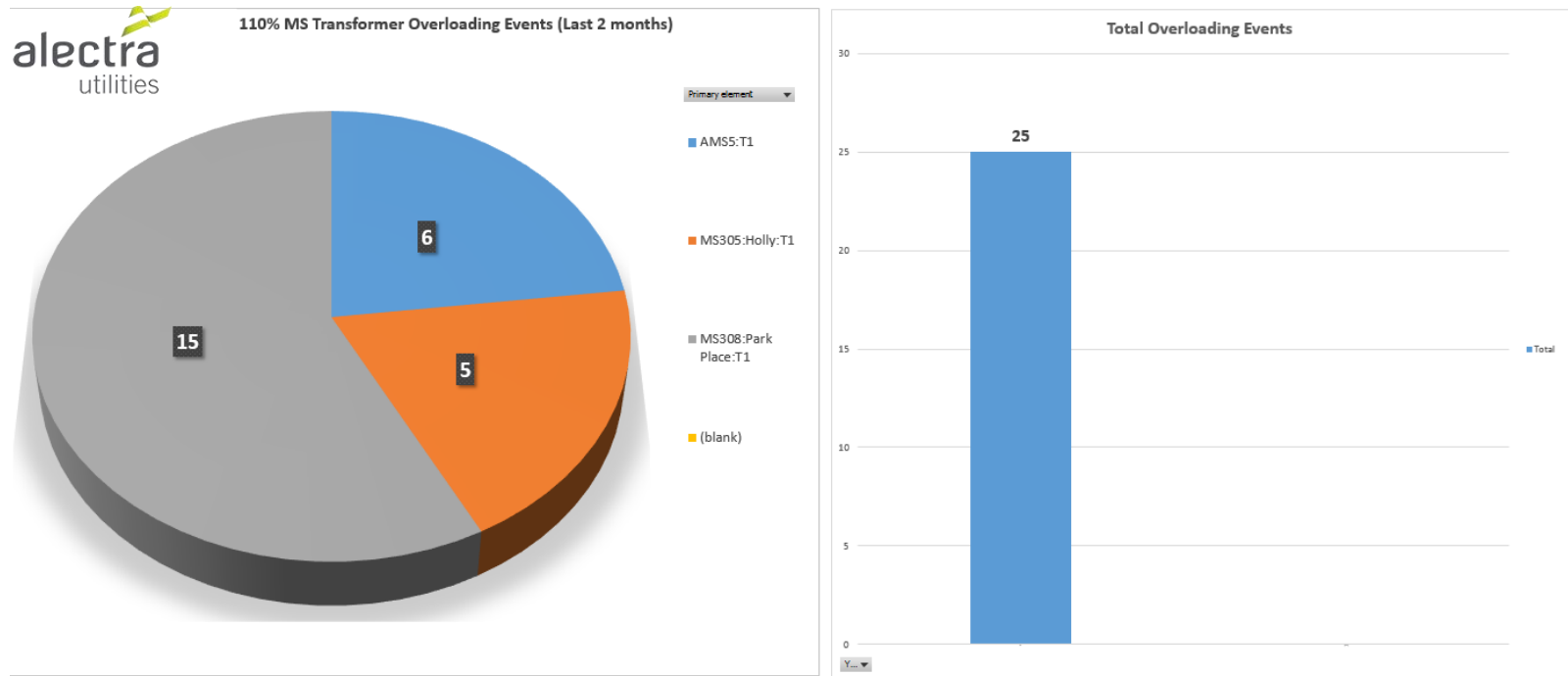


Alectra Service Territory Weather Report

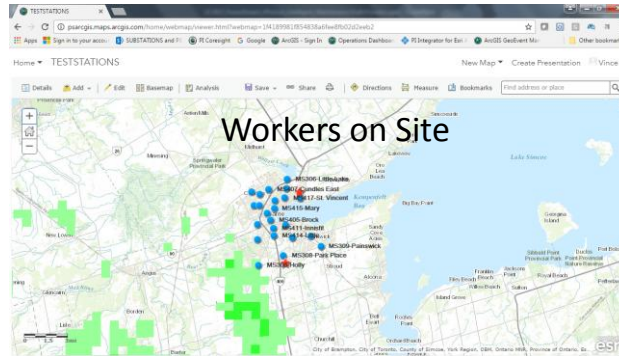
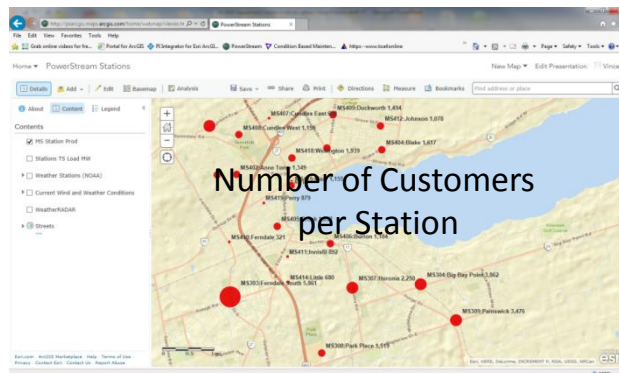
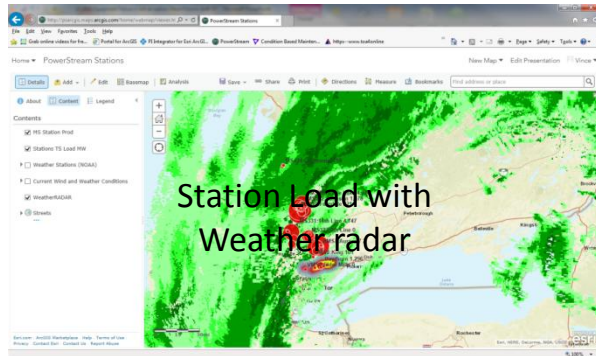
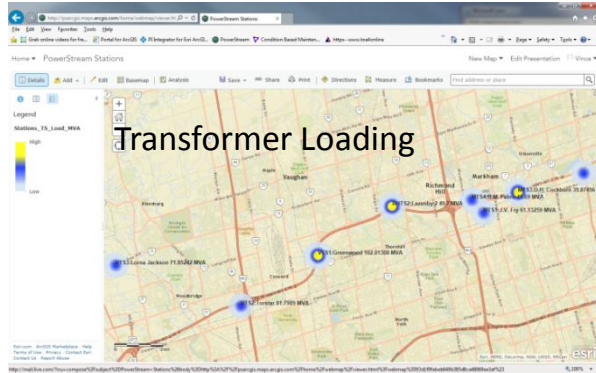
Alectra Service Territory Current Weather



Event Frame Report - Substation Transformer 110% Overloading Events



PI-ESRI Reports



- PI Integrator for ESRI ArcGIS
- ArcGIS Online
- Users of ESRI reports:
 - System Planning
 - Engineering
 - Operations
- Other reports:
 - Outages with Weather Radar and Wind
 - Transformer Health
 - Transformer Loading
 - Transformer Oil Temperature

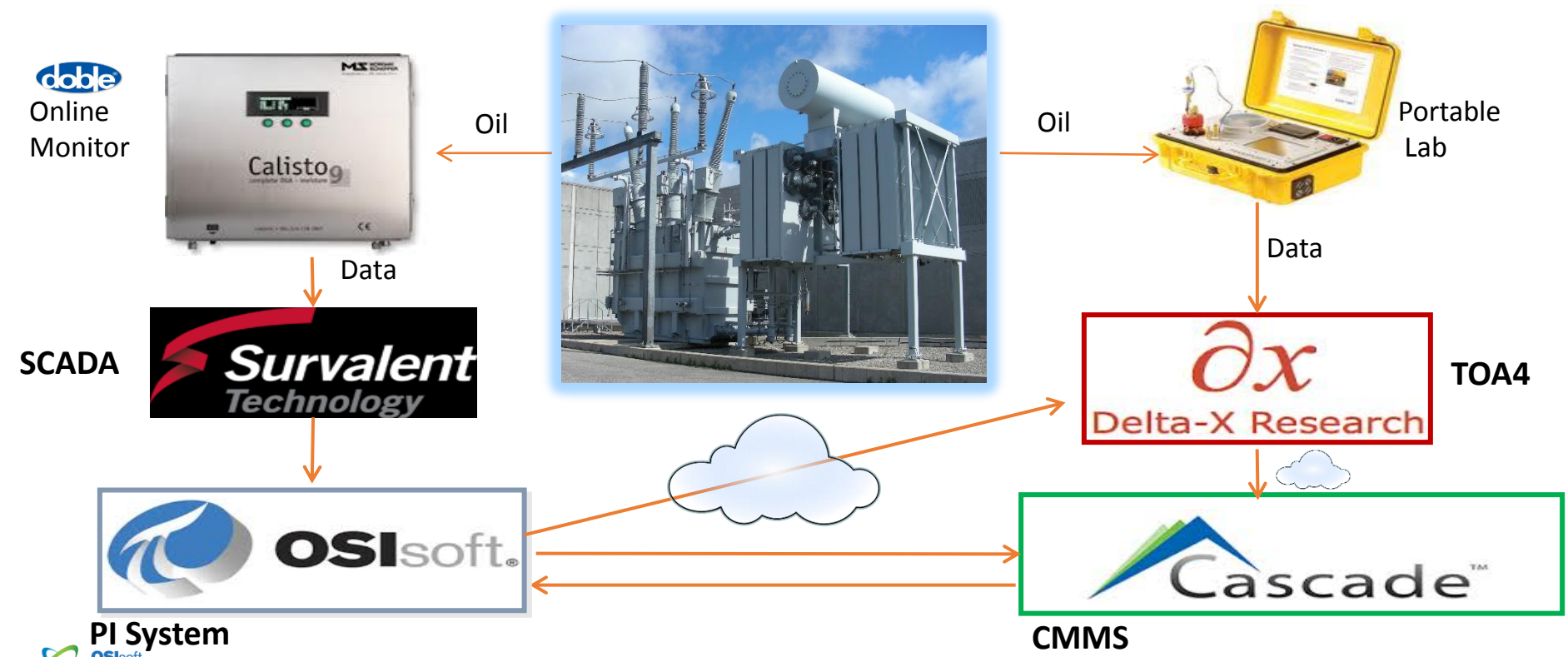
Notable Transformer Saves – Alectra Intelligent Maintenance



Save - 230kV-27.6kV 75/125 MVA



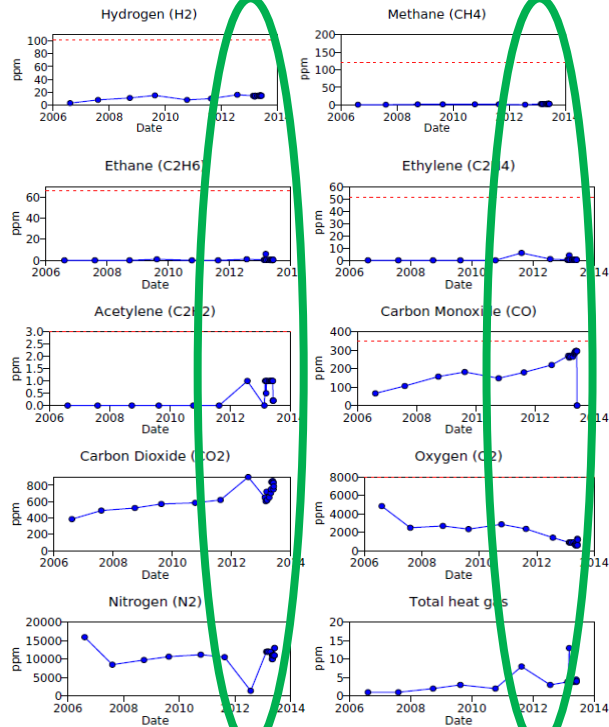
Integrated Expert Systems – Alectra Intelligent Transformer Maintenance



Comparison of Sister Units - DGA Trends

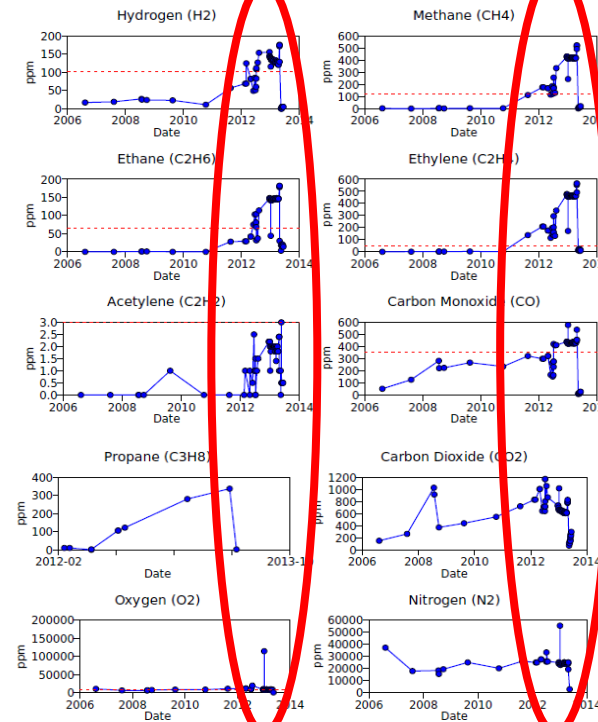
(Good Transformer)

History Graphs and Diagnostic Charts

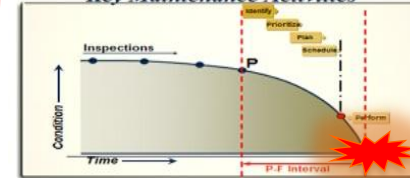


(Failing Transformer)

History Graphs and Diagnostic Charts

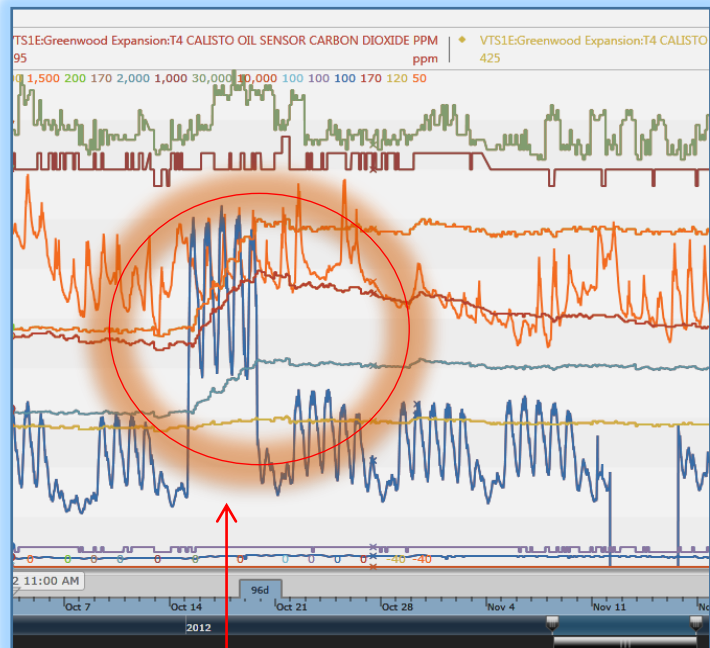


Key Maintenance Activities



Increased Gassing - 2 Significant Events

Event 1

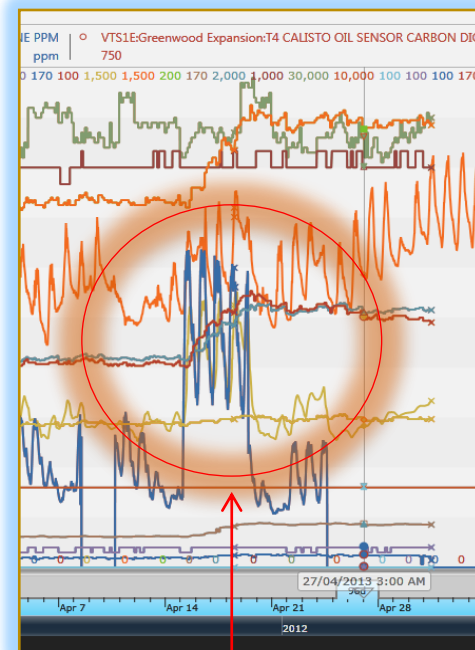


Oct 20, 2012

Gas levels increased as load increased



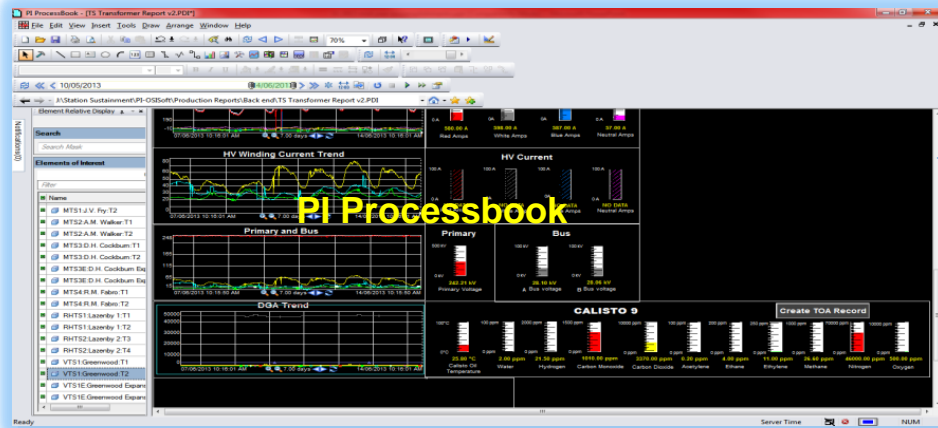
Event 2



April 19, 2013

Gas levels increased as load increased

Intelligent Maintenance CMMS-PI System-TOA4 - Dissolved Gas Analysis in Transformer



The screenshot shows a 'Fluid Analysis Report' for 'Transformer 01'. It includes a 'Gas Analysis' section with a table of gas concentrations and a 'TOA4 Analysis' section with a table of TOA4 codes. The TOA4 codes are listed in a column, with some values highlighted in red, indicating a problem.

Gas	Concentration (ppm)	TOA4 Code
Hydrogen	100	1.0
Acetylene	5	1.0
Ethylene	10	1.0
Ethane	20	1.0
Methane	50	1.0
Carbon Monoxide	100	1.0
Carbon Dioxide	1000	1.0
Oxygen	100	1.0
Nitrogen	1000	1.0



Daily Synch
or On Demand



Daily synch



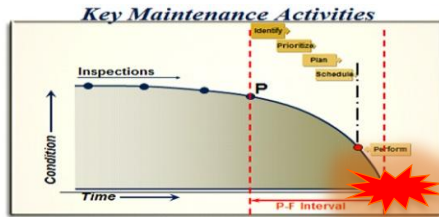
**Transformer Problem Identified
(Health and Risk Increase)
PI Notification, CMMS Alert and
Auto Generated CM Work Order
(Alert Generated if TOA4 DGA code is >2)**

The screenshot shows the CMMS (Cascade 3.40 Consolidated) interface. It displays a table of equipment with columns for 'Equipment', 'Triggers', 'McOrders', 'History', 'Forecasts', 'Comments', 'Alerts', and 'Finalized'. The table lists various transformers and their associated equipment. A red circle highlights a specific row, indicating a problem.

Equipment	Triggers	McOrders	History	Forecasts	Comments	Alerts	Finalized
MTS1 J.V. Fry T2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MTS2 A.M. Walker T2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MTS3 D.H. Cockburn T2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MTS4 R.M. Faber T2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
RHTS1 Laseley 1 T1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
RHTS2 Laseley 2 T1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
RHTS3 Laseley 3 T1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
RHTS4 Laseley 4 T1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
YTS1 Greenwood T1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
YTS2 Greenwood T2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
YTS3 Greenwood T3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
YTS4 Greenwood T4	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Findings and Cost Avoidance

- It was found that one of the "T" connectors was not crimped during manufacturing to the copper lead.
- Transformer was just over 5 years old.
- Problem was identified just after warranty period ended.



Cost Avoidance:

- Onsite Repair: \$100,000 (Potential Failure)
- Over \$3 million if unit failed catastrophically or with serious internal damage to windings or core.



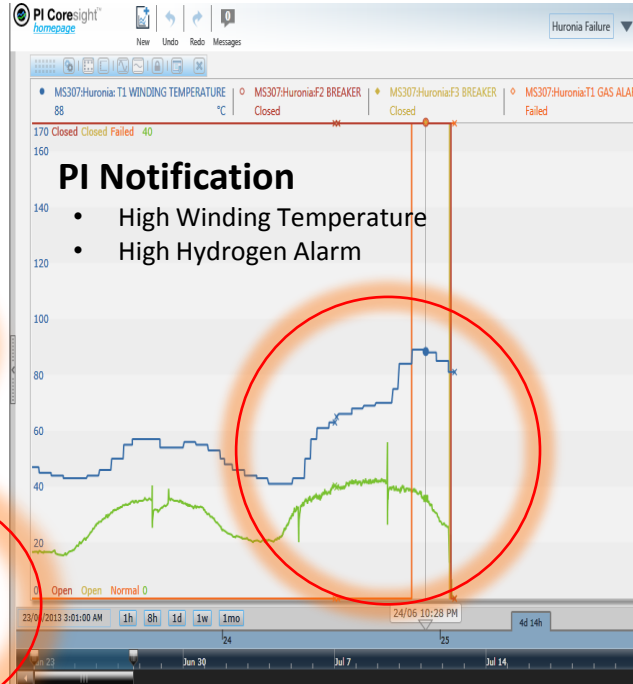
Photo 7 – Discolored Lead Paper Insulation



Photo 8 – Burned and Carbonized Lead Insulation



Save - 10MVA 44kV-13.8 kV Transformer



Cost Avoidance: \$500,000 averted

- Repair Cost: \$130,000
- No customer outages
- Transformer taken out of service before failure, repaired and replaced with spare

Installed a Hydrogen Gas Monitoring Unit and connected to SCADA (PI and CMMS)



Increased Visibility – Transformer Maintenance Programs



Dramatic Increase in Visibility and Awareness of Asset Condition and Program Performance



Equipment Reliability (Availability/Uptime)



Decrease Emergency Maintenance Tasks



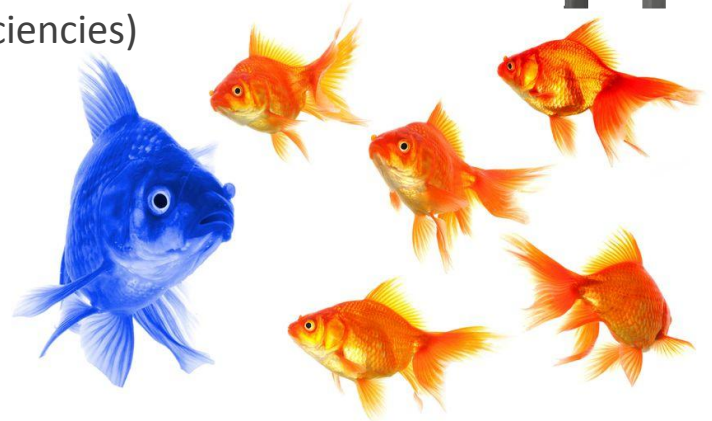
Increase Corrective Maintenance Tasks (no missed deficiencies)



Decrease in Preventive / Predictive Maintenance Tasks



Detective Maintenance (Failure Finding from RCM3)





HUGE SAVINGS - Intelligent Maintenance

- Failure Avoidance Costs – RCM3 → CBM
 - 2 Notable Catastrophic Transformer Failure Avoidances
 - \$3.5 Million Avoided Costs
- Many Reliability Improvements through CBM Identified Potential Failures
 - No missed failures no matter how small
- Safer Working Environment / Safer for Public
- Improved Risk Management
- Better Asset Condition Assessment (Health and Risk)

Benefits of Leveraging PI System for Transformer Management

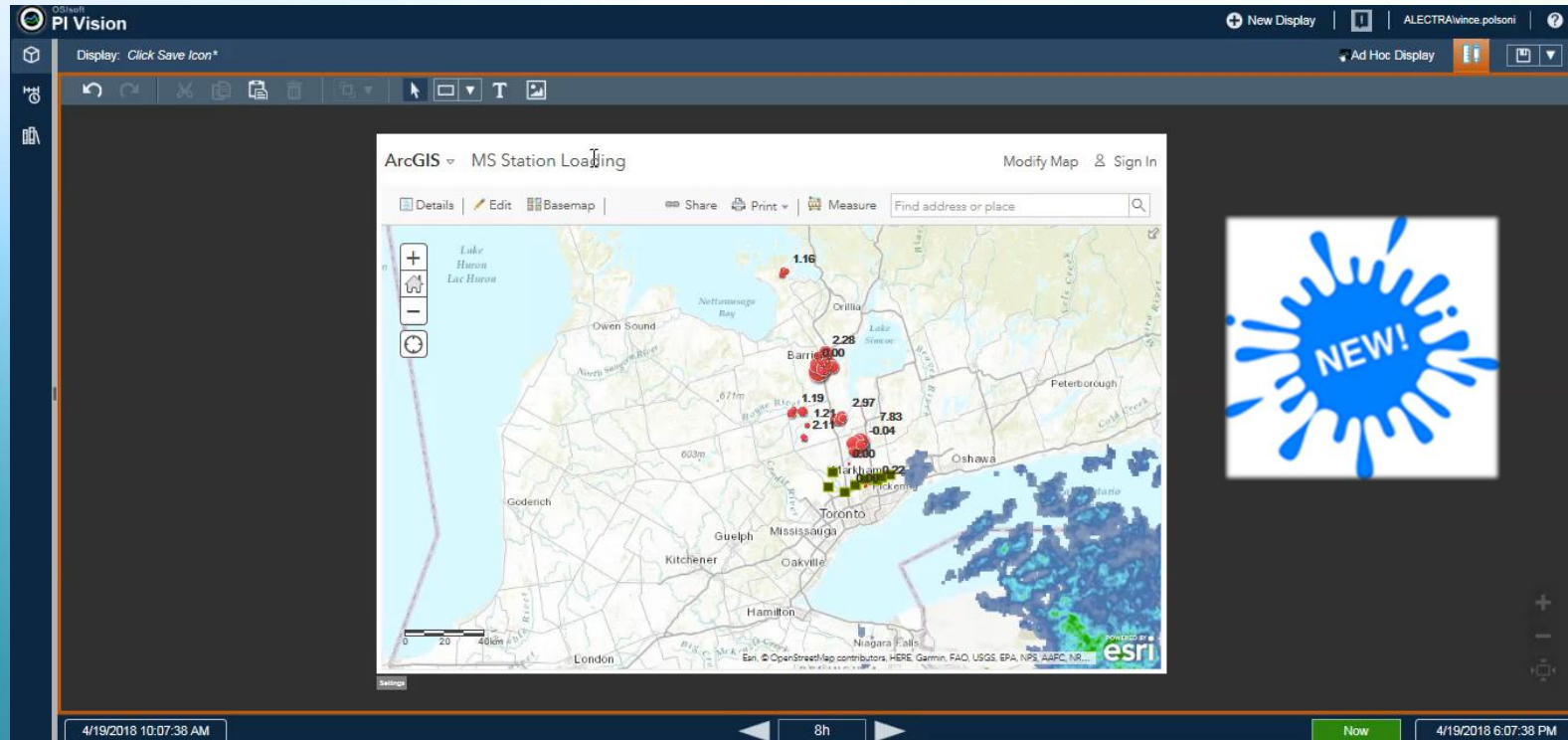
- Makes it **Easy** to turn Real-time Data into Information
 - Stores Key Information for Asset Management Decision Making
- **Enabler** for Risk Based Condition Based Maintenance
- Maintenance **Optimizer**
- **Innovation** stimulant
- PI System is **Easy** to learn
- Keeping it **Simple** is better



New – Live Video Streaming PI Report



New - ESRI Report in PI Vision Report



Questions

Please wait for the **microphone** before asking your questions

State your **name & company**



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Leveraging the PI System Station Transformer Intelligent Maintenance



COMPANY AND GOAL

Alectra Utilities Inc. is a progressive distribution utility company that focuses on Innovation and Technology to achieve operational efficiencies that contribute to maintenance optimization and reduction of equipment failures



CHALLENGE

Implement an Intelligent Transformer Maintenance System that improves worker safety, increases asset availability, improves reliability, lowers Operational costs, and provides Operations information to those who do not have access.

- Adopt a new approach to transformer maintenance which lowers maintenance costs while extending life of asset and improving worker safety.

SOLUTION

Used the PI System as a means of enabling Prioritized Risk based Condition Based Maintenance on station transformer fleet. Interface key systems to allow operational data to aid in Optimizing transformer maintenance.

- Configured Intelligent Maintenance system with RCM3 as core maintenance utilizing CMMS and PI Systems to operationalize the system.
- Integrated to CMMS system to enable True Condition Based Maintenance
- Developed PI Notifications to notify on equipment conditions.

RESULTS

Transformer fleet fully monitored. Deficiencies are automatically detected early and prioritized. Cost avoidance is achieved as a benefit. Life Cycle extension is realized.

- Cost Avoidance achieved with every deficiency find.
- Improved System Reliability
- Improved Response Time to Equipment Abnormalities
- Increased Equipment Availability due to early detection of problems.
- Savings in Operating Costs

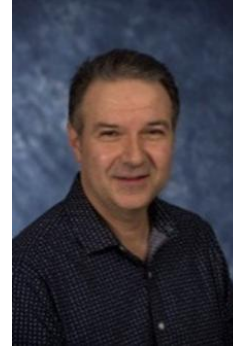
Contact Information

Vince Polsoni

vince.polsoni@alectrautilities.com

Manager Station Sustainment

Alectra Utilities Inc.



Merci

谢谢

Спасибо

Danke

Gracias

Thank You

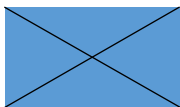
감사합니다

ありがとう

Grazie

Obrigado

Optional: Click to add a takeaway you
wish the audience to leave with.



CHALLENGE



SOLUTION



RESULTS