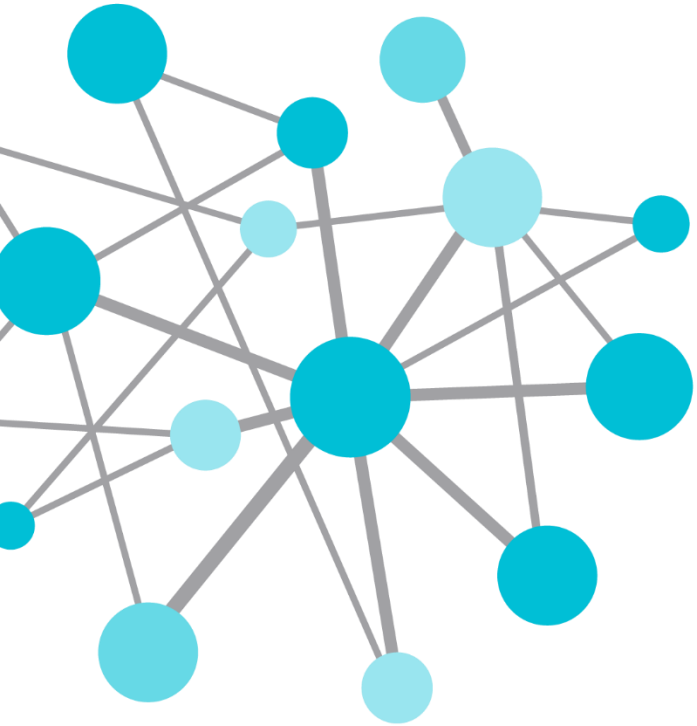


Leveraging PI System at PowerStream: Operations to Micro Grid

Presented by **John McClean, Powerstream Inc**

Vince Polsoni, Powerstream Inc

Presenters

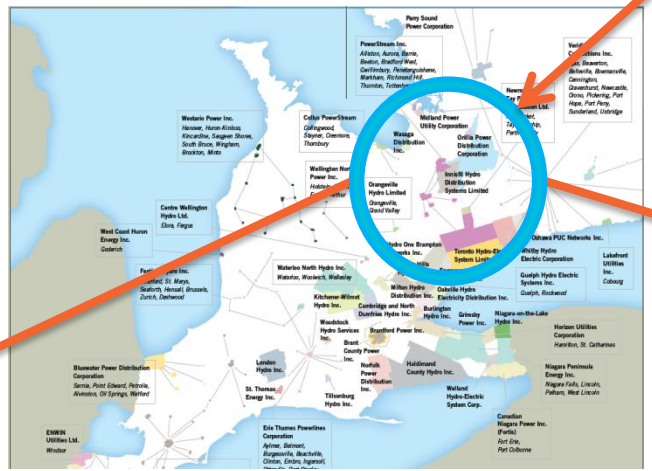
John McClean

- Vice President of Operations for PowerStream
- Energy Technology graduate of Bismarck State College
- Over 31 years of experience in electric utility operations including generation and distribution.
- Led the consolidation of Operations' business units at the formation of PowerStream from 2004 onward and subsequent mergers and acquisitions since then.
- Focus on continuing to leverage technology and process improvement.
- Support and expand Smart Grid applications and technologies in use at PowerStream: FDIR, AFR, Field Intelligence.
- The Operations' business units John currently oversees include System Control, Protection and Control, Station Sustainment, and Metering.
- Member of national and provincial committees in areas of emergency preparedness and system reliability

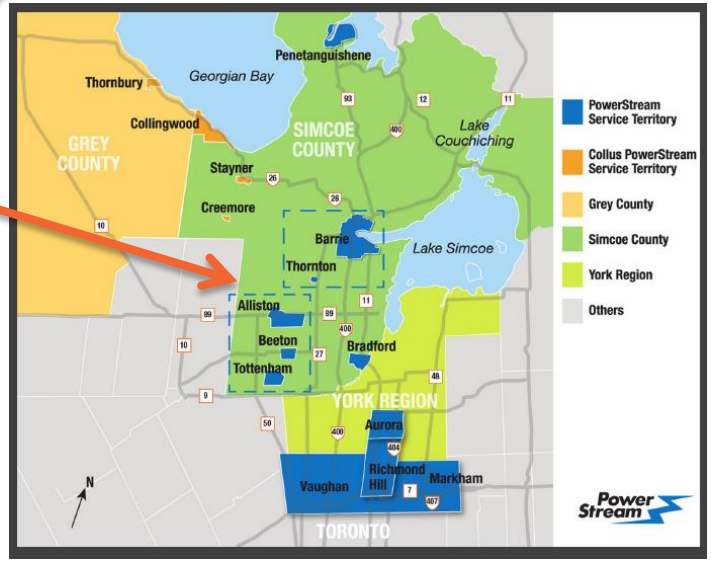
Vince Polsoni

- Manager of Station Sustainment
- Certified Electrical Engineering Technologist and a RCM2 Trained Facilitator
- Over 29 years of experience in the Electrical Utility Industry in Asset Management, Substation Design, Station and Distribution System Maintenance
- Focus on Maintenance Optimization by transitioning from Time Based Maintenance to Risk Based Condition Based Maintenance
- Improving Safety and Reliability by leveraging technology, automation and process improvement (RCM)
- Experience in implementation of Asset Management, Work Management Systems and Reliability Centered Maintenance (RCM)
- Successfully implemented the PI System and CMMS at Powerstream

Where are we?



Powerstream Service Territory



Ontario
1,068,587 km2

Texas
696,200 km2

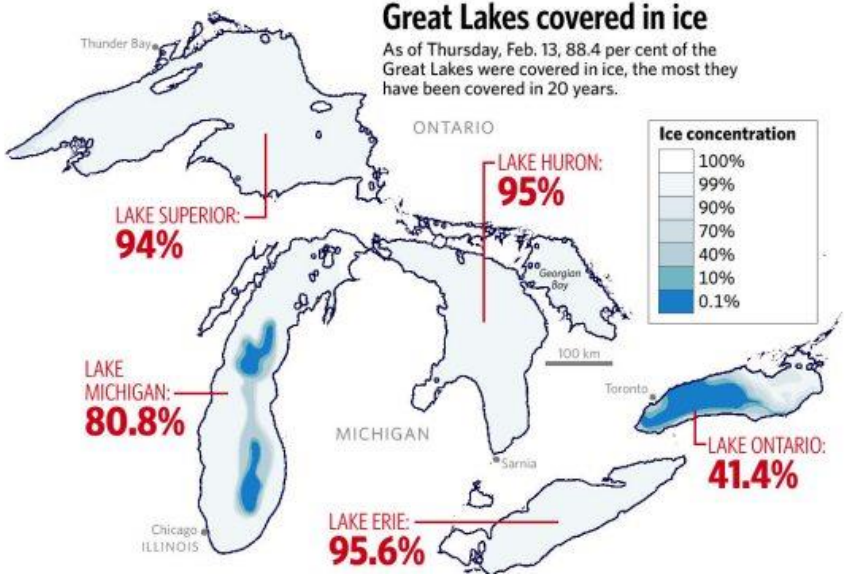
Powerstream Service Territory

- 806 km2
- 11 Municipalities
- Located just North of Toronto

PowerStream Fast Facts

- **2nd Largest Municipally owned Local Distribution Co. (LDC) in Ontario, Canada**
- **Serving 11 Communities through Central Ontario (Serving over 1 million residents)**
- **550 Employees**
- **343,000 Customers** : (Residential (89%) Commercial Ind. (11%))
- **Total Revenue:** **$788 Million**
- **Total Assets:** **$1,087.5 Million**
  - **Overhead Circuit Wires:** **2,500 km**
  - **Underground Cable:** **4,900 km**
  - **Transformer Stations (TS's):** **11**
  - **Municipal Substations (MS's):** **55**
  - **Distribution Transformers:** **43,000**
  - **Switchgears:** **1,800**
  - **Poles:** **40,000**
- **Peak Demand:** **1,972 MW**
- **Geographical Size of Service Territory:** **806 Sq. Km**
- **Distribution Voltages** **4kV, 8kV, 13.8kV, 27.6kV and 44kV**

We are buried and surrounded by ice and snow….Polar Vortex



Agenda

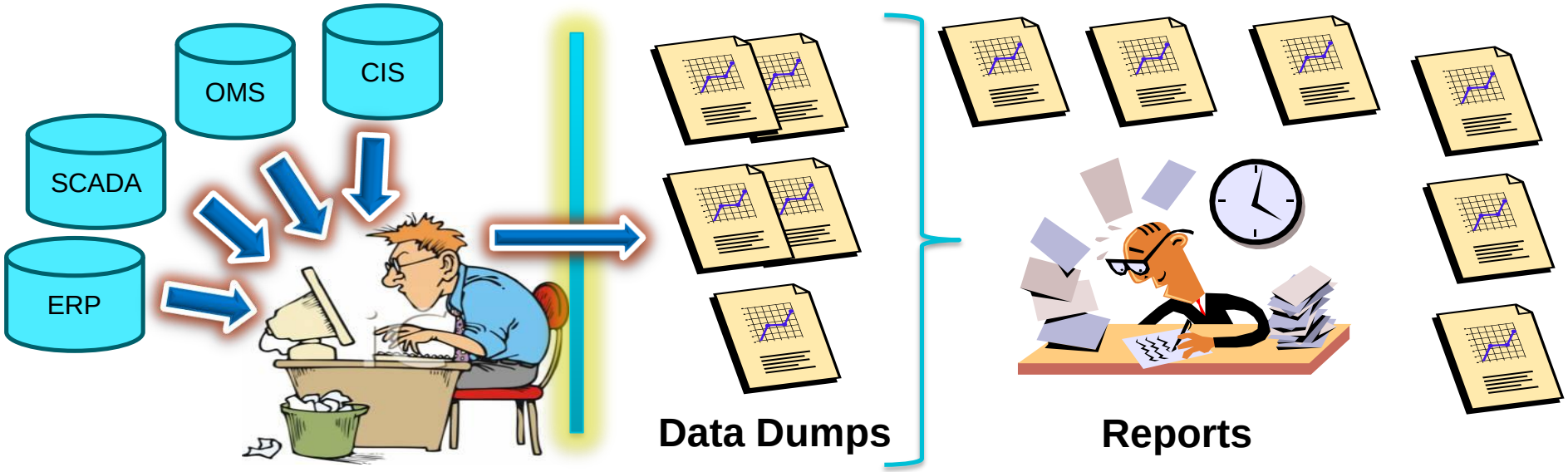
- PI System in use at PowerStream(Operations)
- Micro Grid Demonstration Project
- Overview of Project
- Control and Analytics Systems

Background - PI System at Powerstream

- July 2012 Implementation – 5000 tags
- Purchased as part of Computerized Maintenance Management System (CMMS) implementation strategy
  - Migrate from Time Based Maintenance to Risk Based Condition Based Maintenance model
  - Integrate with CMMS to make SCADA data available
- Operational reports (PI ProcessBook, PI Coresight, PI DataLink, PI Web Parts)
- July 2013 Notifications
  - Equipment alarms, operations, peak load, oil temperatures, fire alarm, SF6 gas, building temp, battery /charger failure, etc

Life before PI System Reporting
SCADA / OMS / CIS / ERP

- Data is overwritten based on **frequency** of data point collection in some databases (e.g. SCADA)
- Archived/Historical data is often extracted and stored in flat files (spreadsheets)



Leveraging PI System at Powerstream

- Asset Dashboard on Company Intranet
- Link to multiple databases/systems
  - SCADA, MicroGrid, CMMS
  - OMS (future), WMS/EAM (future), CIS (future)
- Expand Notifications / Alerting to stakeholders (email)
  - Offload low level SCADA alarms through PI System PI Notifications to field staff (awareness)
- Future - Mobile Dashboard (iPAD and SmartPhone)
- Future – Analytics

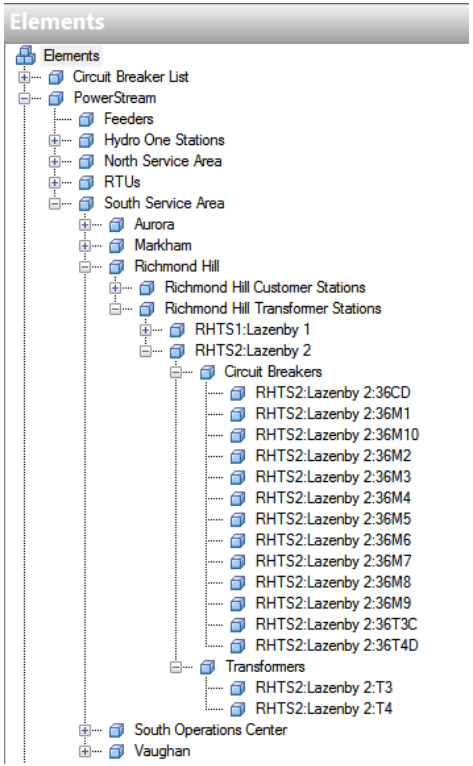
PI System Products used at Powerstream

30,000 tags
(and growing)

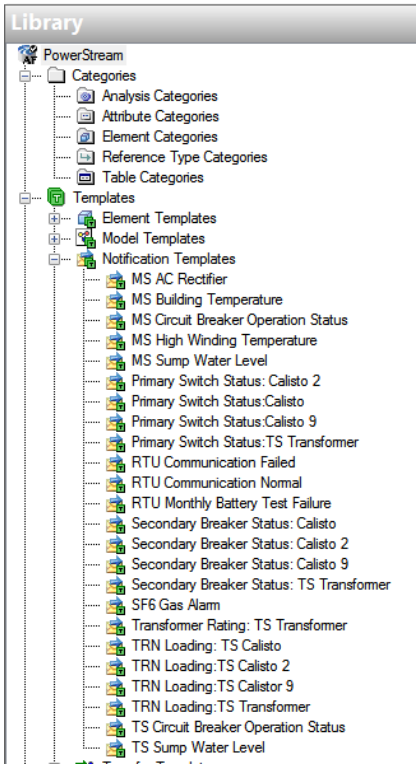
- PI ProcessBook
- PI Coresight
- PI WebParts
- PI DataLink
- PI Data Access
- OSIsoft Utilities Gateway
- PI Asset Framework (AF)
- PI-SMT, PI ICU
- PI System Explorer
- PI Asset Framework (PI AF)
- PI Notifications

PI System Explorer

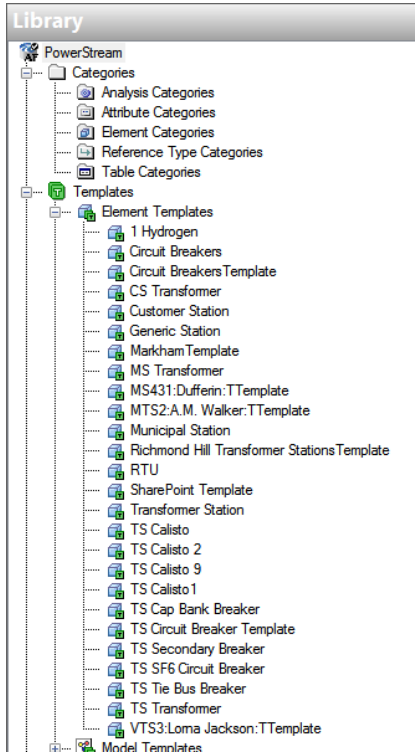
Elements



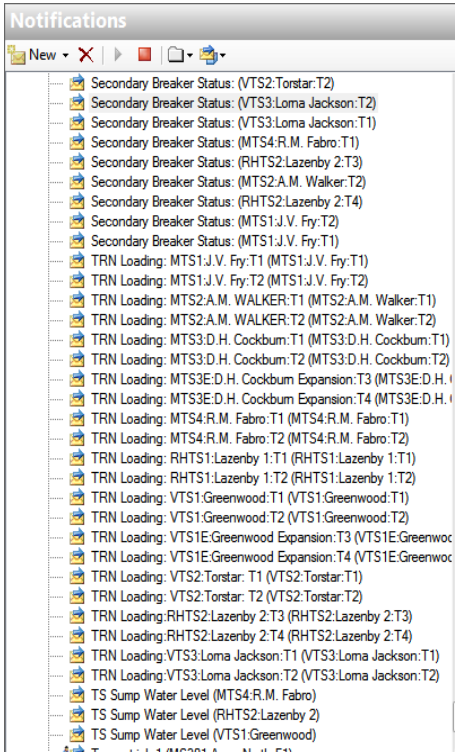
Element Templates



Notification Templates



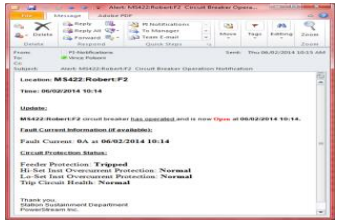
Notifications



Leveraging PI System for Risk Based CBM

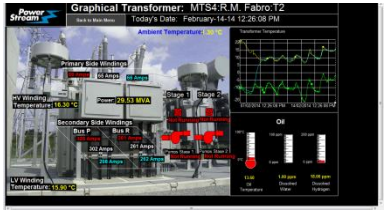
Integration

- Automatically Generate maintenance task in CMMS system based on triggers



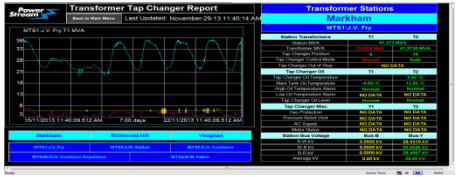
Real-time Alerting

- Notifications and alarms (Real-time)



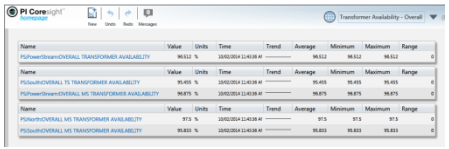
Visual Reports

- Various displays catering to different audiences
- Various display tools
- Drill–down user interface

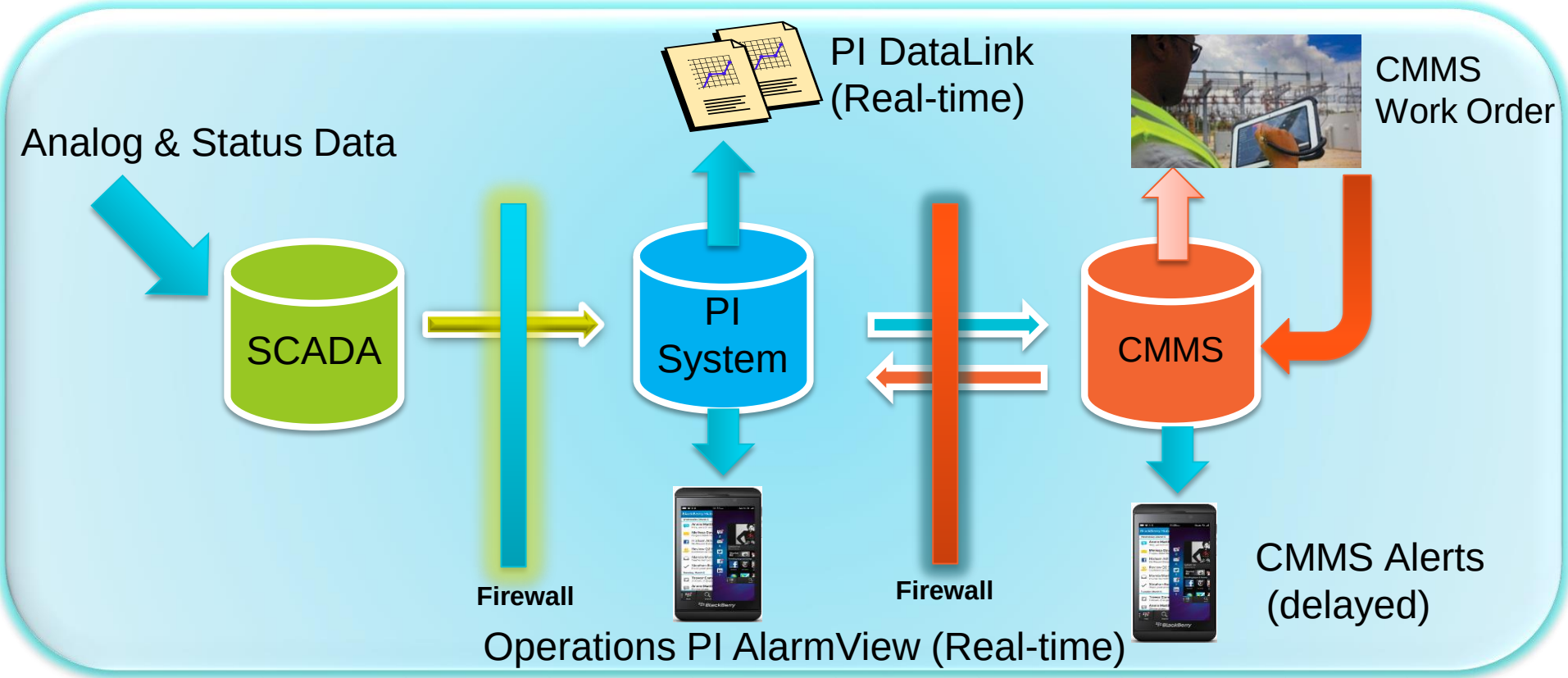


User Friendly Simple Tools

- Basic functions (average, max, min)
- Trends, calculated values, counters



Condition Based Maintenance - Data Flow



PI ProcessBook Reports - Powerstream

- System Demand
- Station Performance/Risk
- Under Frequency Load Shed
- DC System
- Building Heating
- Station Single Line Diagrams
- Station Fire Alarm
- Primary Switch Status

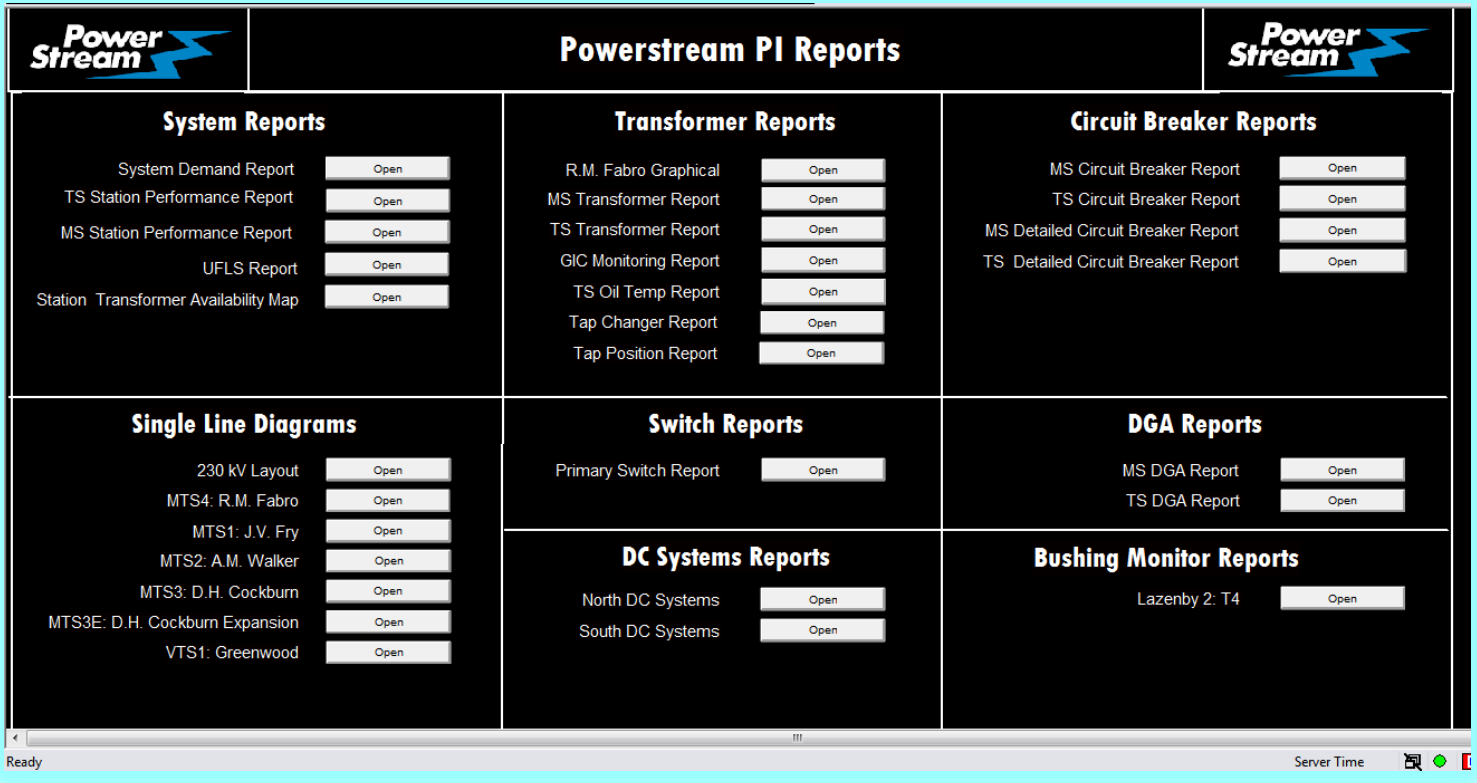
- Transformer
  - Condition
  - Dissolved Gas Analysis
  - Oil Temperature
  - Tap Changer and Tap Changer Position
  - Bushing Monitoring
- Circuit Breaker
  - Status and Detailed
  - SF6 Status

PI CoreSight Reports - Powerstream

- System Demand
- Station Risk Index
- Station Loading
- Transformer
  - Loading
  - Winding temperature
  - Oil temperature
  - Hydrogen and Moisture
  - Cooling
  - Availability

- Bus Availability
- GIC Monitoring
- Sump Water level
- Station Building Temperature
- Ambient Temperature
- Primary Switches
- Equipment Failures (history)
- Adhoc Reports

PI ProcessBook Reports Home Page



PI ProcessBook – TS Transformer Report

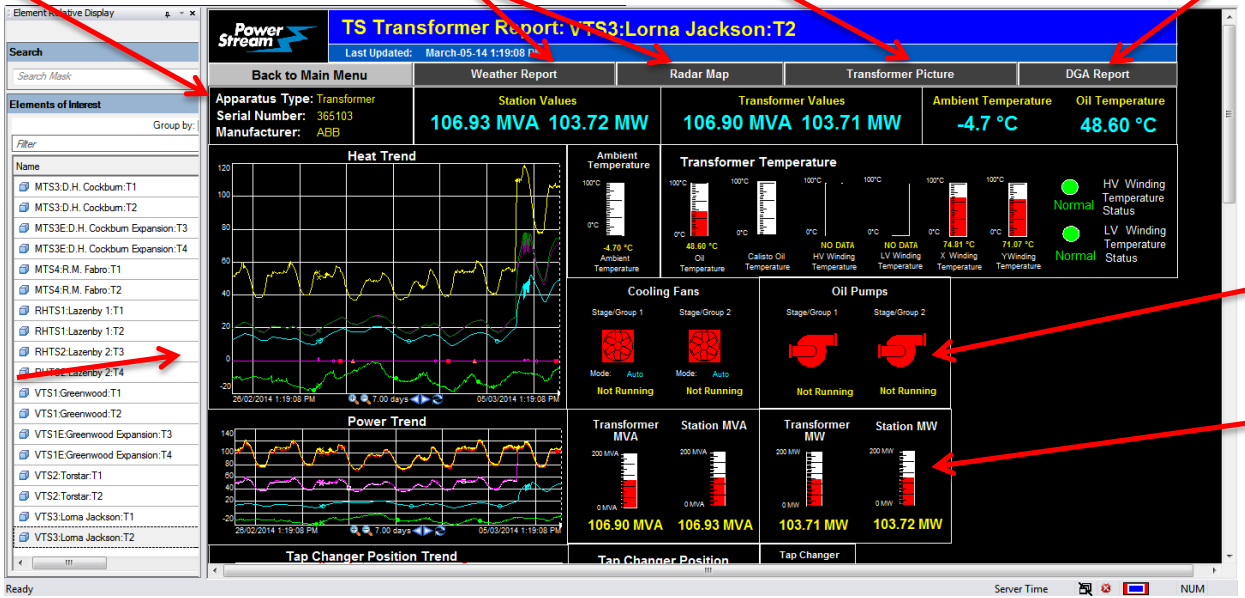
Equipment Attributes

Links:
- Weather report
- Radar Map Link

Pictures

External Database/App

PI AF Elements



PI AF Elements

PI ProcessBook Trends

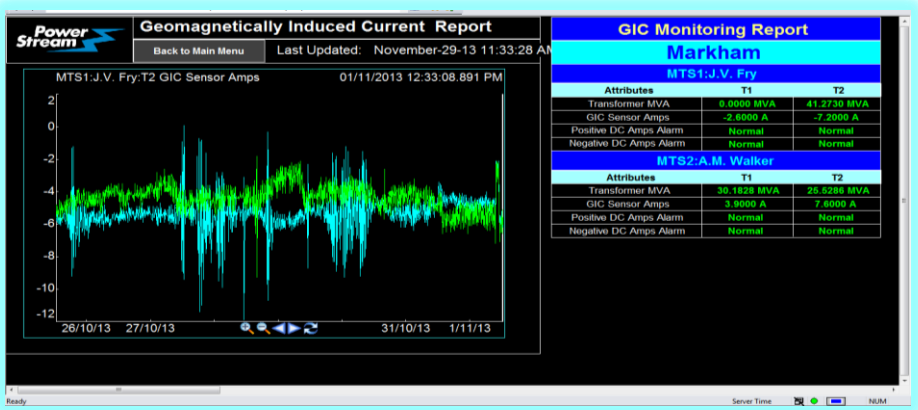
PI ProcessBook Symbol Animations

PI ProcessBook Gauges

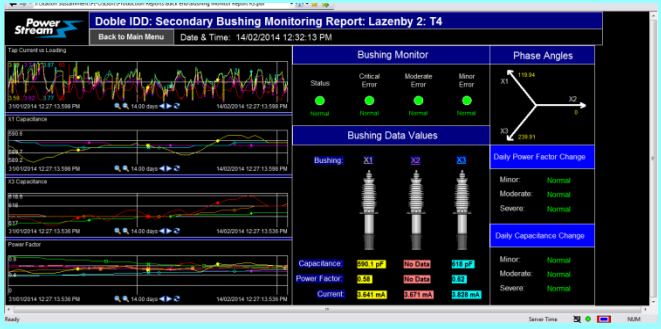
Template Report

PI ProcessBook Reports

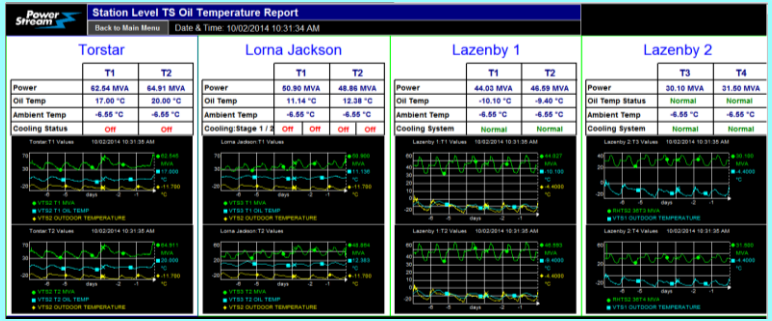
Geomagnetically Induced Current (GIC)



Transformer Secondary Bushing Monitoring

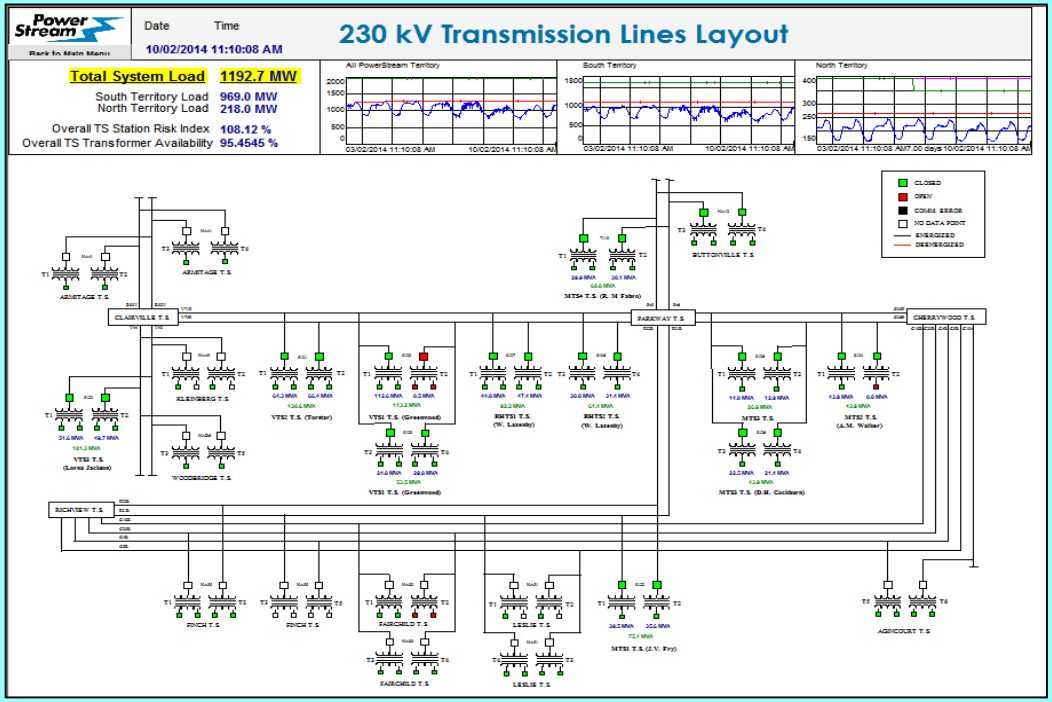


Transformer Oil Temperature

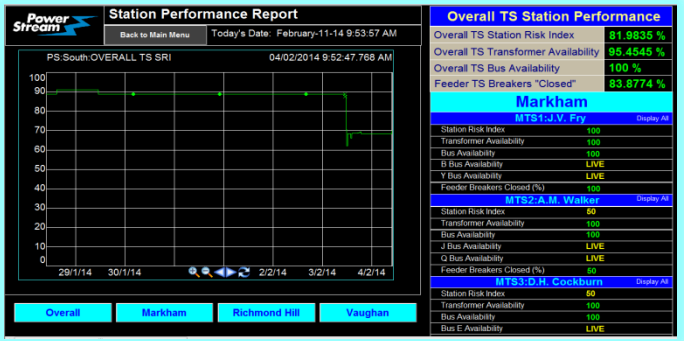


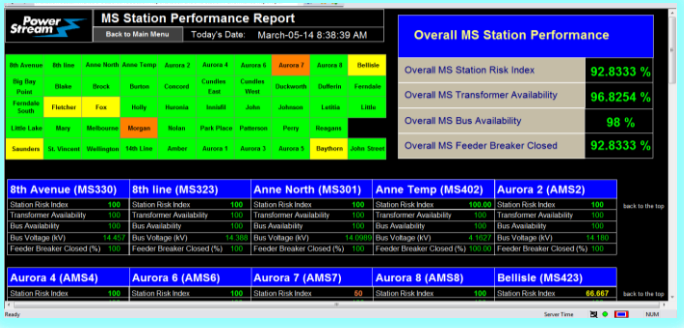
PI ProcessBook Reports

230 kV Transmission System Layout



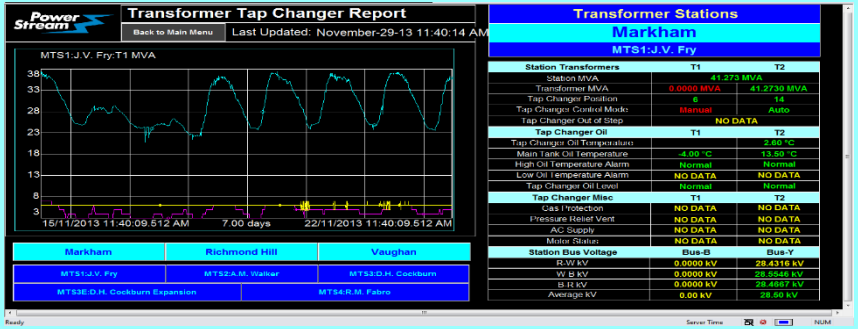
Station Performance (Risk)





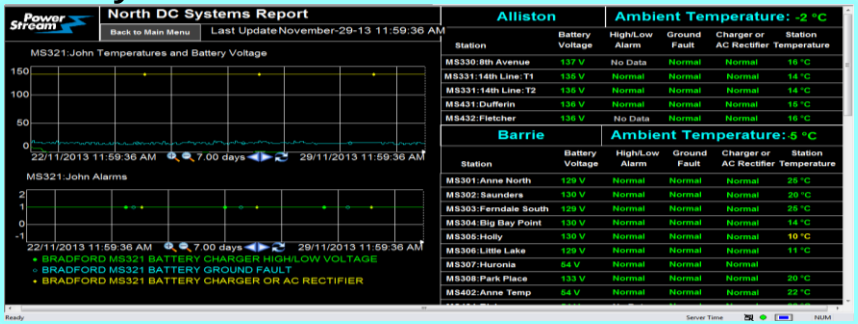
PI ProcessBook Reports

Tap Changer

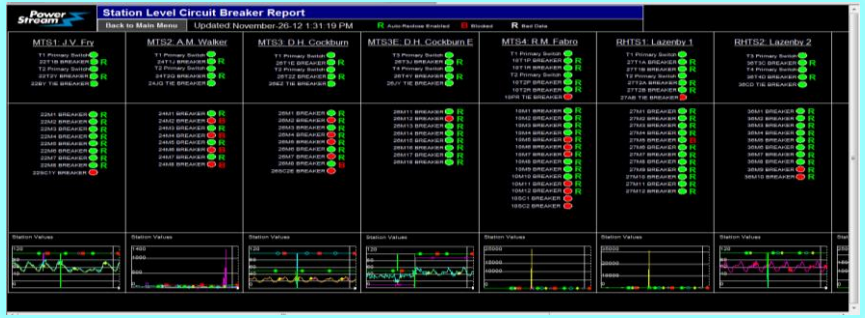


230 kV Primary Switch Status

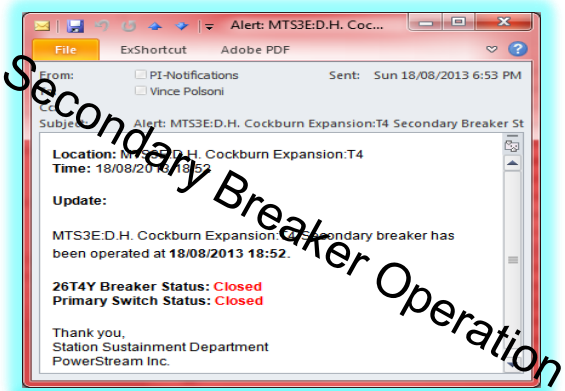
DC Systems



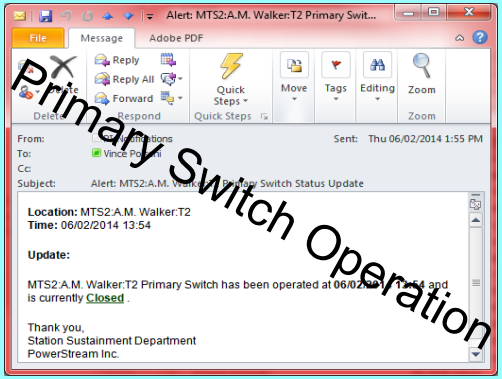
Circuit Breaker Status



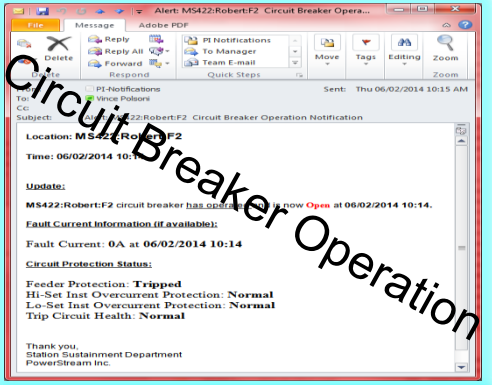
PI Notifications



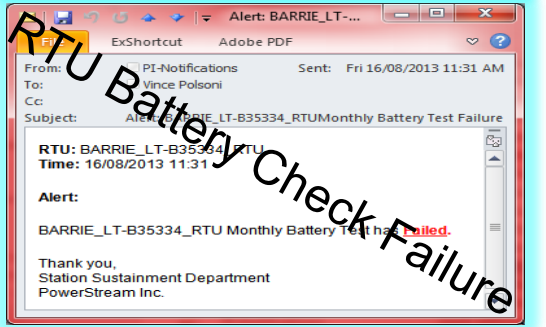
Secondary Breaker Operation



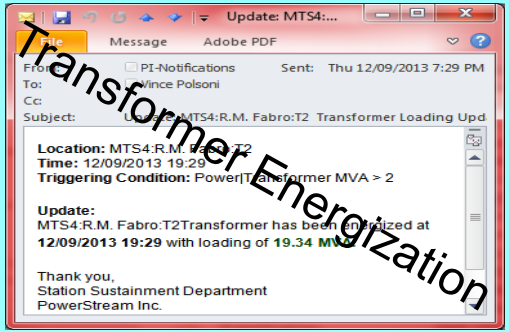
Primary Switch Operation



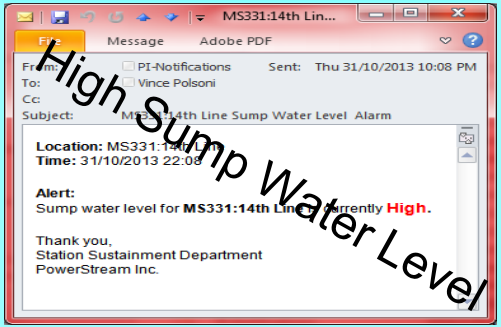
Circuit Breaker Operation



RTU Battery Check Failure



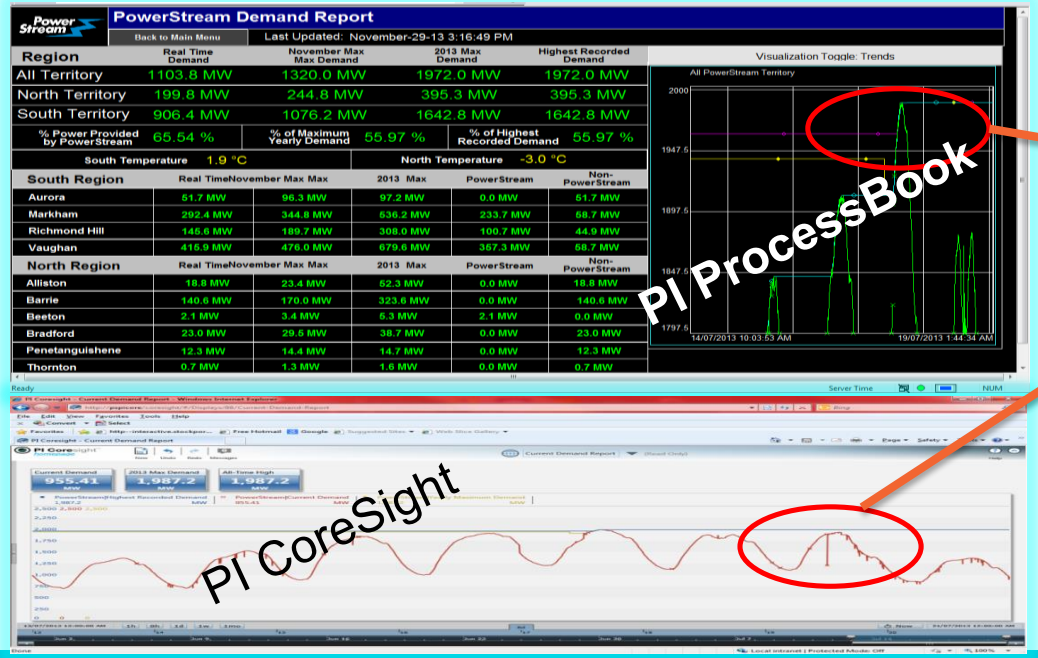
Transformer Energization



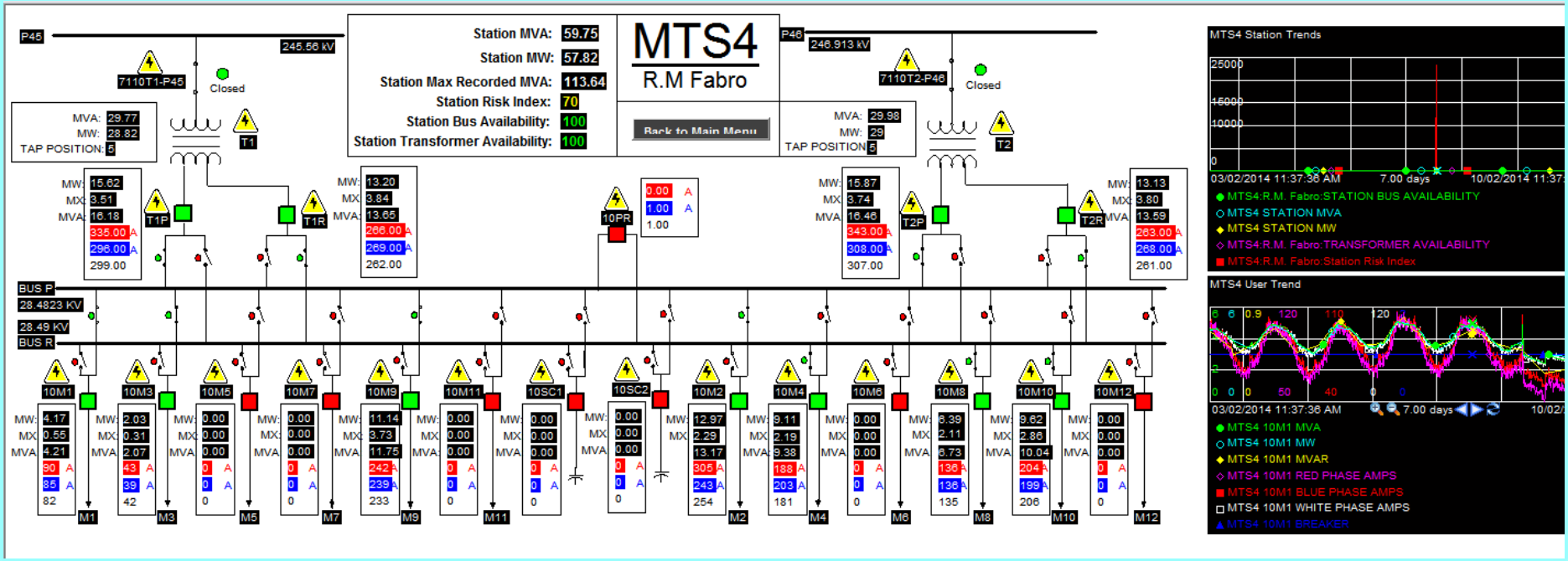
High Sump Water Level

Demand Report

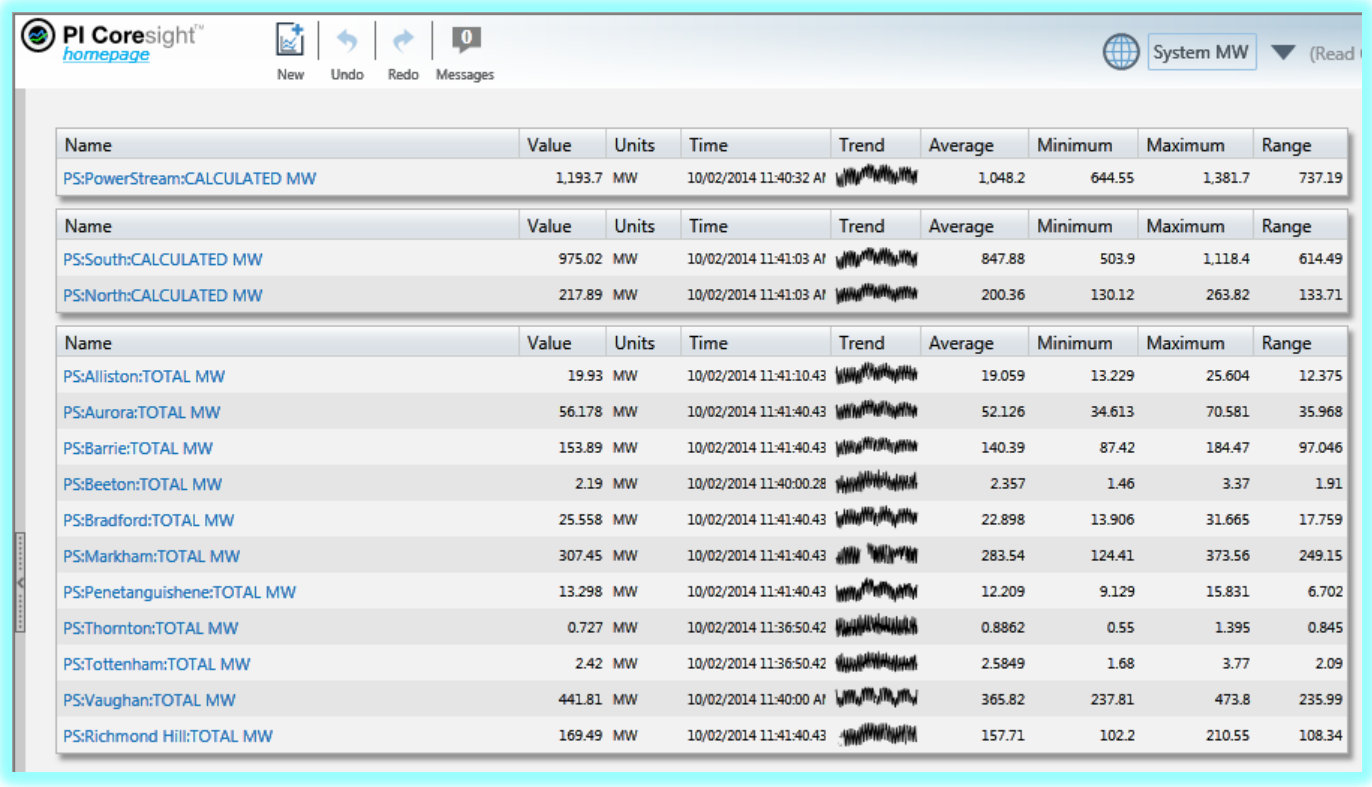
- Used PI System to view and notify System Demand as it reached Powerstream's "All-Time" peak of 1972 MW on July 17, 2013 at 4:01pm



PI ProcessBook – Station Single Line



PI Coresight – System MW Report



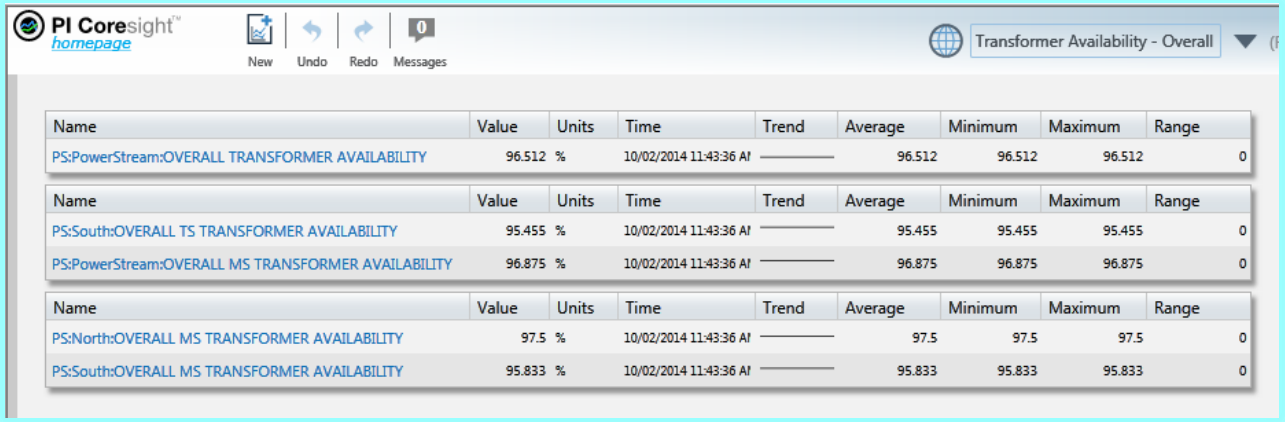
Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:PowerStream:CALCULATED MW	1,193.7	MW	10/02/2014 11:40:32 AM		1,048.2	644.55	1,381.7	737.19

Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:South:CALCULATED MW	975.02	MW	10/02/2014 11:41:03 AM		847.88	503.9	1,118.4	614.49
PS:North:CALCULATED MW	217.89	MW	10/02/2014 11:41:03 AM		200.36	130.12	263.82	133.71

Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:Alliston:TOTAL MW	19.93	MW	10/02/2014 11:41:10.43		19.059	13.229	25.604	12.375
PS:Aurora:TOTAL MW	56.178	MW	10/02/2014 11:41:40.43		52.126	34.613	70.581	35.968
PS:Barrie:TOTAL MW	153.89	MW	10/02/2014 11:41:40.43		140.39	87.42	184.47	97.046
PS:Beeton:TOTAL MW	2.19	MW	10/02/2014 11:40:00.28		2.357	1.46	3.37	1.91
PS:Bradford:TOTAL MW	25.558	MW	10/02/2014 11:41:40.43		22.898	13.906	31.665	17.759
PS:Markham:TOTAL MW	307.45	MW	10/02/2014 11:41:40.43		283.54	124.41	373.56	249.15
PS:Penetanguishene:TOTAL MW	13.298	MW	10/02/2014 11:41:40.43		12.209	9.129	15.831	6.702
PS:Thornton:TOTAL MW	0.727	MW	10/02/2014 11:36:50.42		0.8862	0.55	1.395	0.845
PS:Tottenham:TOTAL MW	2.42	MW	10/02/2014 11:36:50.42		2.5849	1.68	3.77	2.09
PS:Vaughan:TOTAL MW	441.81	MW	10/02/2014 11:40:00 AM		365.82	237.81	473.8	235.99
PS:Richmond Hill:TOTAL MW	169.49	MW	10/02/2014 11:41:40.43		157.71	102.2	210.55	108.34

PI Coresight – Transformer Availability

Transformer Availability – 2 views



Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:PowerStream:OVERALL TRANSFORMER AVAILABILITY	96.512	%	10/02/2014 11:43:36 AM		96.512	96.512	96.512	0

Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:South:OVERALL TS TRANSFORMER AVAILABILITY	95.455	%	10/02/2014 11:43:36 AM		95.455	95.455	95.455	0
PS:PowerStream:OVERALL MS TRANSFORMER AVAILABILITY	96.875	%	10/02/2014 11:43:36 AM		96.875	96.875	96.875	0

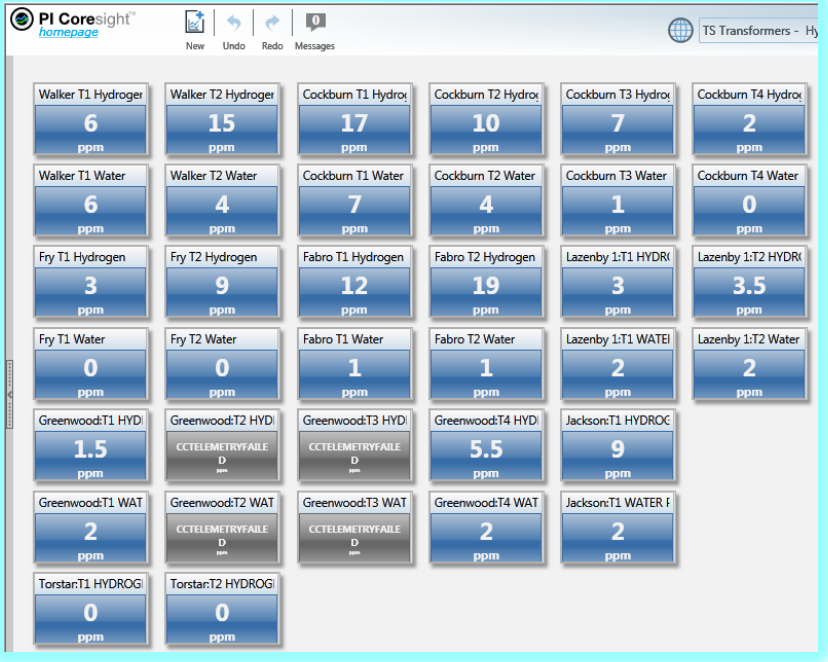
Name	Value	Units	Time	Trend	Average	Minimum	Maximum	Range
PS:North:OVERALL MS TRANSFORMER AVAILABILITY	97.5	%	10/02/2014 11:43:36 AM		97.5	97.5	97.5	0
PS:South:OVERALL MS TRANSFORMER AVAILABILITY	95.833	%	10/02/2014 11:43:36 AM		95.833	95.833	95.833	0

PI Coresight – Transformer Reports

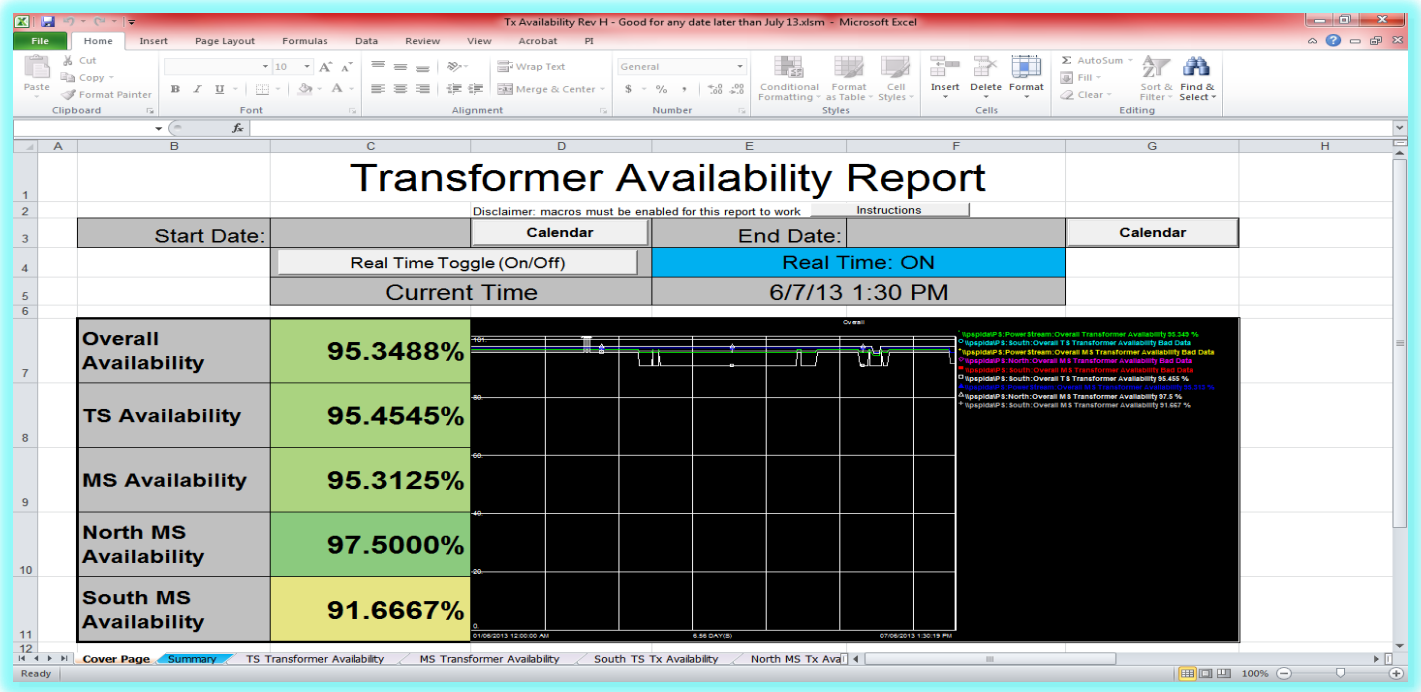
Transformer Load (MW)

Transformer Winding Temperature

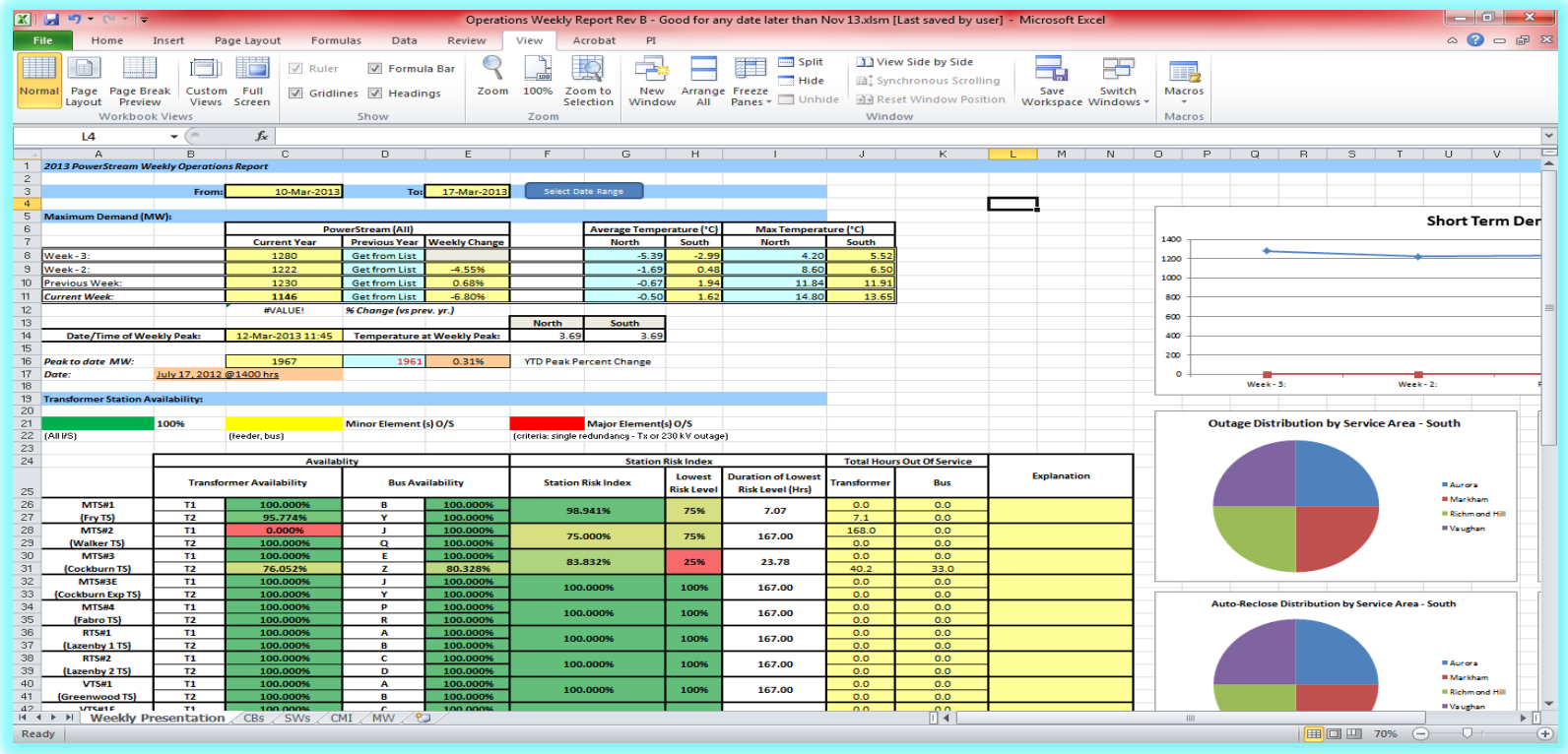
Transformer Hydrogen and Moisture



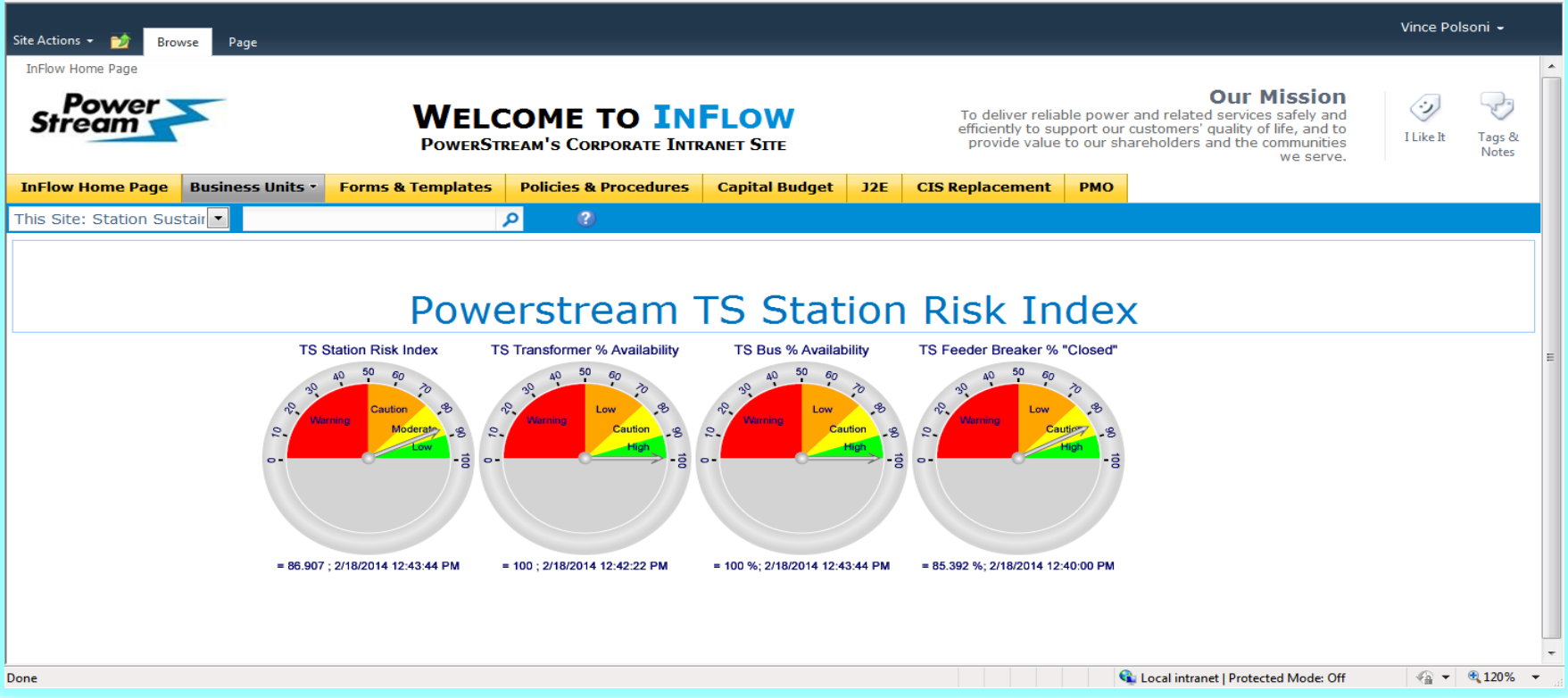
PI DataLink - Transformer Availability Report



PI DataLink – Weekly Operations Report



PI WebParts – Risk Index Report



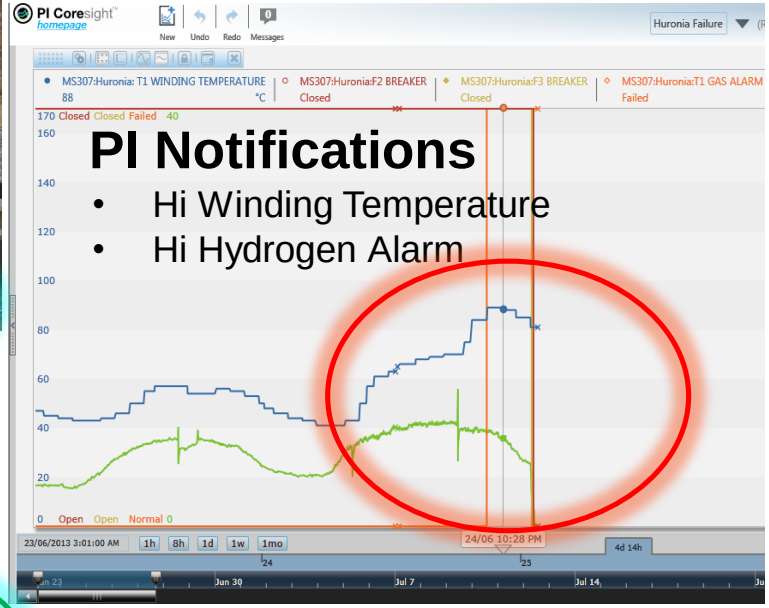
Big Saves - Thanks to PI System

Sharks

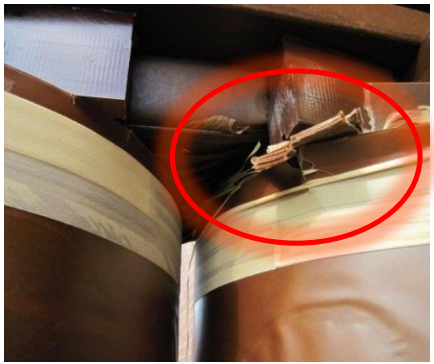
Earthquake

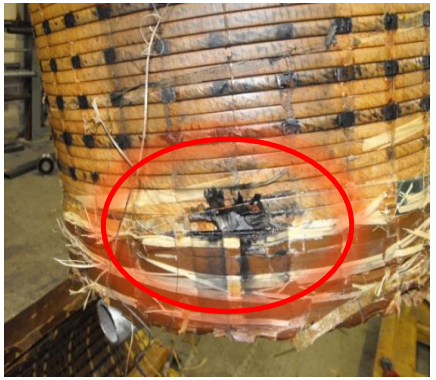
Giants

Save - 10MVA 44kV-13.8 kV Transformer



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





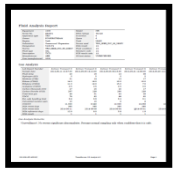
- **$500,000 averted**
- **No customer outages**

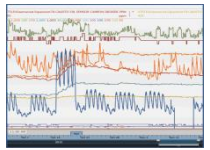
- **Transformer taken out of service before failure and replaced with spare**

Save - 75/125 MVA 230kV-27.6kV

Transformer - Save

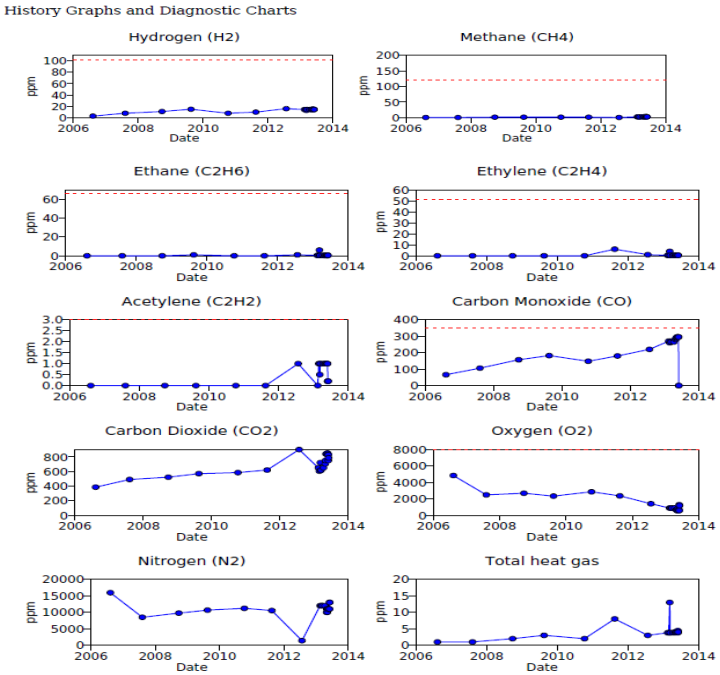
- In late 2011 noticed increased gassing from annual oil test results from laboratory.
- In early 2012 Purchased a portable DGA unit and began to test and monitor transformer oil.
- In summer 2012 implemented PI System.
- In Fall 2012 installed a 7 gas monitoring units and PI System Tags
- Created PI DataLink report and configured a Trigger in CMMS to monitor gassing vs. load and oil temperature
- Consulted with transformer SME's (with PI System data)



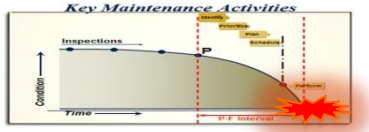


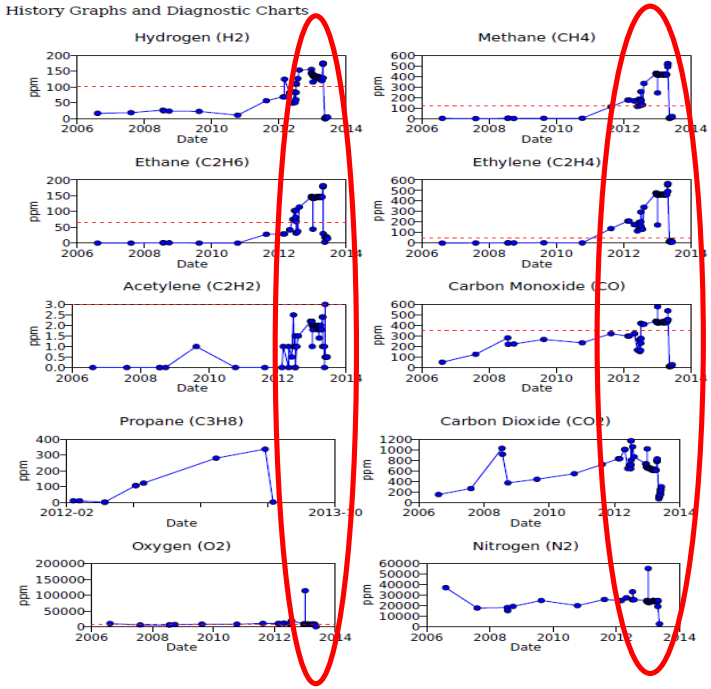
Comparison T3 and T4 DGA Trends

T3 (Good)



T4 (Failing)





Expert Systems Working in Unison

Oil

Oil

Data

Data

Survalent Technology

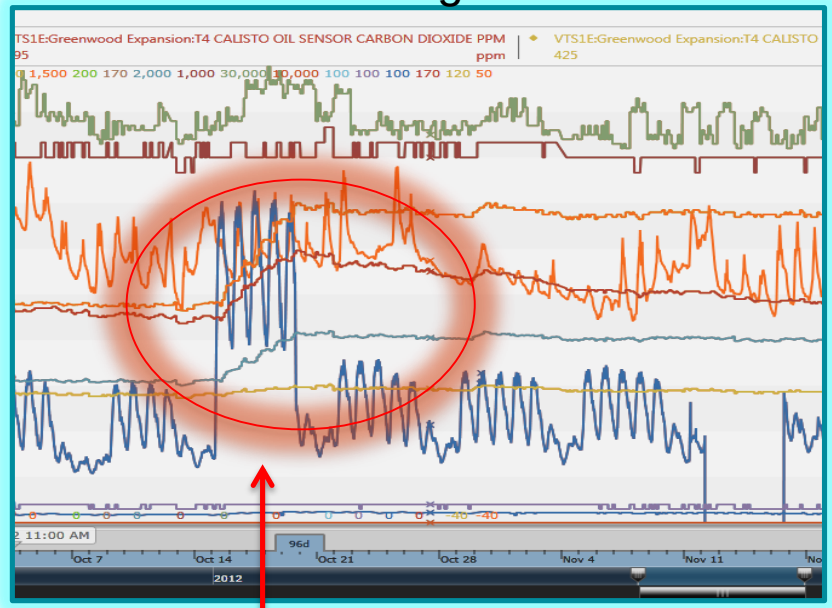
∂x Delta-X Research

OSIsoft.

Cascade™

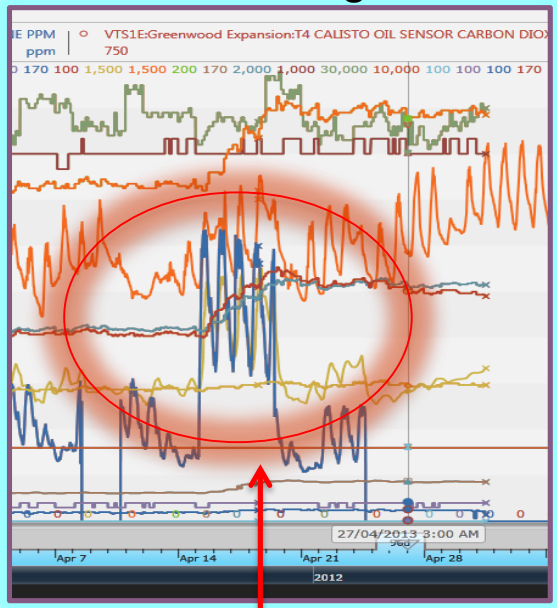
Increased Gassing - 2 Significant Events

PI Coresight



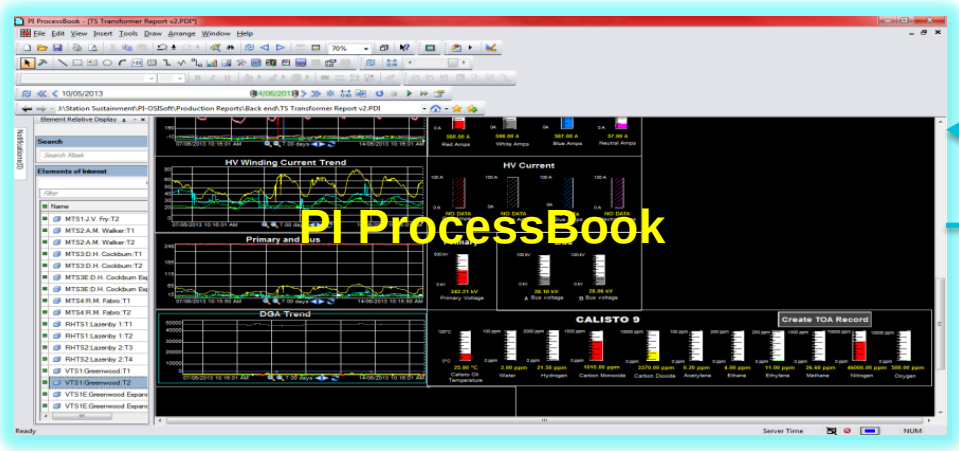
Oct 20, 2012

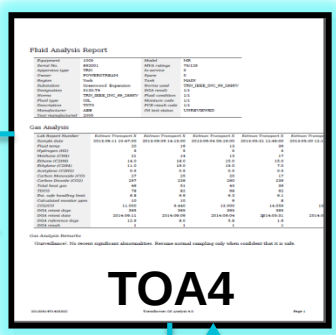
PI Coresight



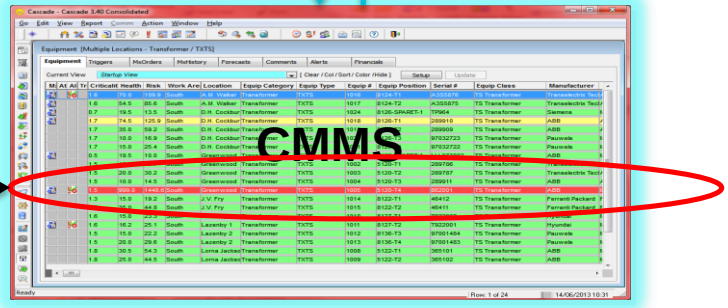
April 19, 2013

Gassing in Transformer
PI ProcessBook, TOA4 and CASCADE CMMS



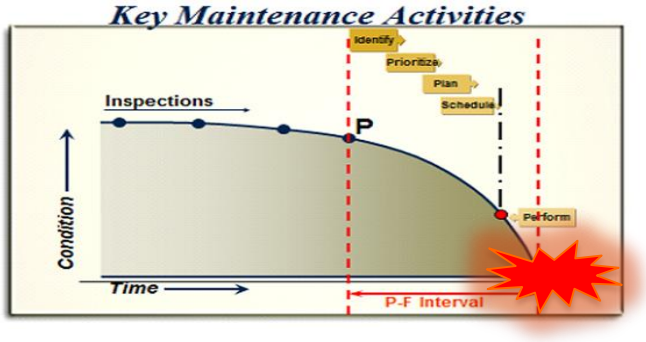


Transformer Problem Identified (Health and Risk)



Findings

- It was found that one of the "T" connectors **was not crimped during manufacturing** to the copper lead.



Up to $2 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

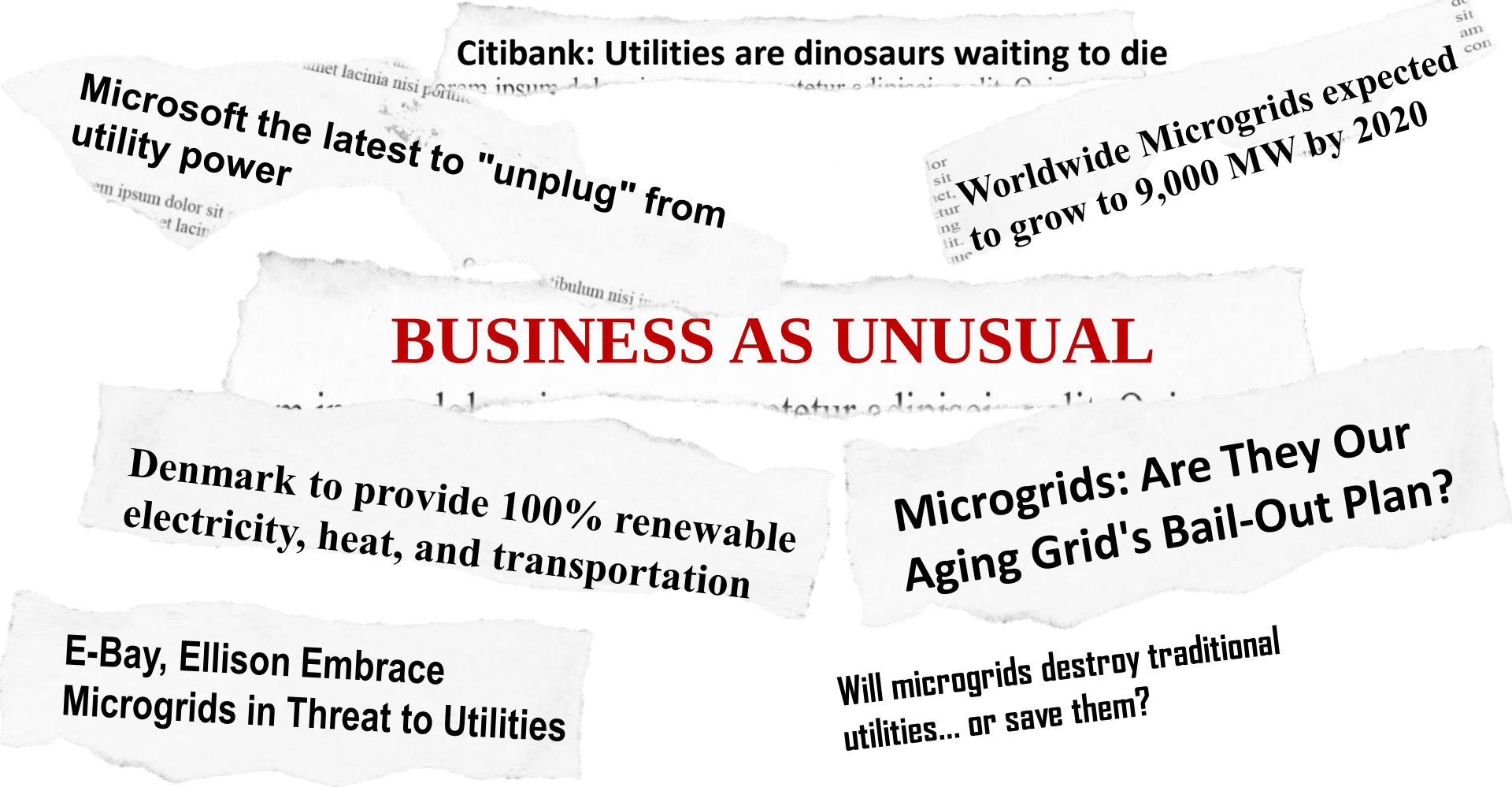
Repair: $100,000 (Potential Failure)

Benefits of Life after PI System

- Able to accomplish a lot with minimal resources
- Fast learning curve
  - YouTube, Manuals, Support, Training
- Maintenance Optimization
- Innovation stimulant
- Information to those who need it

PowerStream's Micro Grid Project

Video



Powerstream definition of Micro Grid

"A Micro Grid is a sustainable and reliable energy system comprising of a number of different energy sources capable of seamlessly operating on or off the provincial grid."

- Loads typically located in close proximity:
  - may include a single customer, or
  - a load center such as a hospital, school or campus.
- Generation side consists of renewable and sustainable sources,
  - May have economic, environmental, or reliability-related dispatch signals,
- May have multiple connection points to distribution system,
- May have load prioritization.

Micro Grid Project Details

- Launched the Micro Grid demonstration project in November 2013 at its head office in Vaughan, Ontario.
- Using the project to evaluate a Micro Grid's performance while it is connected to, and also disconnected from, the provincial grid.

Generation Assets

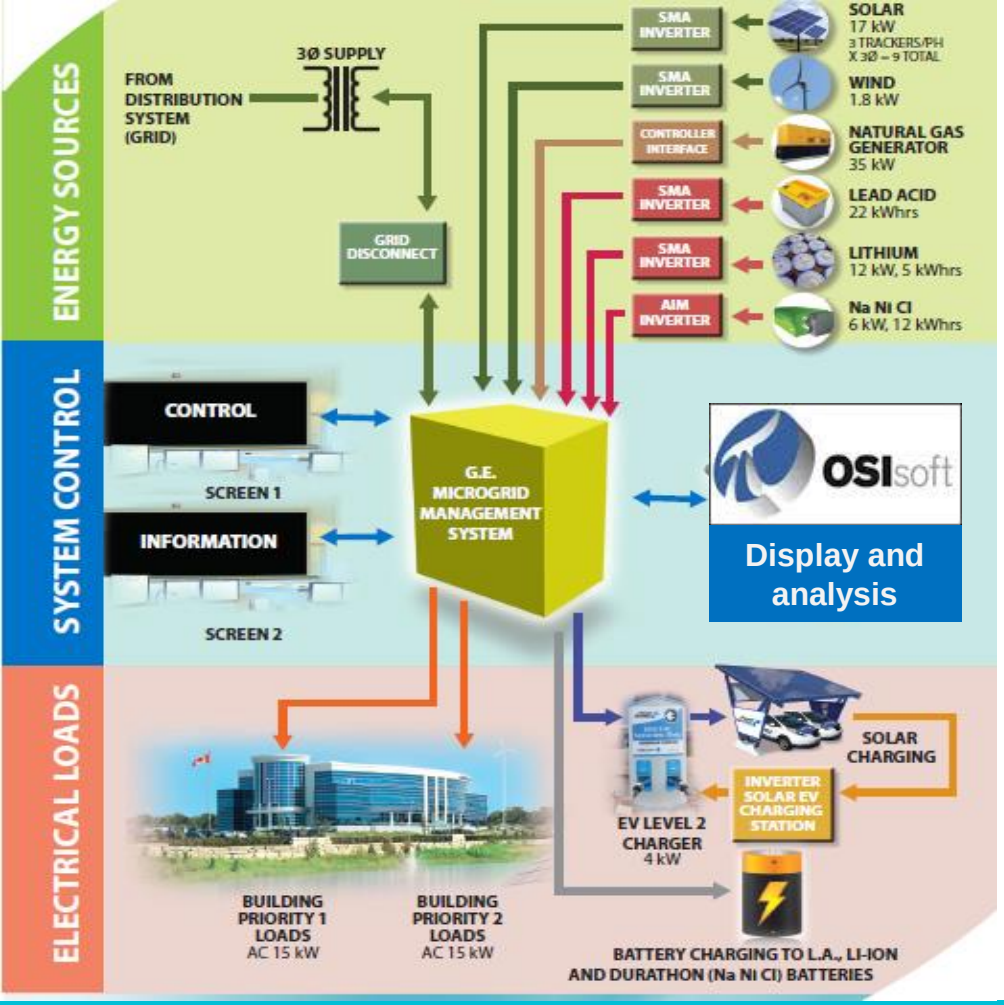
5 kW Solar Generator (EV Car Port)

35 kW Natural Gas Generator

17 kW Tracking Solar Generator

1.8 kW Wind Generator

Control and Storage Assets



- 25 kW Renewables
  - Solar
  - Wind
- 35 kW Natural Gas Generator
- 40 kWh storage
  - Batteries
    - Lead Acid
    - Lithium
    - Na Ni CL
- 30 kW load

Modes of Operation

1. Supply to Grid
2. Supply from Grid
3. Island (Generator)
4. Island (No Generator)
5. Black Start
6. Unintentional Grid Outage (Generator)
7. Unintentional Grid Outage (No Generator)
8. Intentional Grid Outage (Generator)
9. Intentional Grid Outage (No Generator)

2 Phases of Micro Grid project

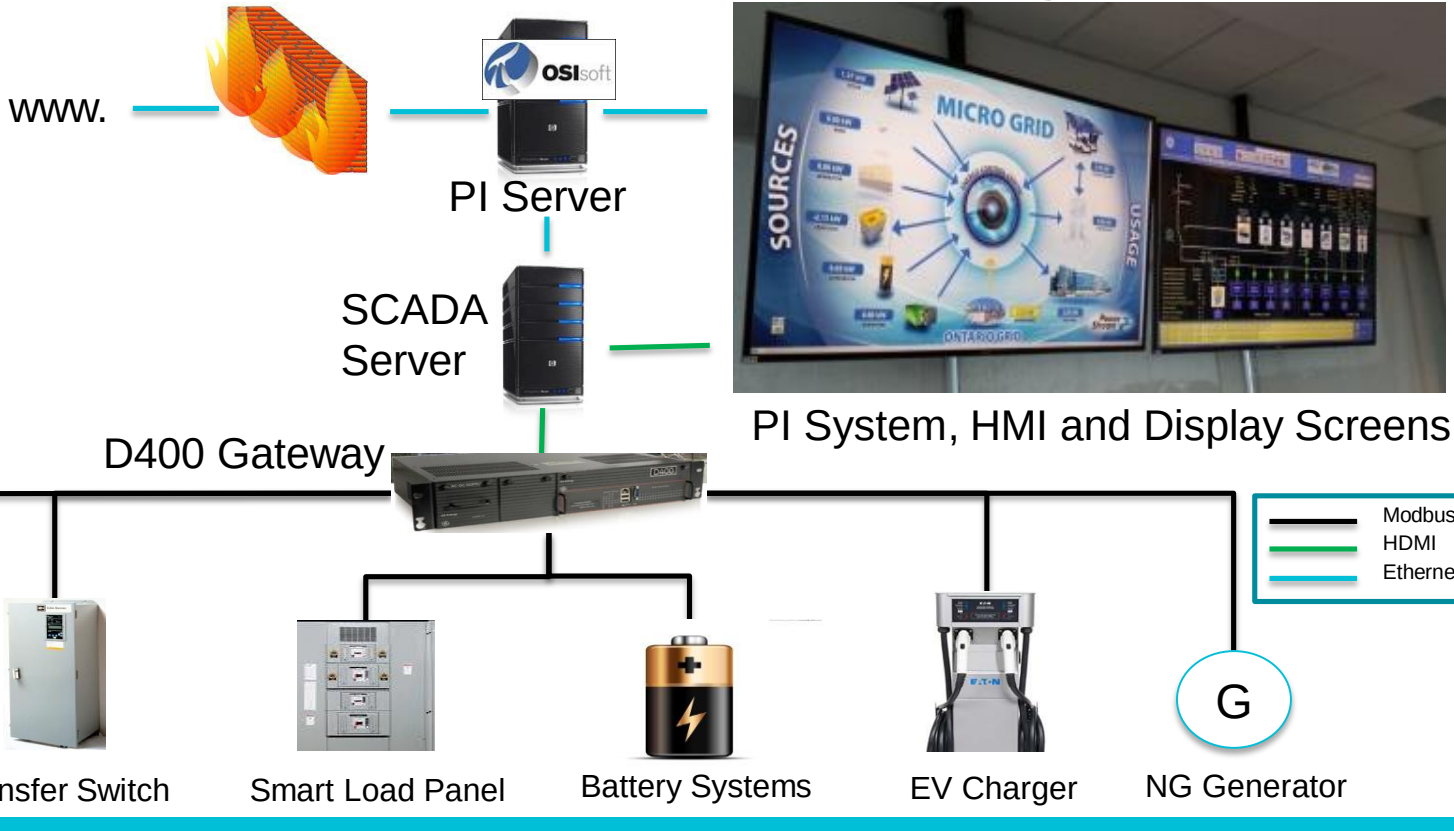
Phase 1

- drawing electricity from several sources – a solar array, a wind turbine, natural-gas generator, solar-assisted carport charging station as well as Lead Acid, Lithium Ion and Sodium Nickel Chloride batteries
- provide electricity for loads at its head office building such as lighting, air conditioning and refrigeration as well as to provide charging its fleet of electric vehicles.

Phase 2

- add additional components such as vehicle-to-grid EV charging systems and further automation systems.

Communications and Control System



PI ProcessBook Micro Grid Display

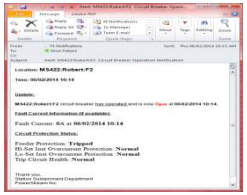
PI System Benefits – Micro Grid Project

Real-Time Display

- Intuitive Display
- Various displays catering to different audiences
- Drilldown user interface

Notifications / Alarms

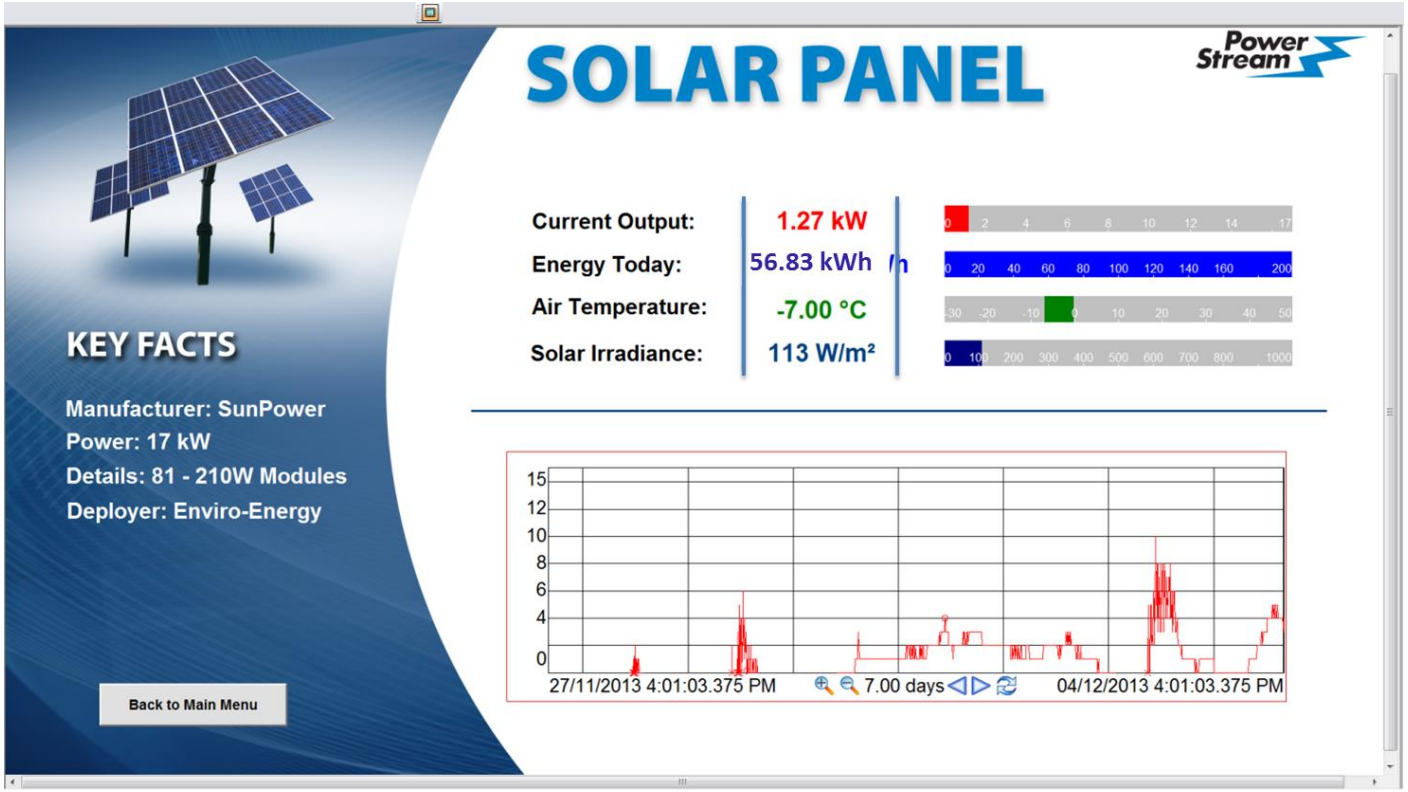
- Notifications and alarms (Real-time)



User Friendly Simple Tools

- Multiple report options
- Historical data
- Mobility (Smartphone, tablet)

PI ProcessBook Report – Solar Panel



Early Project Take-Aways

- Ongoing discussion of trade-off of SCADA level automation versus device by device intelligence (e.g. intelligent inverters), similar to distribution level discussion
- Alarm systems provide backup to automation systems, e.g. switching to on-grid when batteries run low!
- Analyzing historical events allows good comparison with simulation and specs expectation, e.g. response of loads and other assets when switch to off-grid

www.powerstream.ca\microgrid

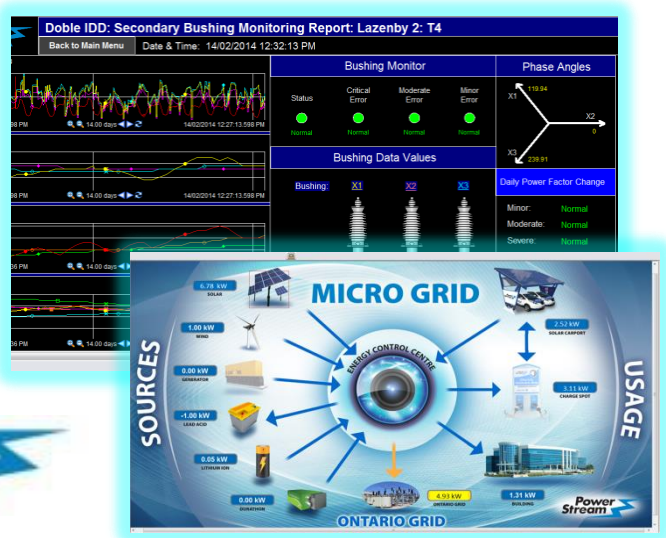
Phase 2 (Now Underway)

- Further test the system under different operating scenarios:
  - minimizing costs of operation,
  - maximizing use of renewables, and
  - reducing peak loads.
- PowerStream will also collect data that will analyze the performance of the system, including "lessons learned".
- We expect to include new generating technologies such as fuel cells and electric vehicles to grid support.
- Over the longer term, PowerStream expects to install a Micro Grid on a larger scale, one that will connect directly to power lines and that will serve larger loads.

Summary

There is a constant pressure to do more with less; Improve reliability and availability. In order to achieve this, the same information needs to be made available in multiple systems.

Data turned into Information is the key to a successful transition of maintenance methodology.



1. Provide and utilize Operational data outside of SCADA (Operations)
2. Present Micro Grid system architecture and data in an appealing, easy-to-understand format.

- SCADA to PI connectivity (Ops)
- Integrated PI System to CMMS (Ops)
- Micro Grid SCADA to PI for demonstration presentation

- Real-time information to those who need it (Ops)
- Increased equipment monitoring and alerting (Ops)
- Eye-pleasing and functional presentation of Micro Grid data

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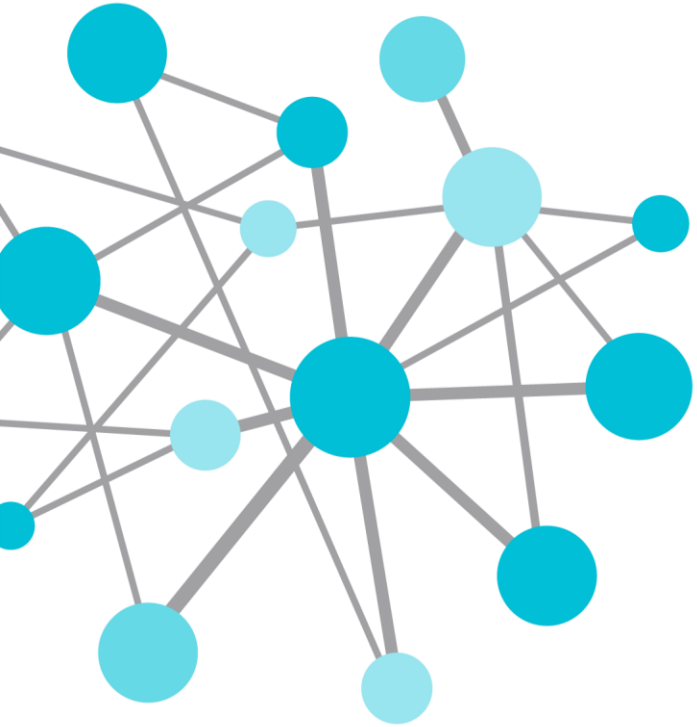

THANK YOU

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