PI System Based
Air Emission Calculation &
Reporting System at
Dolphin Energy

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Agenda

AIR EMISSION CALCULATION SYSTEM
VALIDATION STUDY

Dolphin Energy, Ras Laffan Industrial City

DOLPHIN ENERGY

Final Report

- Project Overview
- Dolphin Energy Limited (DEL)
- Project Drivers and Objectives
- Project Scope and Schedule
- System Total Revamp Activities
- System Results and Examples
- Best Practices and Lessons Learned

Project Overview

- Dolphin Energy Limited (DEL) developed the Air Emissions Calculation System (AECS) in PI for real-time monitoring of instruments such as continuous emissions monitoring system (CEMS), fuel gas flow meters for *environmental regulatory and corporate sustainability reporting requirements*.

- AECS was commissioned in 2006. Overtime, many changes and errors were found and the calculation results became unreliable for reporting.

- Since 2010, Trinity T3 was engaged by DEL Environmental to identify root causes and update air pollutants calculation methods, add greenhouse gas emissions, and reconfigure PI Performance Equations (PI PE) to improve AECS quality.

AECS with The PI System

"We did the project to ensure the AECS can produce reliable data for all air emission reporting including corporate KPI. The new system will save us a lot of time for QA/QC and produce accurate reports."

Dr. Rola Atiyeh

Dolphin Energy
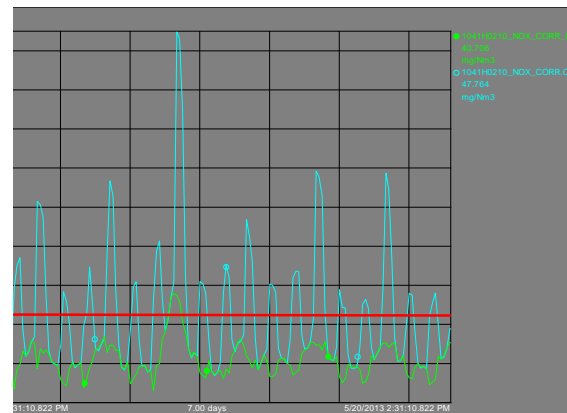
Business Challenge

- Mistakes caused by AECS equations, instrument failures, process shutdown
- Difficult to QA/QC and time consuming for reporting process

Solution

- Verify & document equation methods
- Tag status check & reconcile values for accurate data
- Establish calculations based on reporting requirements

Results and Benefits

- **Accurate, verifiable, and documented** technical/scientific calculation methodologies
- Calculations with **100% validated data** & meeting EHS compliance/ reporting requirements

Dolphin Energy Limited
## Commitments to Clean Energy and Sustainability

DEL's Commitment to Environmental Sustainability

- AECS is essential for providing reliable emission data to measure environmental performance

- The AECS improvement project involved many groups:
  - Environmental Department
  - Automation Engineers
  - Operation Groups
  - Process and Application Engineers
  - Instrument Department
  - Laboratory
  - Consultants

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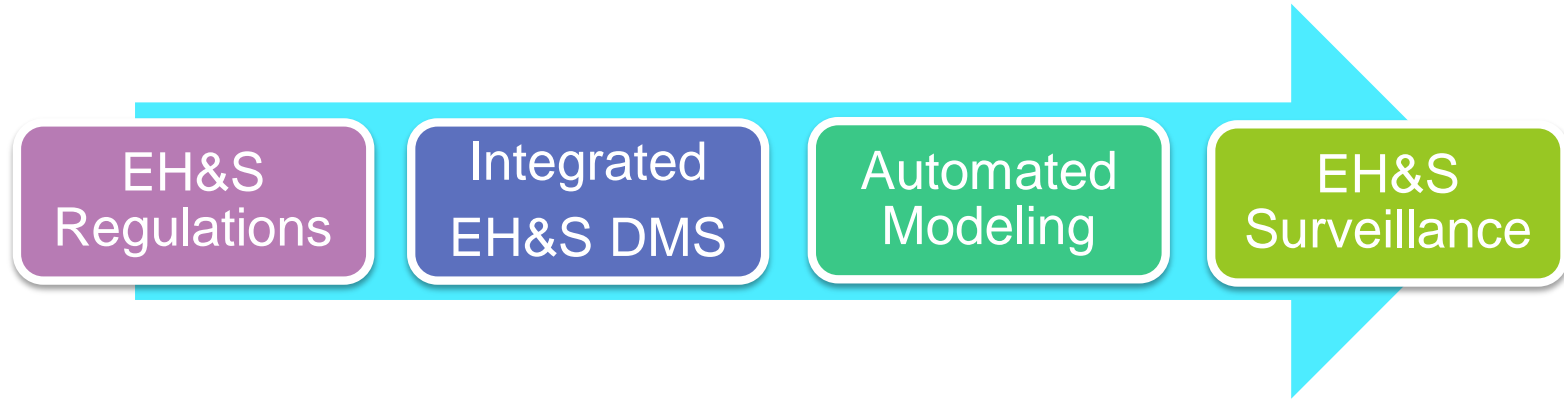
Project Drivers – AECS Data & Calculation Issues

- Process unit shutdown but CEMS analyzers still in operation

- PI Tag shows "Bad Data" due to instrument failure while unit still in operation caused missing emission data

- Incorrect or missing raw data PI Tags as inputs to calculation equations

- Incorrect equations coded previously in PI Performance Equations

- Incorrect/inconsistent engineering units labeled for PI Tags result in incorrect calculations

- Poor documentation for calculation methods, PI Performance Equations, and validation process

AECS – Mission Critical System for Reporting Requirements

- Emission Inventory – Pollutants corrected concentrations and emission rates

- GHG Accounting – Carbon footprints

- Flare – Gas flared, heat release, pollutants emission rates

- Process – Efficiency, Excess Oxygen, Exhaust Gas Temperature, Heat Release

- Production – SRU throughput, efficiency, fuel usage

Project Objectives

- To ensure the AECS related calculations are established in the PI System based on the following criteria:

  – Calculations can meet environmental compliance and reporting requirements

  – Calculation equations are coded accurately in the PI Tags with proper validation procedure to fill-in missing data gaps

  – Calculation input data are based on real time process data in RTDB for **real-time data quality and emission limits monitoring**

  – Well documented calculation methodologies to support the system **be verified by 3rd party auditors**

Project Scope

- AECS enhancement started in Q1 2012:

  - Reviewed and confirmed all existing AECS related emission calculation methodologies

  - Revised, removed, and added PI PE with logics and formulae

  - Configured tags in tiers to handle sequential calculations

  - Simulated all PI Tag calculations in a PI System simulation environment; validated calculation results from simulation system to ensure equations were coded properly

  - Transferred all new/revised PI Tags to the DEL PI System; tested calculation process in April 2013

  - Documented technical basis of AECS for future references

  - On-going validating/updating AECS since April 2013

Air Emissions Calculation System

- Process Units:
  - Boilers/Heaters/ Furnace
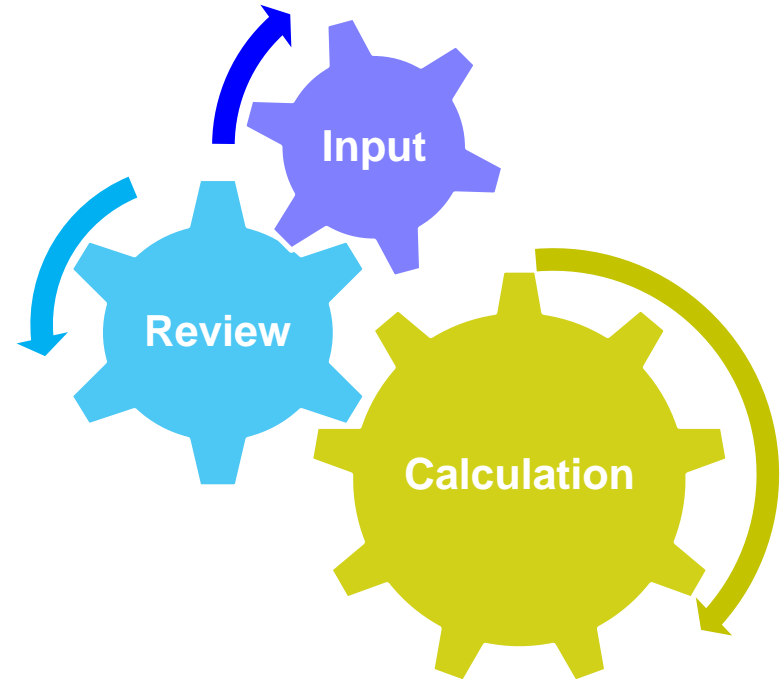 - Turbines
  - Incinerators
  - Sulfur Recovery

- Flares
  - Offshore Flares
  - Onshore Flares

- Compounds/ Pollutants:
  - O_2
  - NO_x
  - CO
  - SO_2/H_2S
  - Greenhouse Gases (GHG):
    - CO_2
    - CH_4
    - N_2O

AECS
Total Revamp
Activities

Input

Review

Calculation

AECS Review –
Process & Environmental Knowledge

- Reviewed/confirmed/revised/added calculation methods

- Identify all PI Tags related to air emissions calculations

- Review/confirm existing tags and tag equations

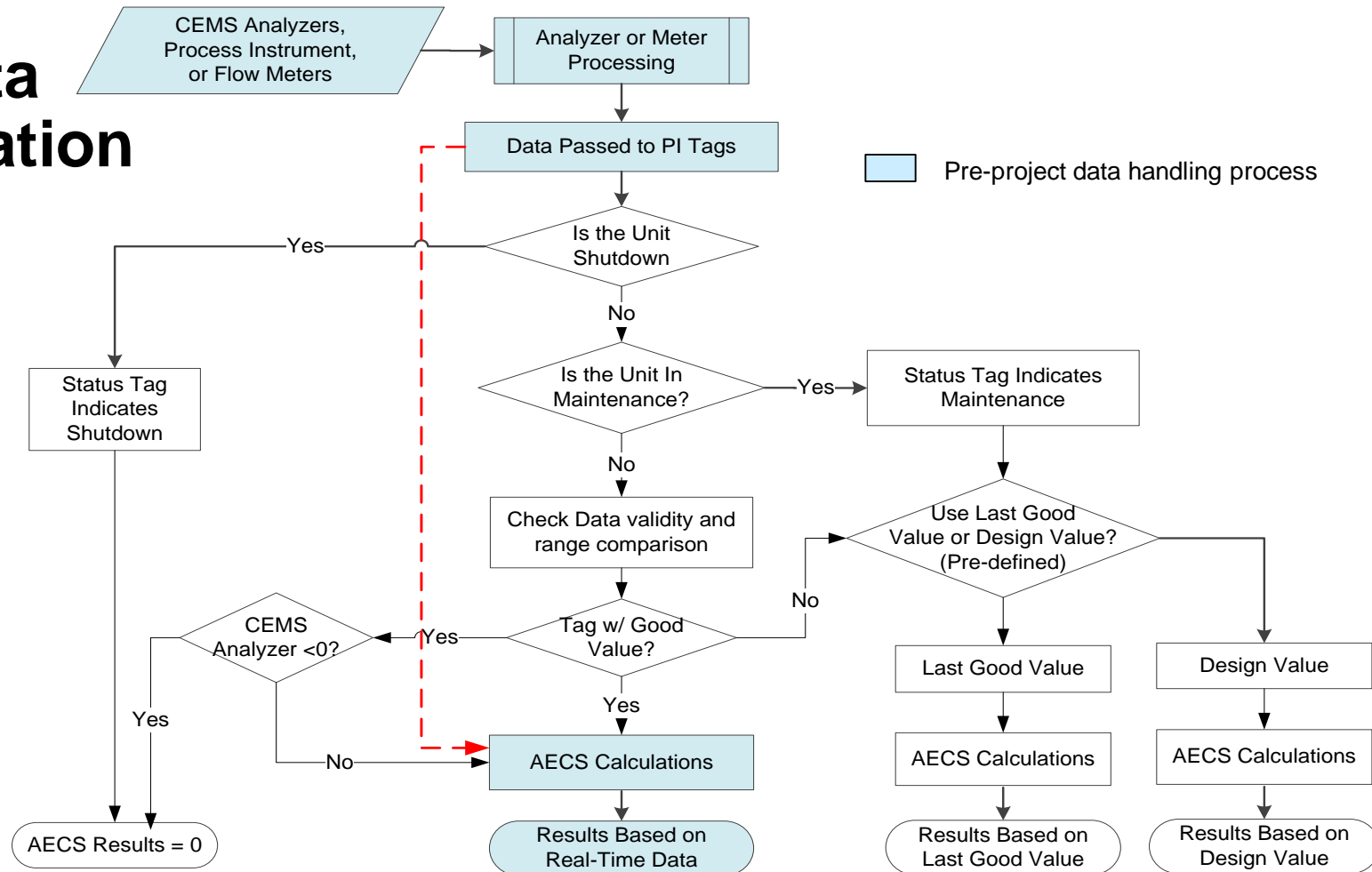- Revise and add new tags based on environmental regulatory compliance requirements

$$W_N = 28.02 \cdot \frac{C_{N2}}{100}$$

$$W_O = 16.00 \cdot \frac{C_{COS}}{1000000} + 16.00 \cdot \frac{C_{H2O}}{1000000}$$

$$W_S = 32.07 \cdot \frac{C_{COS}}{1000000} + 32.07 \cdot \frac{C_{H2S}}{1000000} + 32.07 \cdot \frac{C_{RSH}}{1000000}$$

$$C = \frac{W_C}{W_C + W_H + W_N + W_O + W_S}$$

$$H = \frac{W_H}{W_C + W_H + W_N + W_O + W_S}$$

$$N = \frac{W_N}{W_C + W_H + W_N + W_O + W_S}$$

$$O = \frac{W_O}{W_C + W_H + W_N + W_O + W_S}$$

$$S = \frac{W_S}{W_C + W_H + W_N + W_O + W_S}$$

$$MW_{FG} = 16 \cdot \frac{C_{C1}}{100} + 30 \cdot \frac{C_{C2}}{100} + 44.1 \cdot \frac{C_{C3}}{100} + 48.1 \cdot \frac{C_{iC4} + C_{nC4}}{100} + 72.1 \cdot \frac{C_{iC5} + C_{nC5} + C_{neoC5}}{100} + 86 \cdot \frac{C_{nC6}}{100} + 44 \cdot \frac{C_{CO2}}{100} + 34 \cdot \frac{C_{H2S}}{100}$$

```
IF '1402FI0212_RVAH.CA' < 1.1 * 237.7 THEN '1000FI8504_RVAH.CA'/2 +'2000FI8502_RVAH.CA' +'1082FI8502_RVAH.CA'
+'1032FI8503_RVAH.CA' +'1013FI8503_RVAH.CA' +'1014FI8503_RVAH.CA' +'1072FI8504_RVAH.CA'
+'1090FI8502_RVAH.CA'/2 +'2000FG9810.MI'/2 +'2000FG9880.MI'/2 +'1000FG9805.MI'/2 +'1082FG9800.MI'
+'1121FG9800.MI'/2 +'1122FG9820.MI' +'1032FG9805.MI' +'1182FG9800.MI' +'1053FG9805.MI'/2 +'1013FG9807.MI'
+'1013FG9837.MI' +'1054FG9805.MI' +'1014FG9807.MI' +'1014FG9837.MI' +'1072FG9807.MI' +'1142FG9835.MI'
+'1162FG9805.MI' +'1162FG9825.MI' +'1090FG9807.MI' +'1402FI0200_RVAH.CA' +'1402FI0207_RVAH.CA' ELSE IF
'1402FI0212_RVAH.CA' < '1402FI0212_LOW_RANGE.MI' THEN '1402FI0212B_RVAH.CA' ELSE '1402FI0212_RVAH.CA'
+'1402FI0200_RVAH.CA' +'1402FI0207_RVAH.CA'
```

PI Tag Data Reconciliation Process

CEMS Analyzers, Process Instrument, or Flow Meters → **Analyzer or Meter Processing** → **Data Passed to PI Tags**

☐ Pre-project data handling process

Is the Unit Shutdown
- Yes → **Status Tag Indicates Shutdown** → **AECS Results = 0**
- No ↓

Is the Unit In Maintenance?
- Yes → **Status Tag Indicates Maintenance** → **Use Last Good Value or Design Value? (Pre-defined)**
  - ↓ **Last Good Value** → **AECS Calculations** → **Results Based on Last Good Value**
  - No → **Design Value** → **AECS Calculations** → **Results Based on Design Value**
- No ↓

Check Data validity and range comparison
↓
Tag w/ Good Value?
- Yes → **CEMS Analyzer <0?**
  - Yes → **AECS Results = 0**
  - No → **AECS Calculations**
- Yes ↓ → **AECS Calculations** → **Results Based on Real-Time Data**
- No → **Use Last Good Value or Design Value? (Pre-defined)**

Revamped AECS PI Tags Summary

- Identified analyzer/instrument/LIMS tags as input data tags to AECS

- Identified instrument maintenance tags to set status

- Add constant tags for design values, emission factors, etc.

- Totally revamped and recreated calculation tags:
  - Tags for existing air emissions calculations
  - Tags for GHG calculations
  - Status tags for each input data tag
  - Reconciled value (RV) PI Tags for each raw tags based on Status PI Tags
  - Hourly average of RV PI Tags for final calculations

OSISoft Products Applied

- PI Performance Equations (PI PE)

- PI System Management Tools (PI SMT)

- PI Tag Configurator

- PI DataLink

- PI ProcessBook
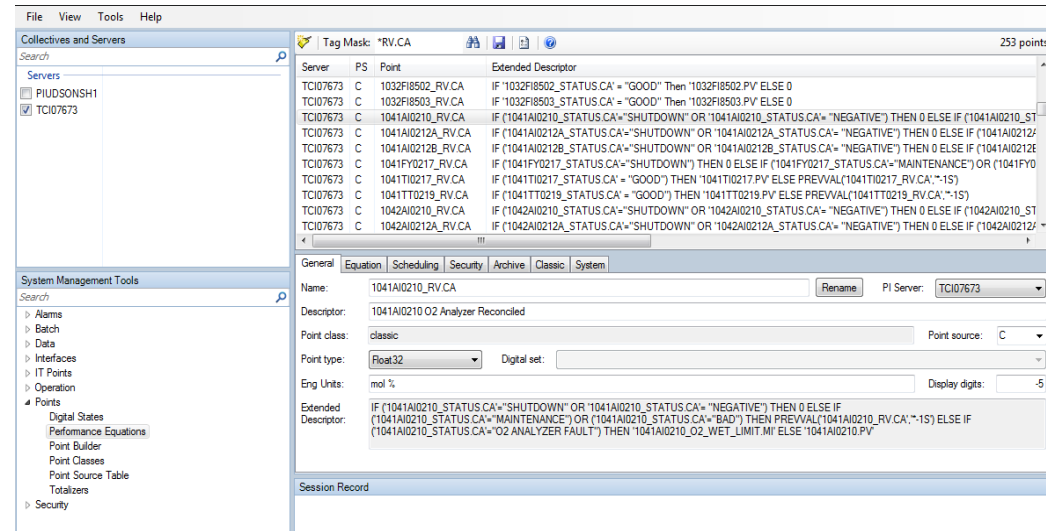
Tags Uploaded to The PI System

Identified sources of calculation input tags; passed DCS tags to PI System; Verify input tags UOM Created new tags in PI System

Determined calculation frequency; Created Hourly Average tags for reporting; Established scan frequency for calculation tiers;

Developed & uploaded additional calculation PI Tags; Tested all calculations

Validate hourly calculation results

# AECS Results

Project Results – AECS Improvement

Pre-Study System

- Questionable calculation methods

- Bad data and failed calculations in various conditions

- Labor intensive and difficult to correct calculated results from the PI System

- Unreliable results for compliance and sustainability reports

Post-Study System

- Calculation methodology has been thoroughly reviewed and confirmed in PI Tag equations

- Reliable and accurate calculations generated in RTDB and accessible to all DEL users

- User can identify analyzer downtime easily

- Data can be relied on for reporting requirements
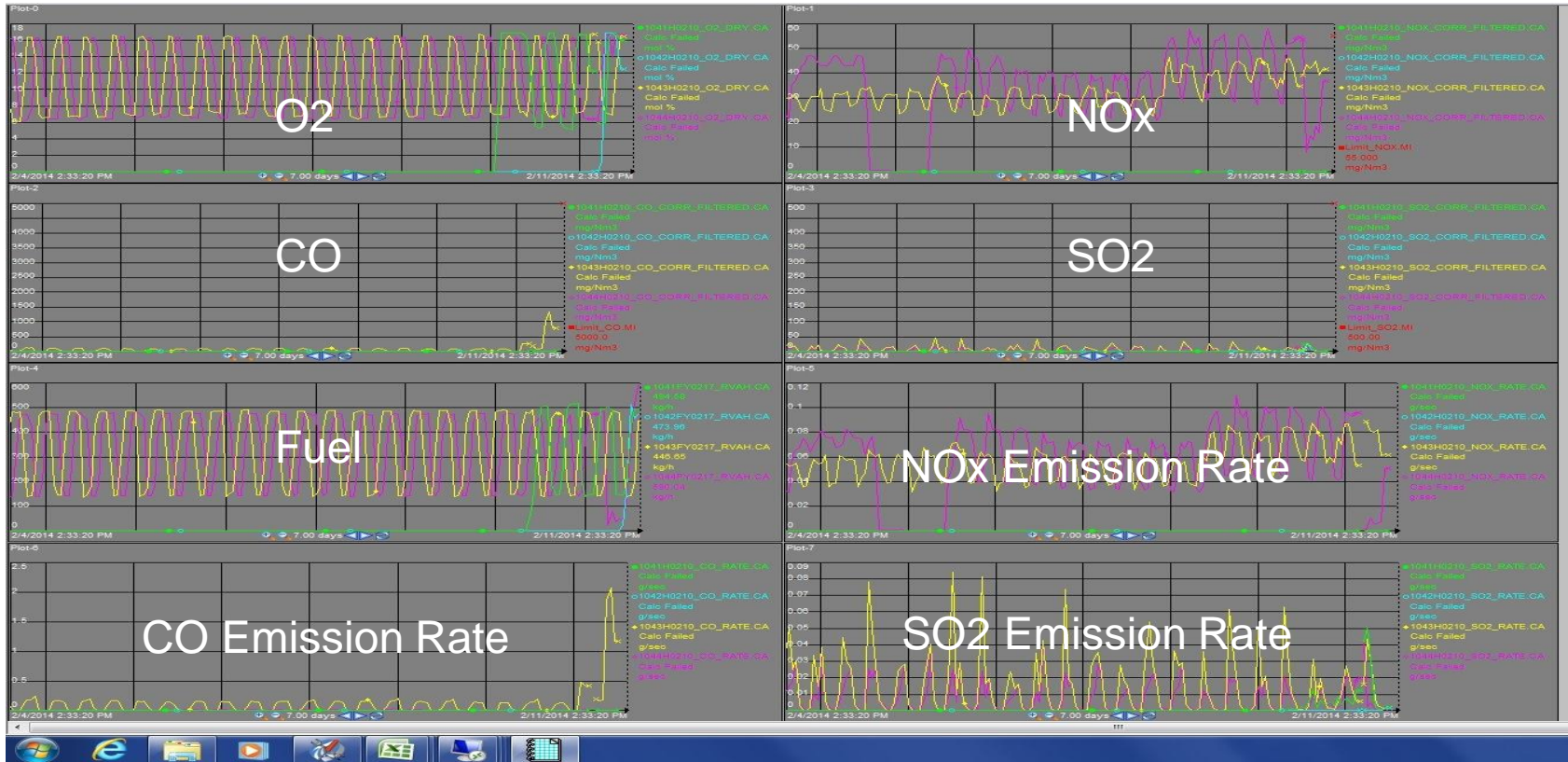
Example – Differences of Calculated Results

Pre-Project Calculation, Post-Project Calculation, Emission Limit
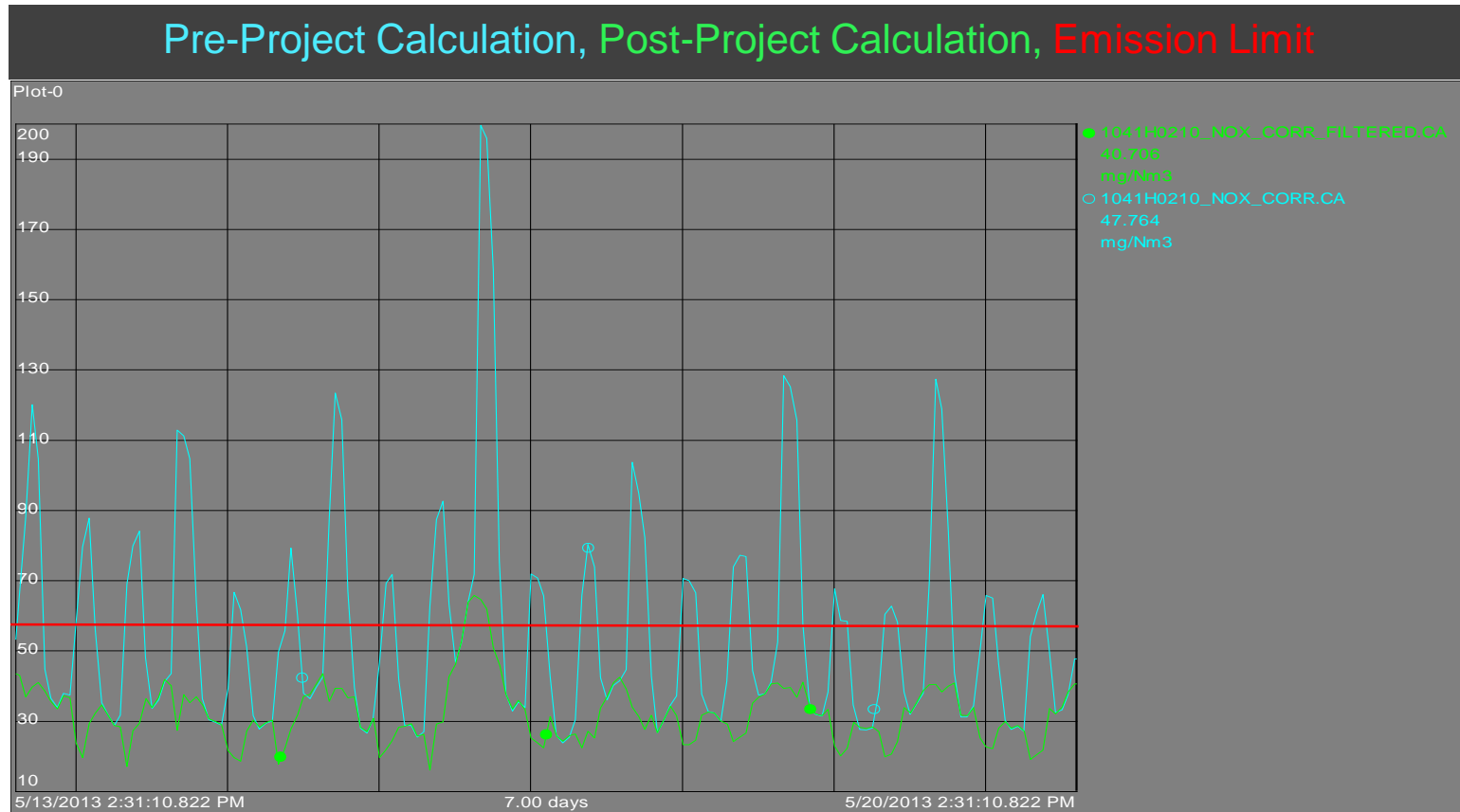
Effects of Reconciliation

Raw PI Tag Value, Post-Project Reconciled Value, Hourly Average of RV

PI ProcessBook Display Example
## A Dashboard of All Key Parameters for A Process Unit

Best Practices and Lessons learned

1. Use data reconciliation for mission critical reports
2. Documentation, Documentation, Documentation
3. Validation, Validation, Validation
4. Training for End-Users to gain confidence in real-time data
5. The PI System is powerful system to enhance EHS compliance:
   - Calculations within the PI System for real-time results to reduce uncertainty of process measurement and monitoring data
   - PI ProcessBook allows user review many data sets and quickly identify proper resolutions to improve data quality.

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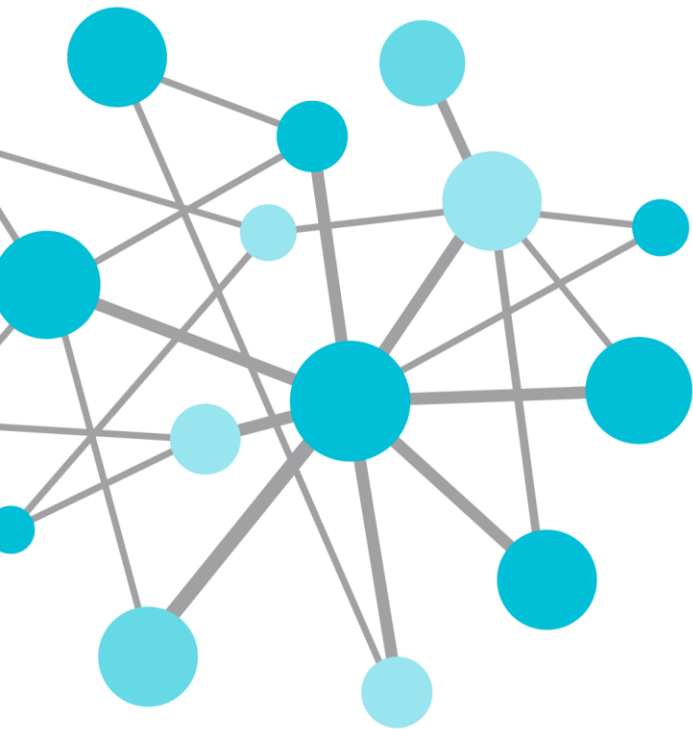
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