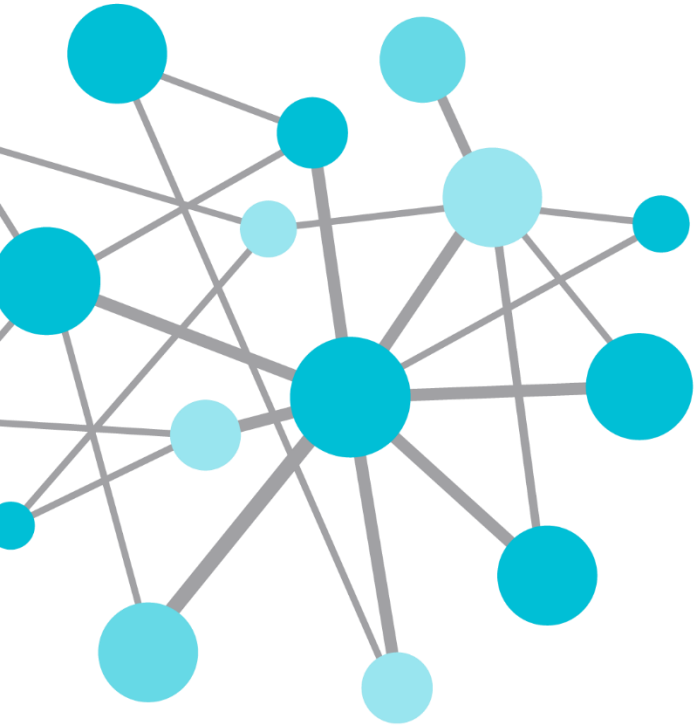


The Value of PI in Power & Utilities

Zsolt Oros - Regional Manager, CEE

Operational Excellence Defined

- **Operational Excellence** is a philosophy of leadership, teamwork and problem solving resulting in continuous improvement throughout the organization by focusing on the needs of the customer, empowering employees, and optimizing existing activities in the process.

Wikipedia

- "**Operational Excellence** is when each and every employee can see the flow of value to the customer, and fix that flow before it breaks down".

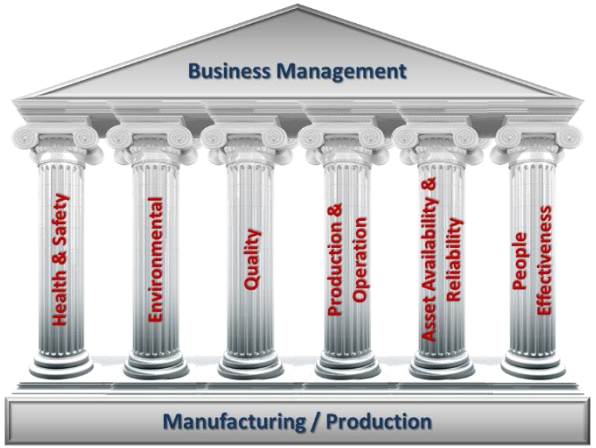
Kevin J. Duggan
Founder, Institute for Operational Excellence

- **Continuous Improvement** of Operational Effectiveness and Implementing ‚Lean' is a journey which takes you to the final destination: Operational Excellence

What does it take to get there?

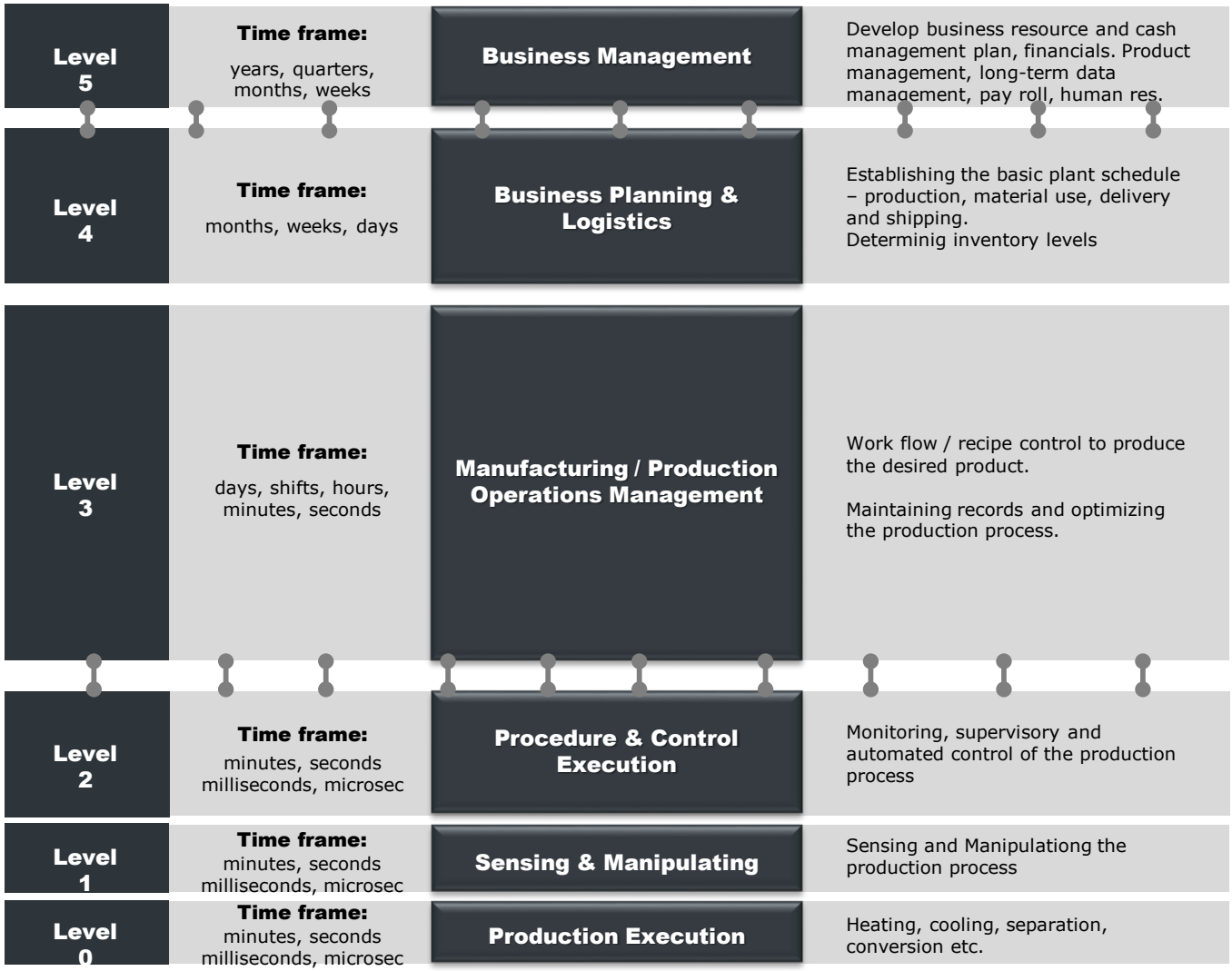
One's who wants to achive Operational Excellence must excel in all aspects of Operational Effectiveness:

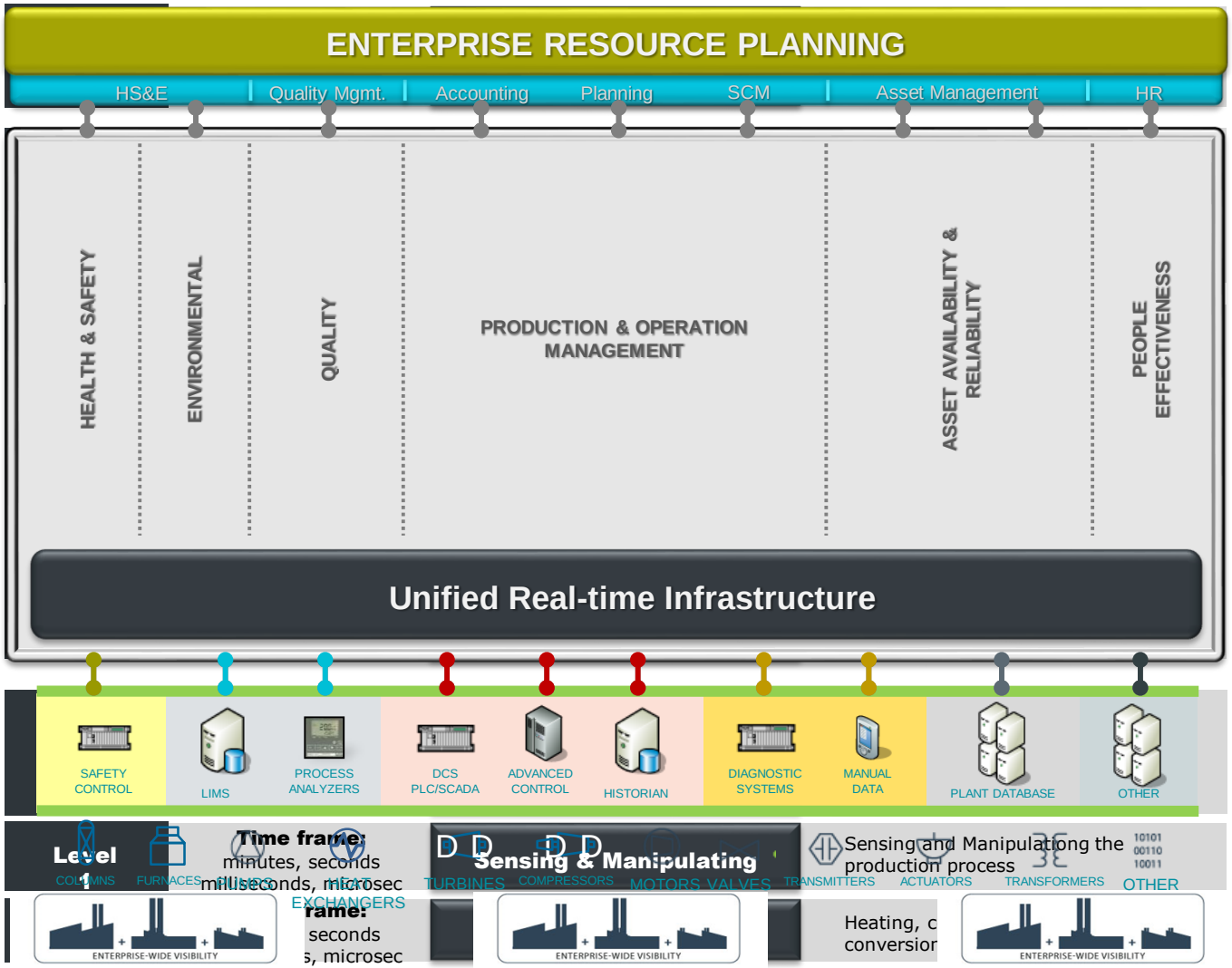
- HS&E
- Environmental
- Quality
- Production
- Operation
- Asset Availability & Reliability
- People

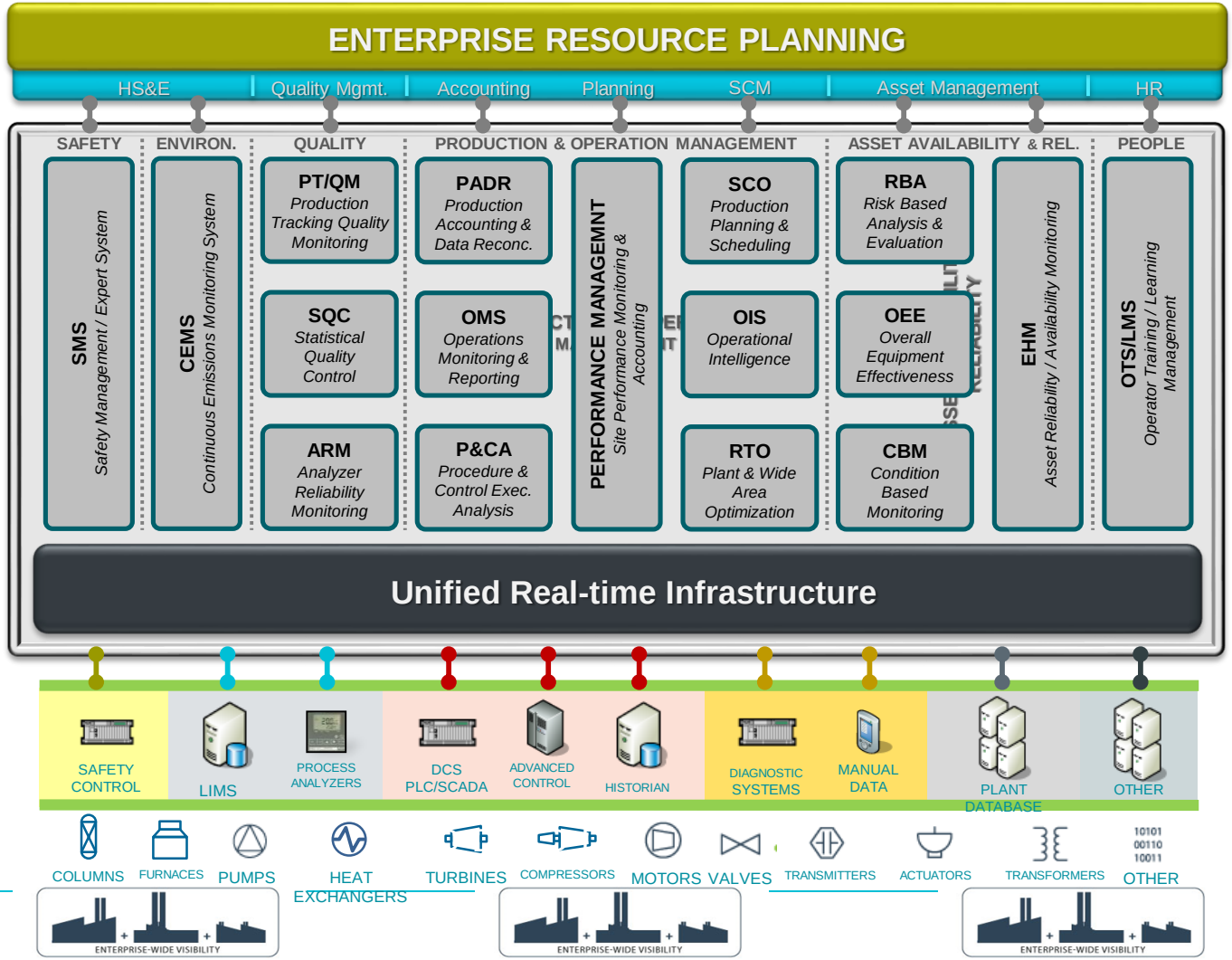


How does it map out to Systems and Solutions ?

ANSI/ISA-95.00.01-2000, Enterprise-Control System Integration


Level 5
Time frame:
years, quarters, months, weeks
Business Management
Develop business resource and cash management plan, financials. Product management, long-term data management, pay roll, human res.
Level 4
Time frame:
months, weeks, days
Business Planning & Logistics
Establishing the basic plant schedule – production, material use, delivery and shipping.
Determinig inventory levels
Level 3
Time frame:
days, shifts, hours, minutes, seconds
Manufacturing / Production Operations Management
Work flow / recipe control to produce the desired product.
Maintaining records and optimizing the production process.
Level 2
Time frame:
minutes, seconds milliseconds, microsec
Procedure & Control Execution
Monitoring, supervisory and automated control of the production process
Level 1
Time frame:
minutes, seconds milliseconds, microsec
Sensing & Manipulating
Sensing and Manipulationg the production process
Level 0
Time frame:
minutes, seconds milliseconds, microsec
Production Execution
Heating, cooling, separation, conversion etc.


ENTERPRISE RESOURCE PLANNING
HS&E
Quality Mgmt.
Accounting
Planning
SCM
Asset Management
HR
HEALTH & SAFETY
ENVIRONMENTAL
QUALITY
PRODUCTION & OPERATION MANAGEMENT
ASSET AVAILABILITY & RELIABILITY
PEOPLE EFFECTIVENESS
Unified Real-time Infrastructure
SAFETY CONTROL
LIMS
PROCESS ANALYZERS
DCS PLC/SCADA
ADVANCED CONTROL
HISTORIAN
DIAGNOSTIC SYSTEMS
MANUAL DATA
PLANT DATABASE
OTHER
Level 1
Time frame:
minutes, seconds
milliseconds, microsec
Sensing & Manipulating
COLUMNS
FURNACES
HEAT EXCHANGERS
TURBINES
COMPRESSORS
MOTORS
VALVES
TRANSMITTERS
ACTUATORS
TRANSFORMERS
OTHER
Sensing and Manipulationg the production process
Time frame:
seconds
s, microsec
Heating, c
conversion
ENTERPRISE-WIDE VISIBILITY
ENTERPRISE-WIDE VISIBILITY
ENTERPRISE-WIDE VISIBILITY


ENTERPRISE RESOURCE PLANNING
HS&E
Quality Mgmt.
Accounting
Planning
SCM
Asset Management
HR
SAFETY
ENVIRON.
QUALITY
PRODUCTION & OPERATION MANAGEMENT
ASSET AVAILABILITY & REL.
PEOPLE
SMS
Safety Management / Expert System
CEMS
Continuous Emissions Monitoring System
PT/QM
Production Tracking Quality Monitoring
SQC
Statistical Quality Control
ARM
Analyzer Reliability Monitoring
PADR
Production Accounting & Data Reconc.
OMS
Operations Monitoring & Reporting
P&CA
Procedure & Control Exec. Analysis
PERFORMANCE MANAGEMNT
Site Performance Monitoring & Accounting
SCO
Production Planning & Scheduling
OIS
Operational Intelligence
RTO
Plant & Wide Area Optimization
RBA
Risk Based Analysis & Evaluation
OEE
Overall Equipment Effectiveness
CBM
Condition Based Monitoring
EHM
Asset Reliability / Availability Monitoring
OTS/LMS
Operator Training / Learning Management
Unified Real-time Infrastructure
SAFETY CONTROL
LIMS
PROCESS ANALYZERS
DCS PLC/SCADA
ADVANCED CONTROL
HISTORIAN
DIAGNOSTIC SYSTEMS
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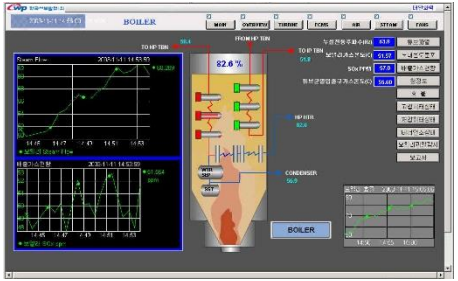
OTHER
COLUMNS
FURNACES
PUMPS
HEAT EXCHANGERS
TURBINES
COMPRESSORS
MOTORS
VALVES
TRANSMITTERS
ACTUATORS
TRANSFORMERS
OTHER
ENTERPRISE-WIDE VISIBILITY
ENTERPRISE-WIDE VISIBILITY
ENTERPRISE-WIDE VISIBILITY

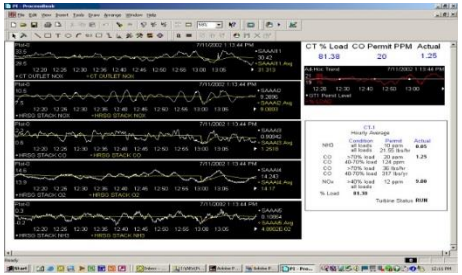
Typical Examples: Value at Site Level

Thermal Generation (Coal, Gas, Oil)

Thermal Performance

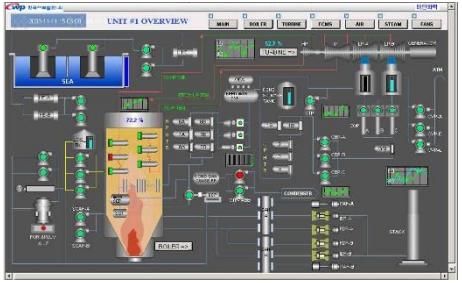


Continuous Emissions Monitoring

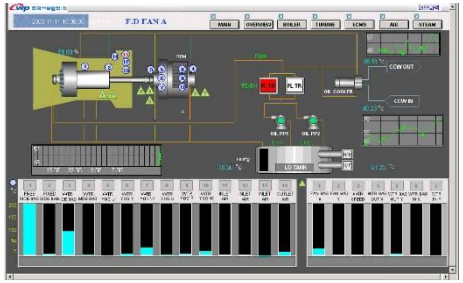


Monitoring Generation Cost

Unit Heat Balance



Equipment Health



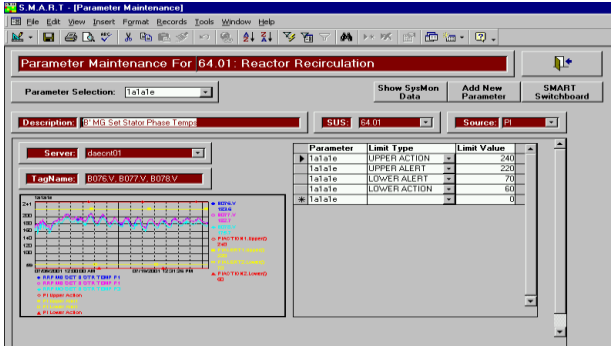
Operational KPIs

Typical Examples: Value at Site Level

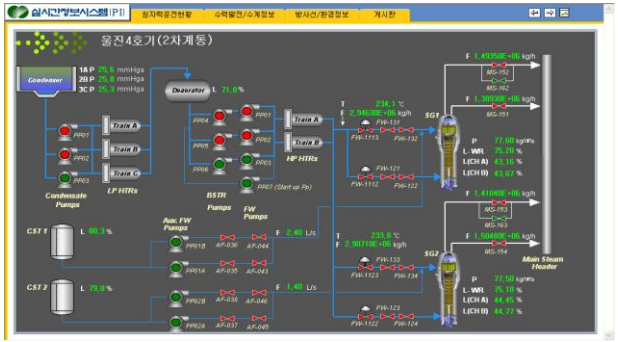
Nuclear Generation

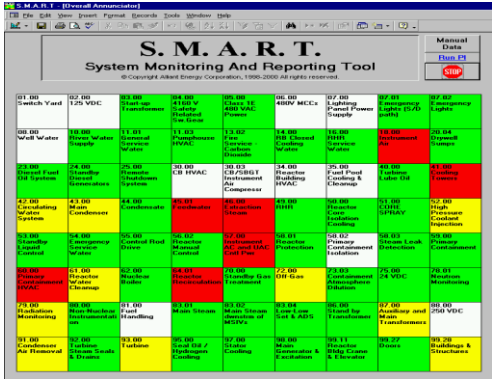
Reactor Performance Monitoring

Equipment Reliability



Emergency Preparedness

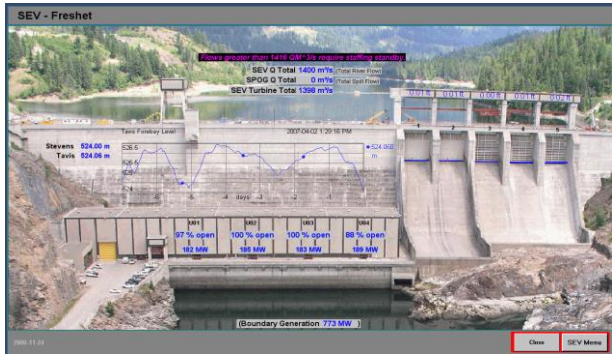




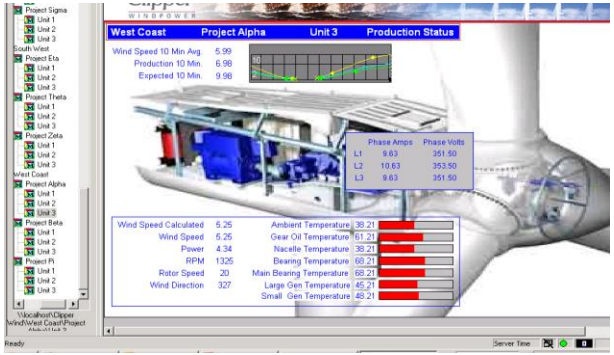
Typical Examples: Value at Site Level

Renewables (Wind, Hydro, Solar/PV)

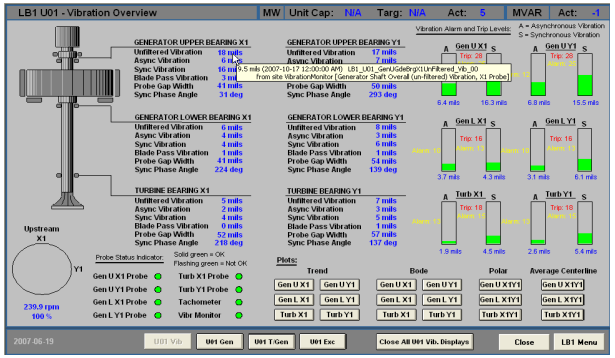
Unit Performance Monitoring



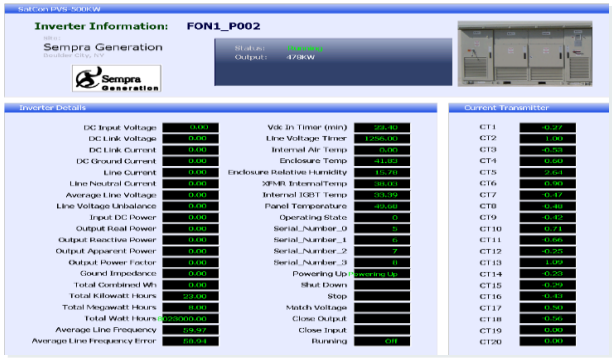
Wind Turbine Warranty Management



Condition Based Monitoring

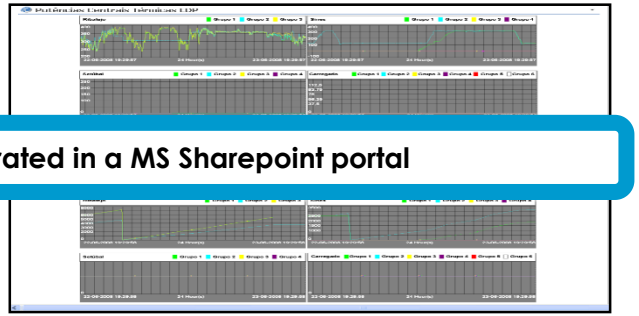


Monitoring Inverters for PV

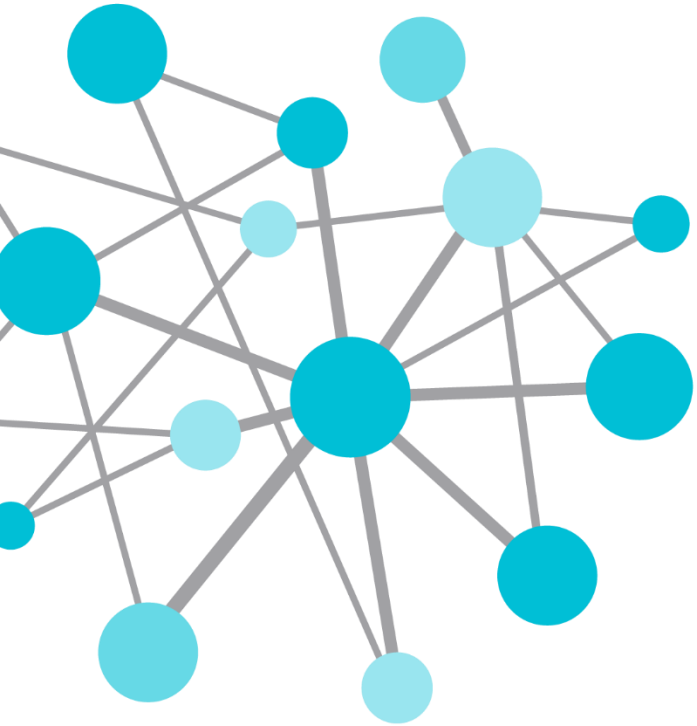


Typical Examples: Enterprise Level

Corporate Portal – Performance Dashboard



Business Objects and PI Webparts integrated in a MS Sharepoint portal



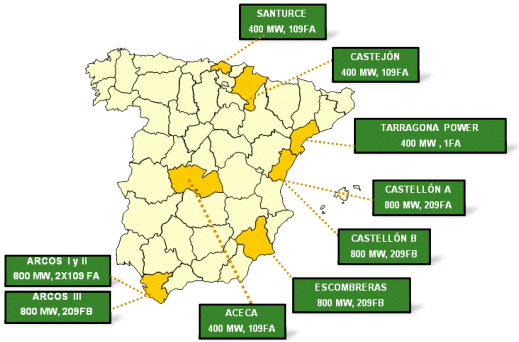
PI Use Cases in the Power Generation Industry

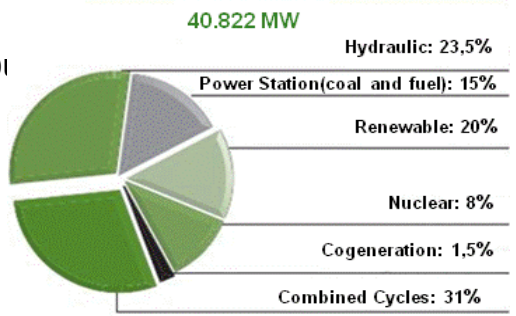
Iberdrola Case Study – CMDS

Overview

- *Background Information on Iberdrola:*
  - Power Generation, Transmission&Distribution
  - Global Operations, one of the biggest in the world
  - World Leader in Renewables
- *Drivers:*
  - One Combined Cycle 2GTx1ST
    - ≈ 350 M€ Investment
    - Gas Prices / Equipment Prices Increasing
    - Environmental concerns increasing

    ⇨ ***Optimization IS A MUST***
- *History:*
  - CMDS: Monitoring, Diagnostics and Simulation Center bu
    - Technology Center for the CC Fleet (O&M)
- *Current Status:*
  - Renewables Integrated (WINDCore)
  - Coal-fired plants underway





Iberdrola Case Study – CMDS

Goals & Objectives

IBERDROLA

MAIN GOALS

- Maximize efficiency, availability and reliability
- Support power plants to:
  - OPERATE &MAINTAIN in an optimum way
  - Minimize costs
  - Unify technology management

POWER PLANTS O&M OPTIMISATION

ADDITIONAL BENEFITS

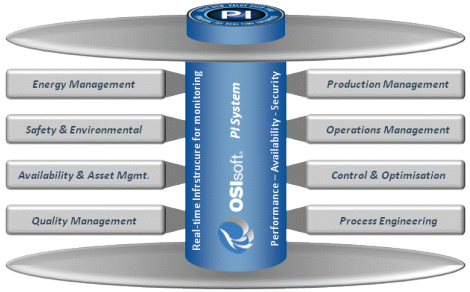
- Common O&M model for all stations : Fleet approach
- O&M on-site and on-line support
- Share operational experiences and best practices
- Center of Excellence
- Reduce OEM dependency

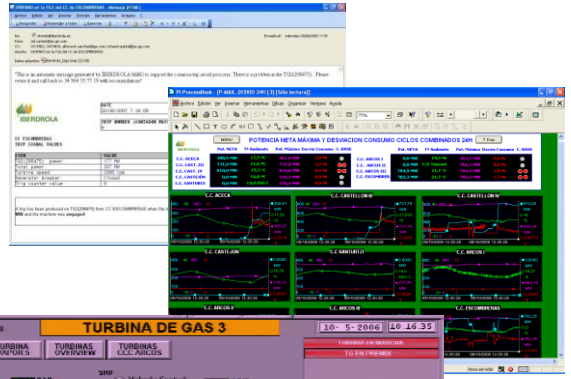
Iberdrola Case Study – CMDS

PI is the foundation for CMDS

- Applications Developed Over Time
  - Performance Tracking
  - Contract Tracking
  - System Advisor
  - AEM (Advanced Equipment Monitoring)
  - IT Doctor
  - GE M&D Connection
  - SAP Connection (PM & BW Module)
  - EMS Connection (Dispatching Center)
  - Daily Inspections

  Others…….





Iberdrola Case Study – CMDS

Benefits / Lessons Learned

- 6 years PI System experience over Combined Cycle Technology:
  - Quick ROI ≈ 1-2 years
  - Increasing efficiency →1%-2%
  - Increasing availability → 0,1%-0,5%
- Easily exportable to another business
- Opening the platform for all users = A lot of value
- Focus on business drivers – Business Agility
- Event based monitoring
- Success requires collaboration between operations, maintenance and engineering

IBERDROLA

BChydro Case Study – OI System

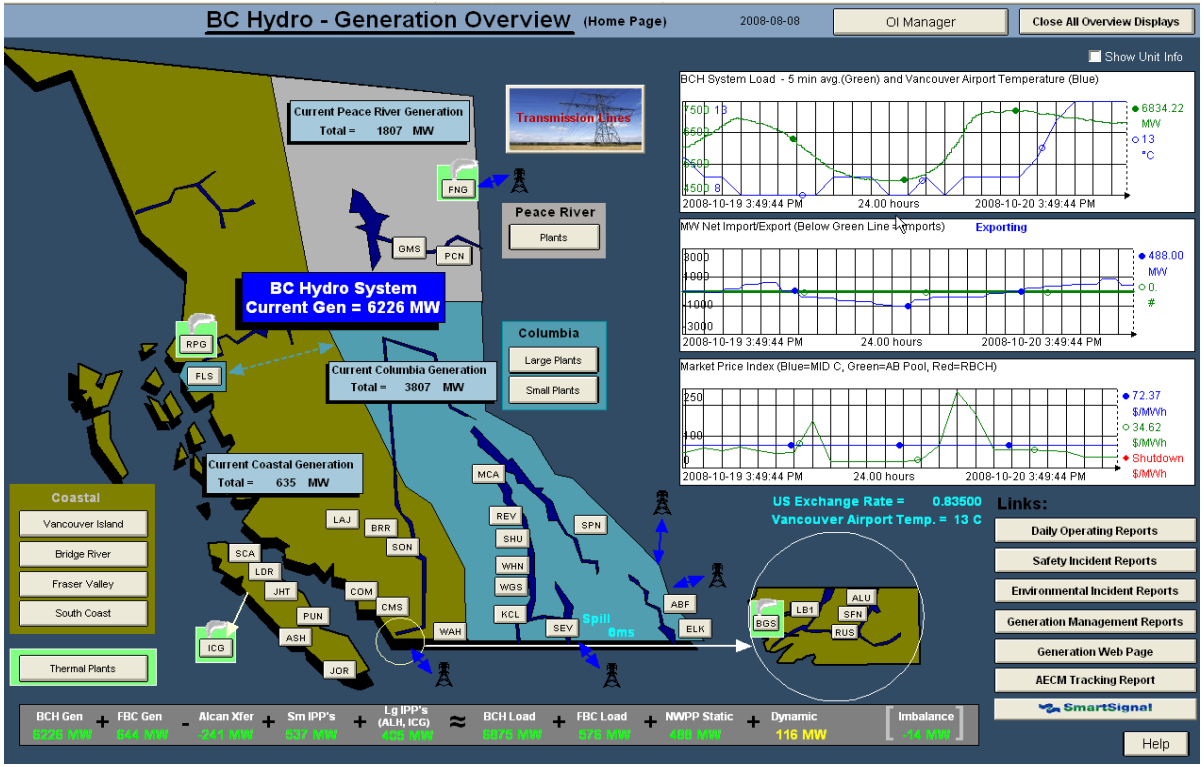
Overview

- *Bacground Information on BChydro:*
  - BChydro is third largest utility in Canada
  - Predominantly a hydro electric utility with 10,000 MW of installed hydro generation capacity
  - 7 largest generating stations with 38 turbines make up 8,850 MW
- *Drivers:*
  - Water use and generation optimization
  - Keep the plants running (O&M)
- *History:*
  - PI has been used since 1996. PI used first as a firewall to the Energy Management SCADA system.
  - In 1999 PI used to support Generation Operations
    - Generating Stations (the power generated in MW)
    - Resource Management (water availability and generation optimization)
- *Current Situation:*
  - PI is the foundation for B.C.Hydro's Operational Information (OI) System

BC hydro

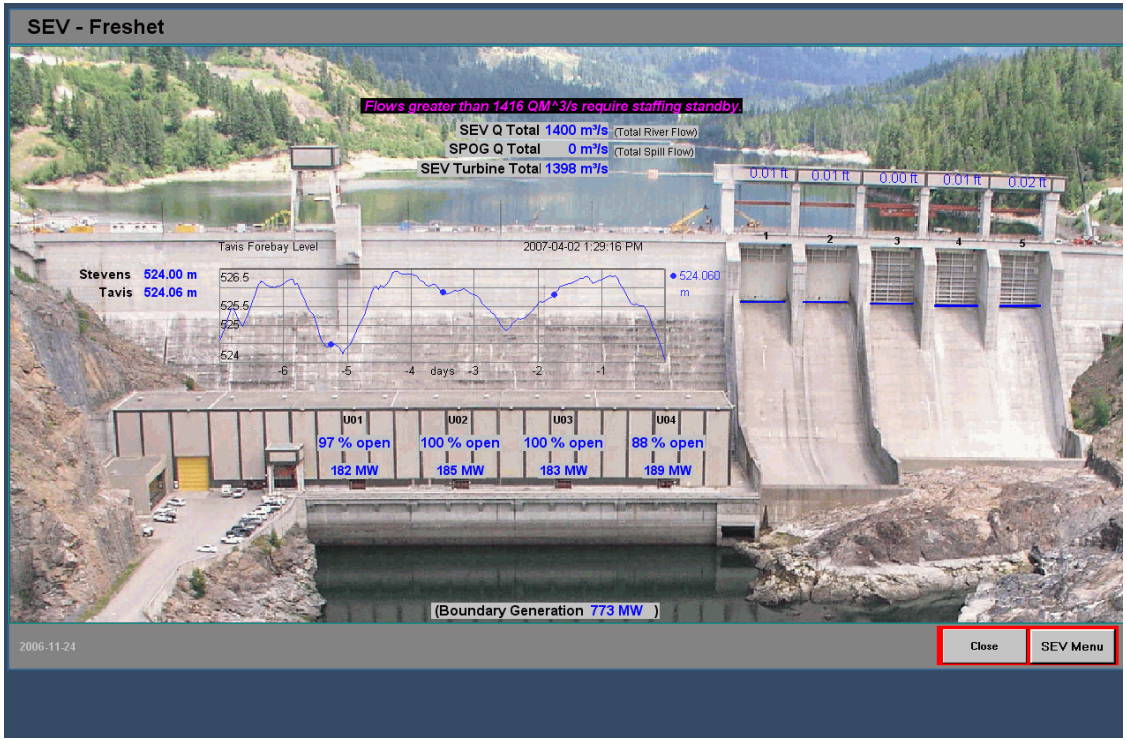
BChydro Case Study – OI System

Operations Executive Overviews



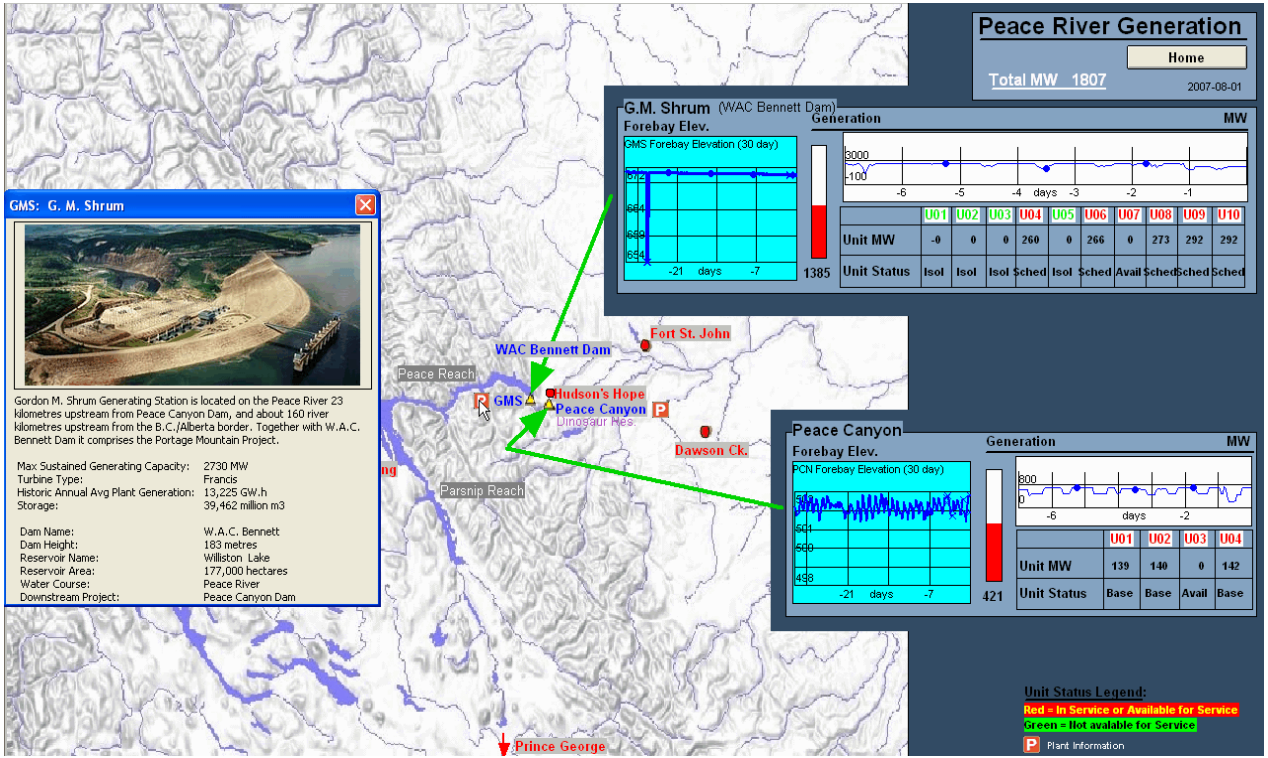
BChydro Case Study – OI System

Unit Detail View



BChydro Case Study – OI System

Executive Overviews for Non Operational Executives

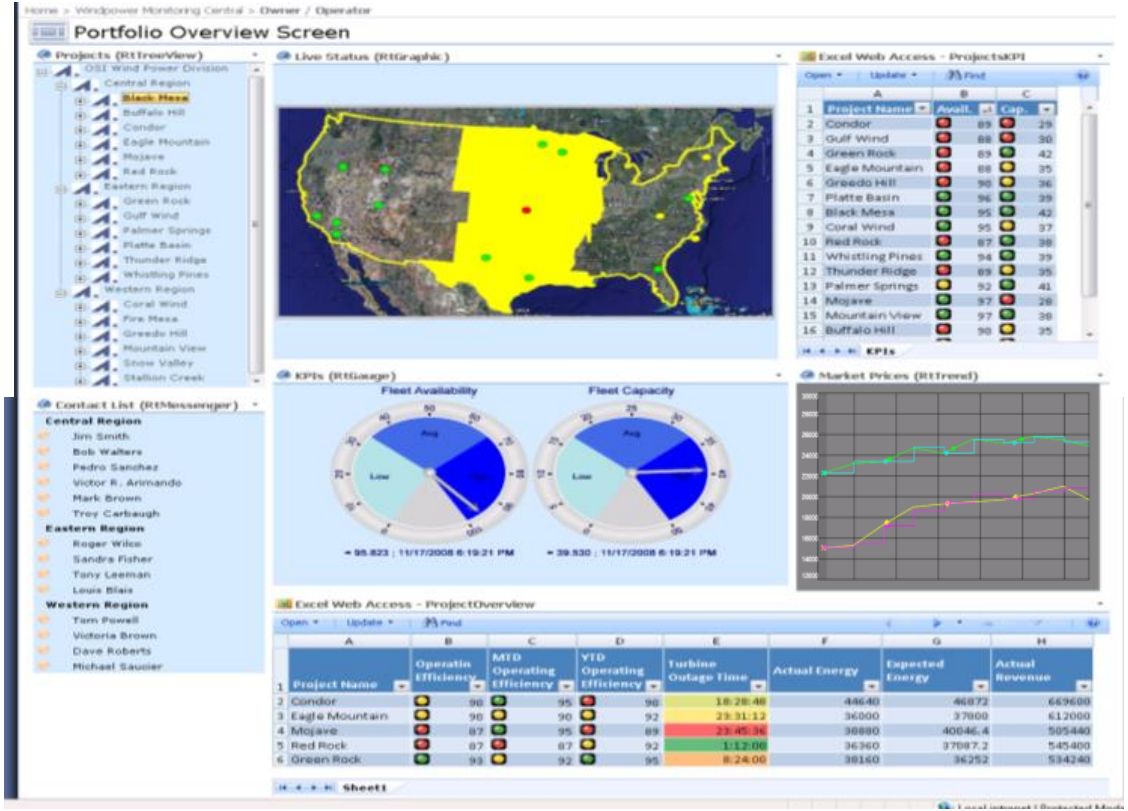


Typical Scenario

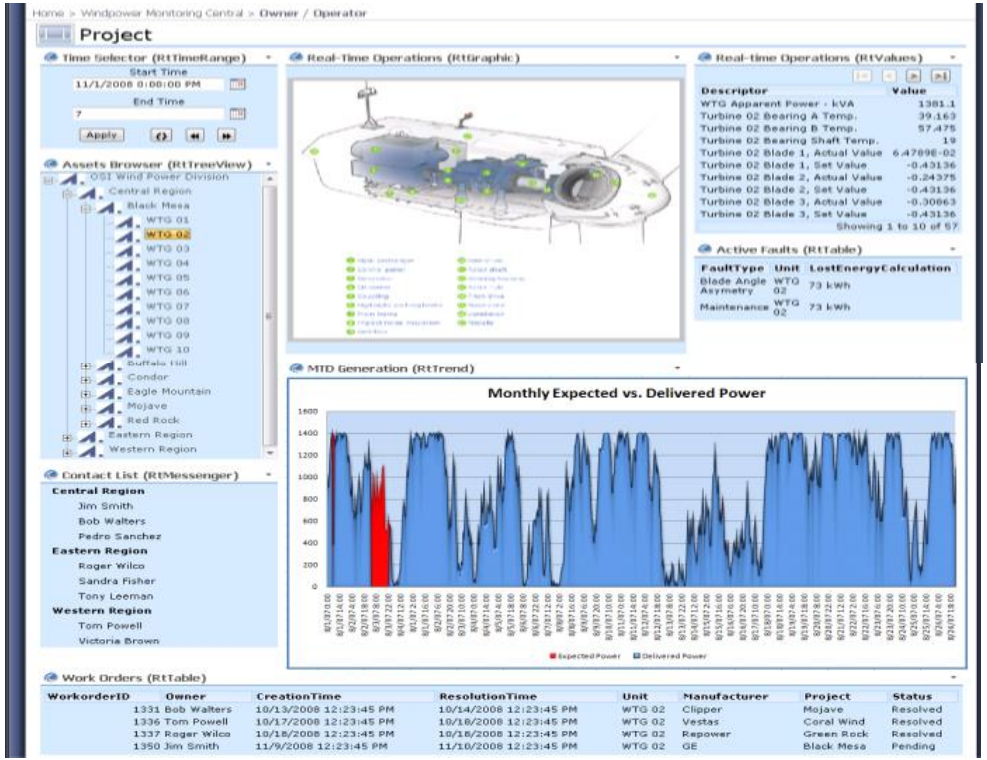
- O&M centers for monitoring the renewables

- Vattenfall Vindkraft
  - World's largest offshore wind farm
  - Commissioned in summer 2010
  - 100 turbines in operation
  - 341 turbines expected

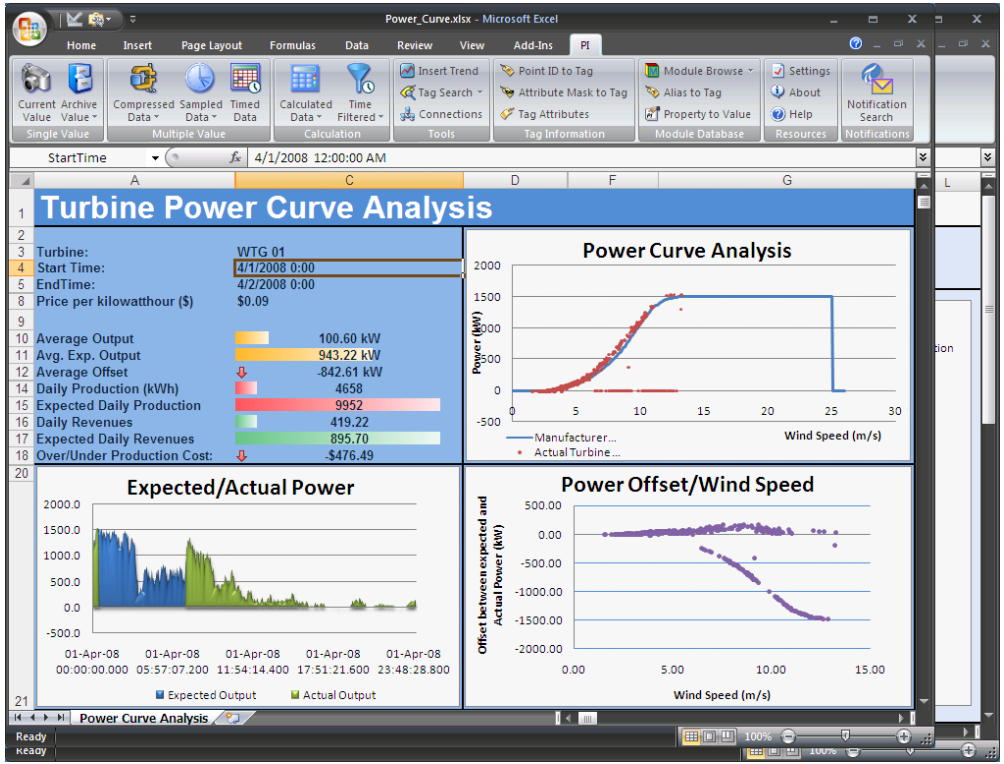
Portfolio Overview



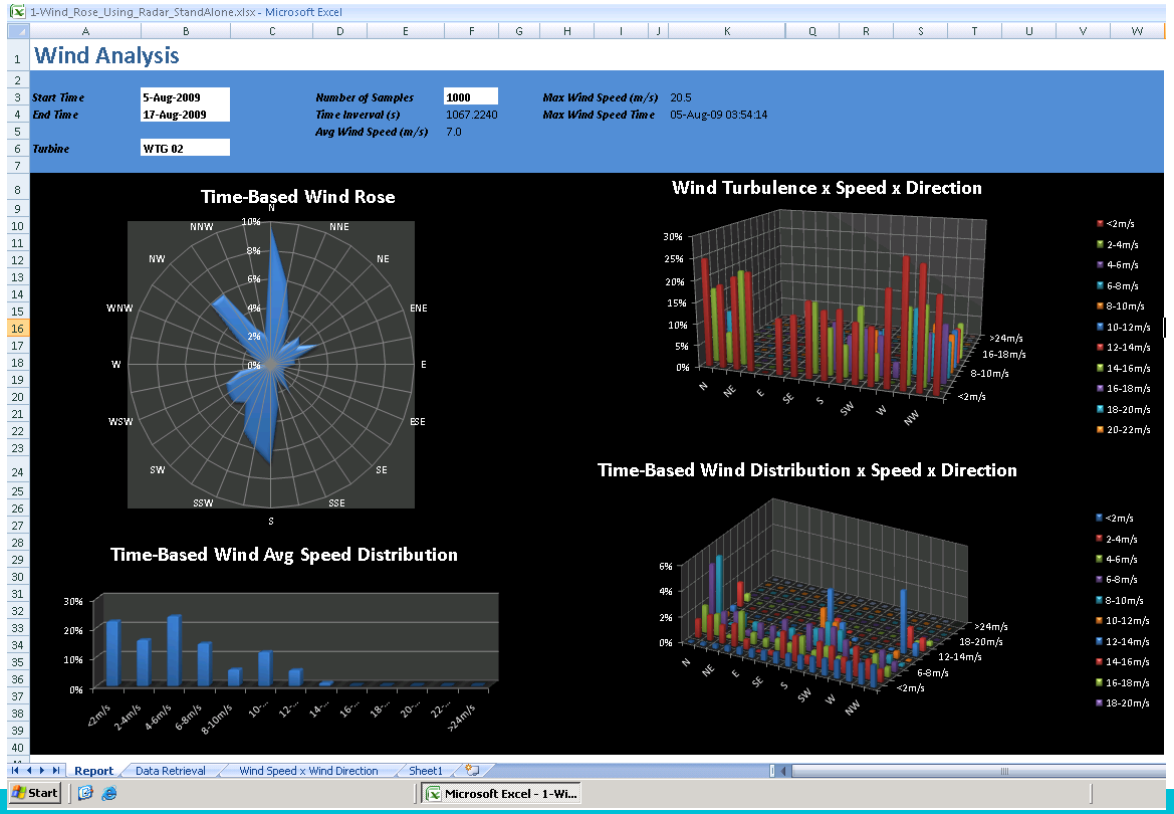
Unit Detail

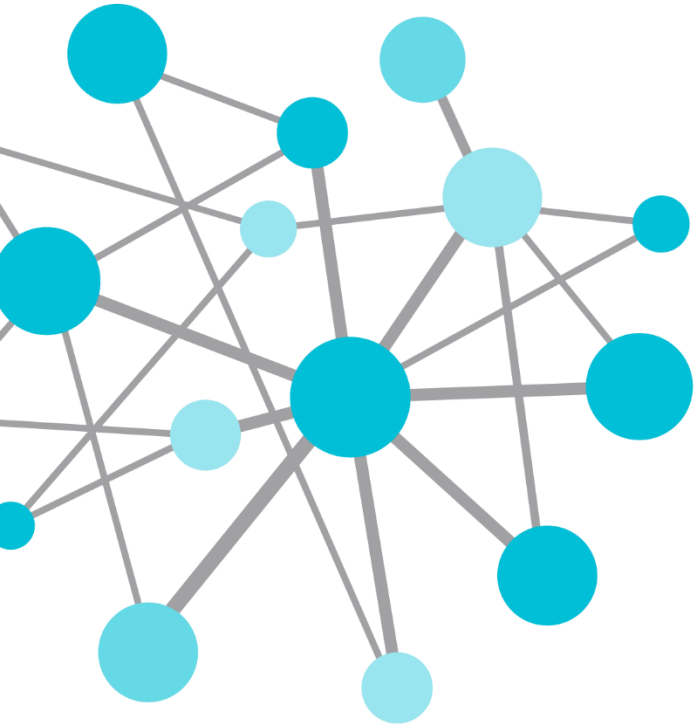


Excel Based Reporting



Wind Analysis

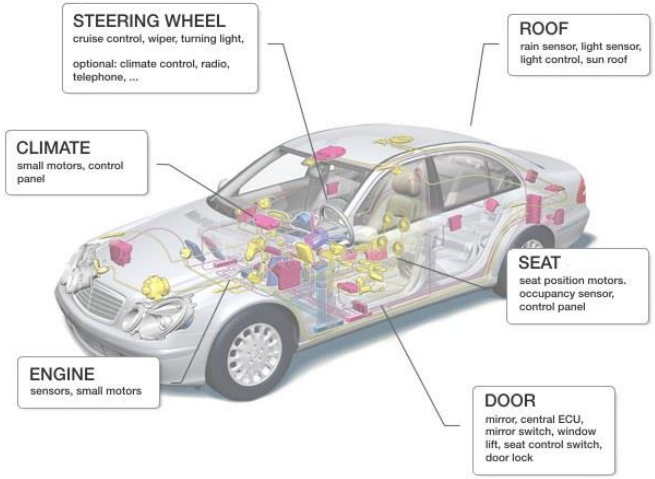


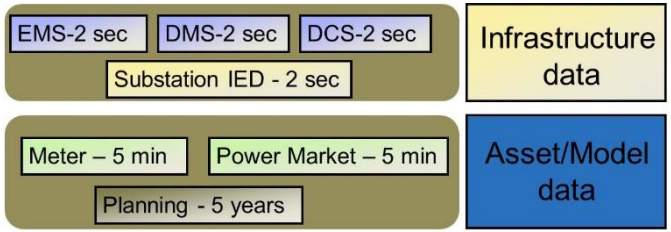


PI Use Cases in the Power Transmission Industry

Industry Characteristic

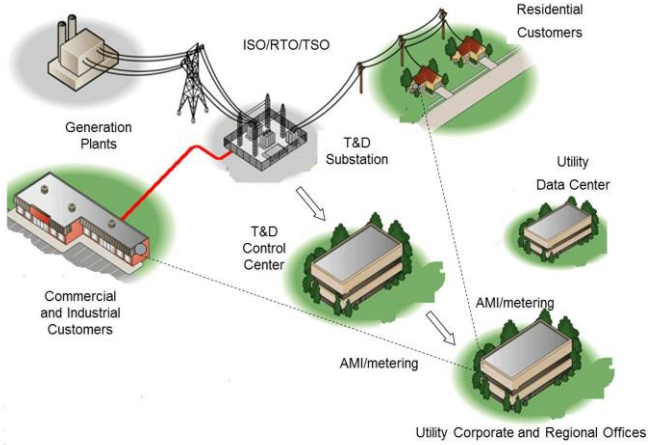
- Very complex and complicated
  - Lots of small systems and devices
- Required to manage many different generation sources
- Geographically dispersed networks
- Data, data, data...
  - SCADA, DMS, OMS, IED, GIS etc.
- Various data granularity and delivery frequencies, that increase over time
  - from sub-second to years range
- Infrastructure / Asset Model





Industry Challenges / Initiatives

- Grid Operations and Reliability
- Power Quality/Transient/Dist. Data
- Condition Based Maintenance
- Asset Management
- Substation Automation
- Distribution Automation
- AMI-Advanced Metering Infrastructure
- Distributed Generation
- Smart Grid/Intelligent Grid



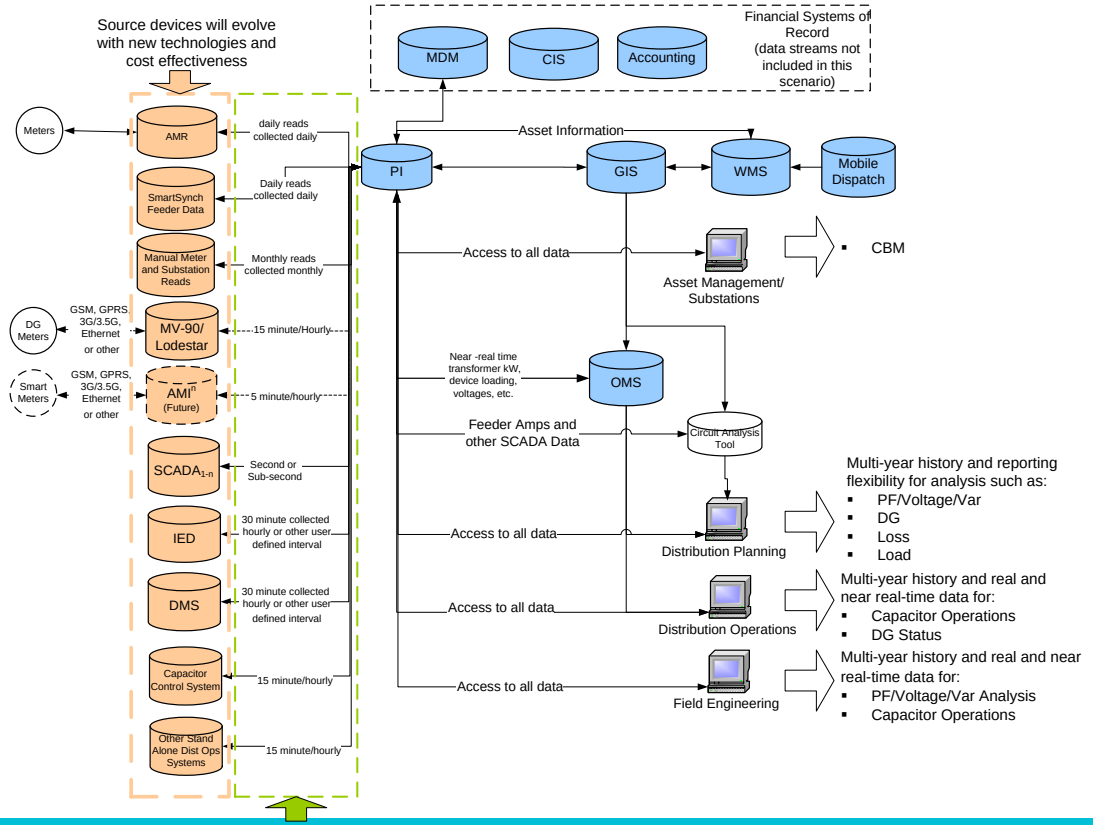
The Common Thing in All:

Requires

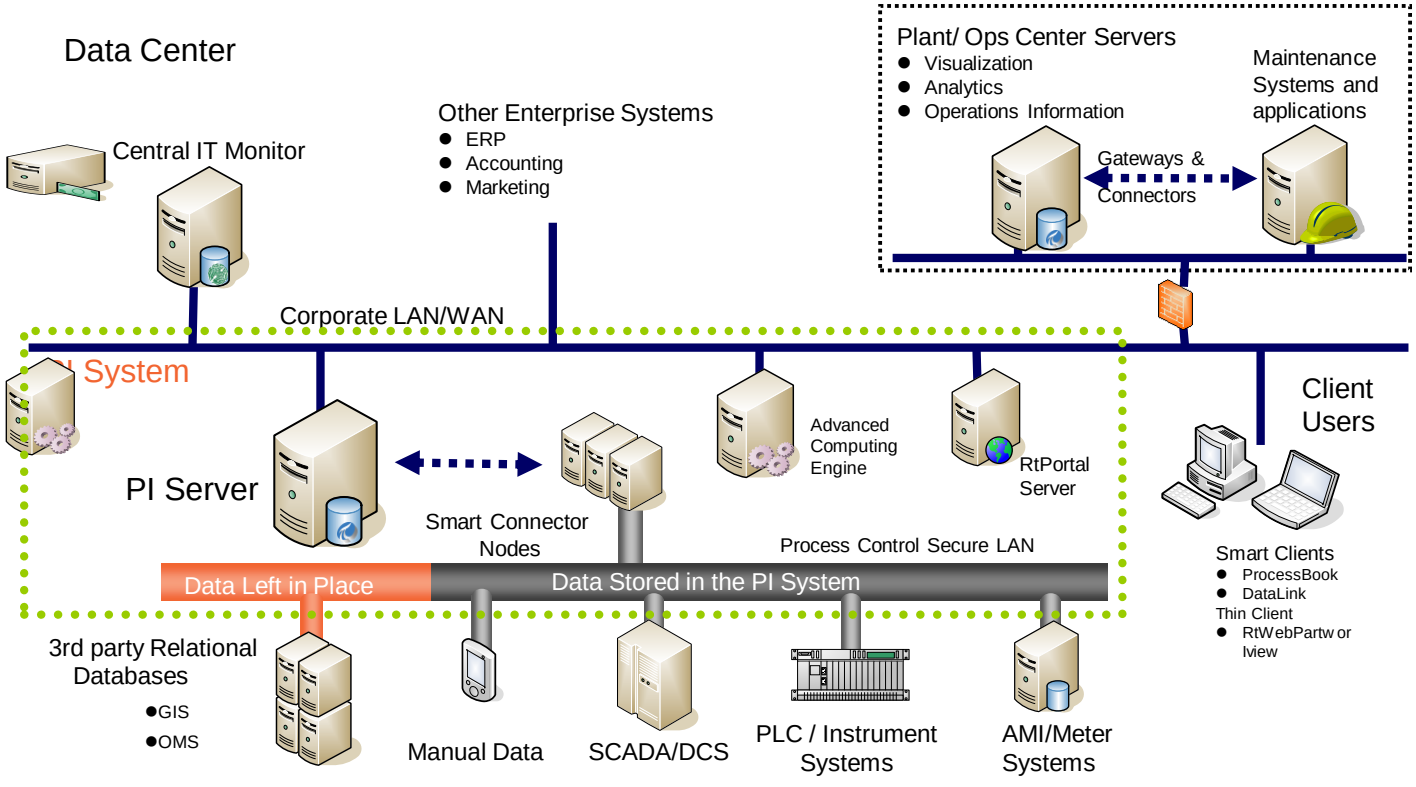
- *Accessible, precise, real-time data*
- *long-term persistent data store*
- *Notifications and analysis*

PI for Operation & Maintenance

Sample Data Flow



Sample Architecture

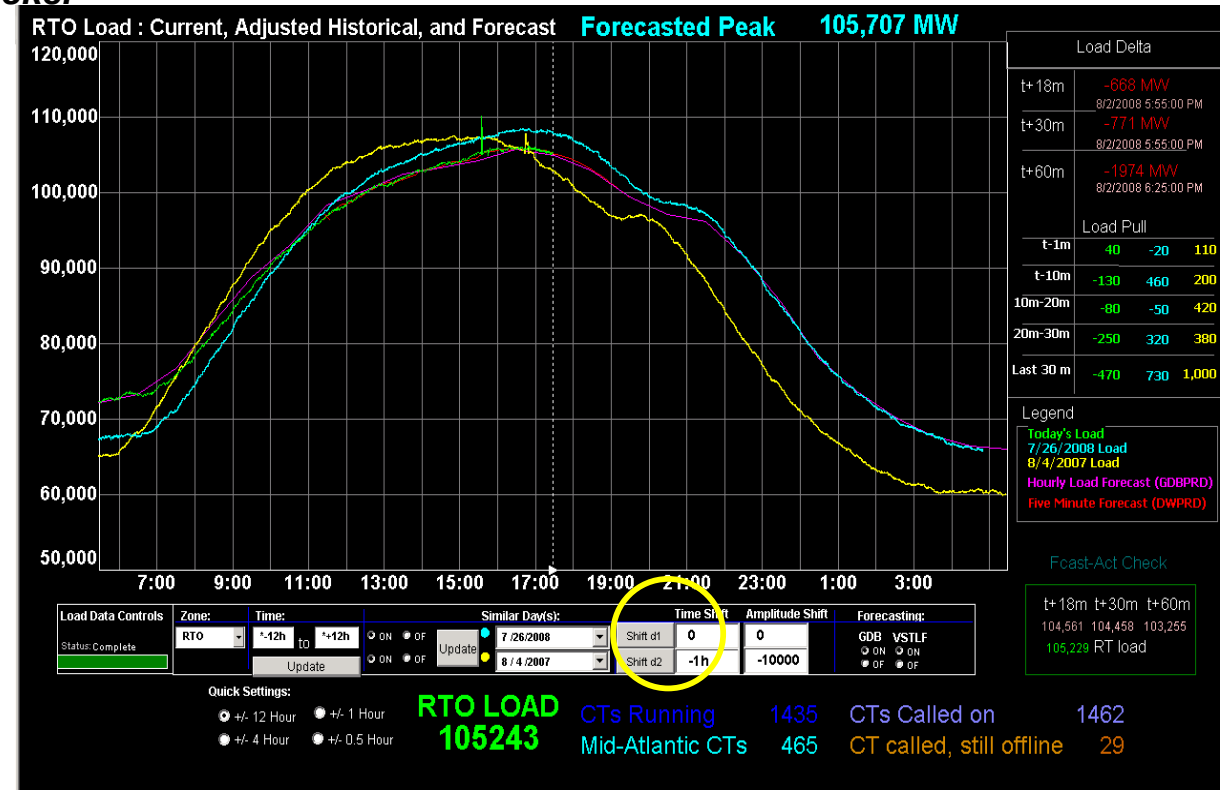


Proven Use Cases

- **Operational:**
  - EMS/DMS/SCADA data monitoring and archiving, event reporting and analysis
- **Non-operational:**
  - substation field device IED, SOE, Power Quality and DFR data monitoring and archiving
- **Asset/Model:**
  - asset model management and analytics
- **Cyber Security / IT:**
  - Critical Infrastructure Protection and Control System IT Infrastructure Monitoring
- **Enterprise:**
  - integration, correlation and repository

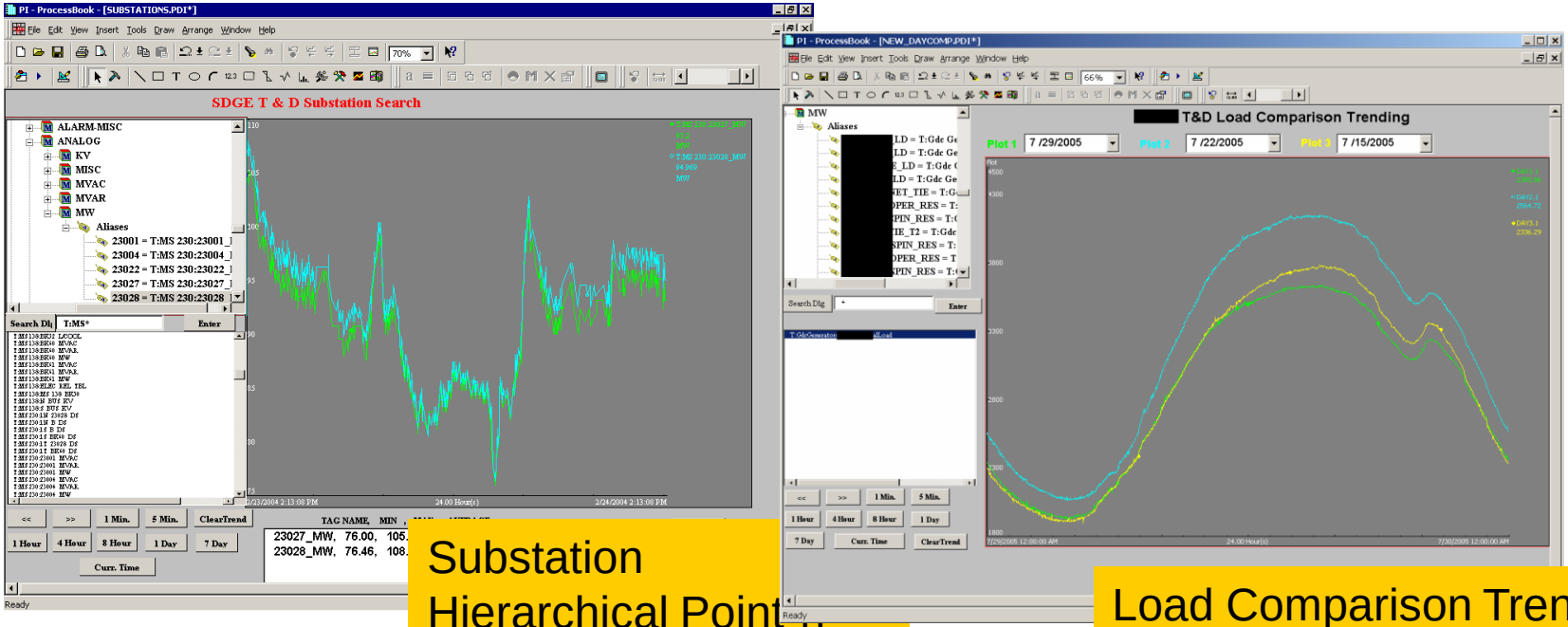
Forecasting Load Peaks

Load Picker



Substation Load Analysis

Load Comparison

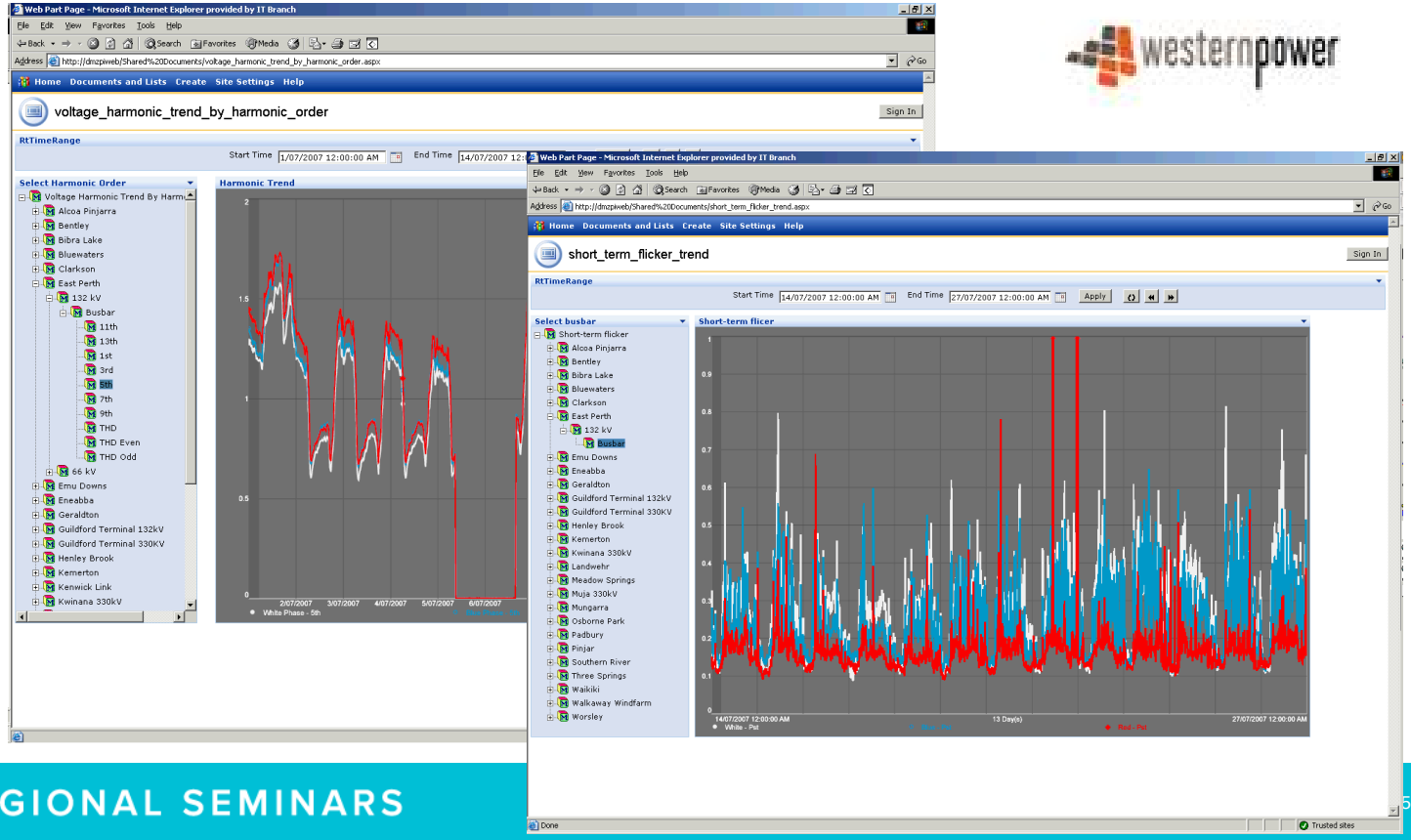


Substation Hierarchical Point-N-Click Trending

Load Comparison Trending

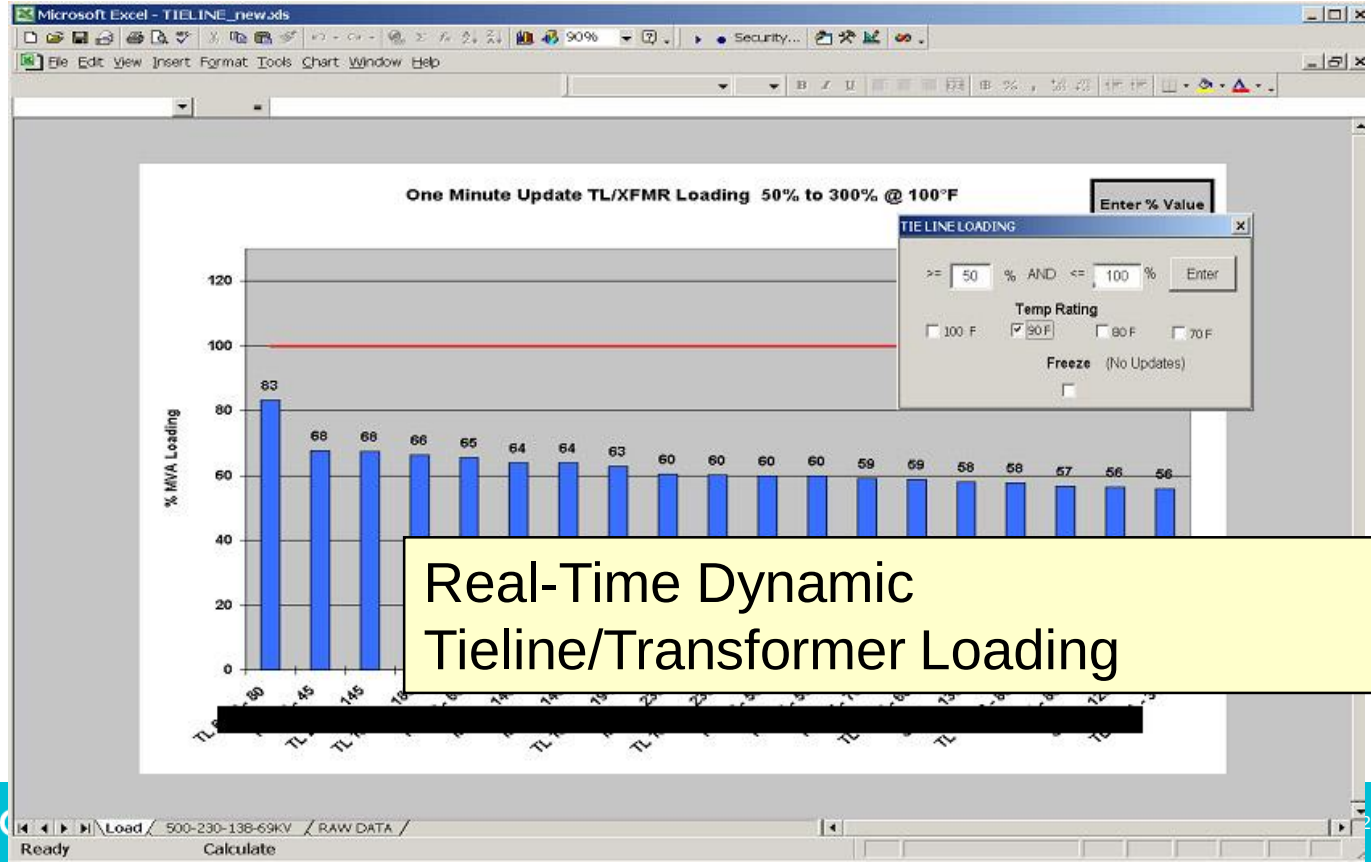
Power Quality Monitoring

Voltage Harmonics / Flickering



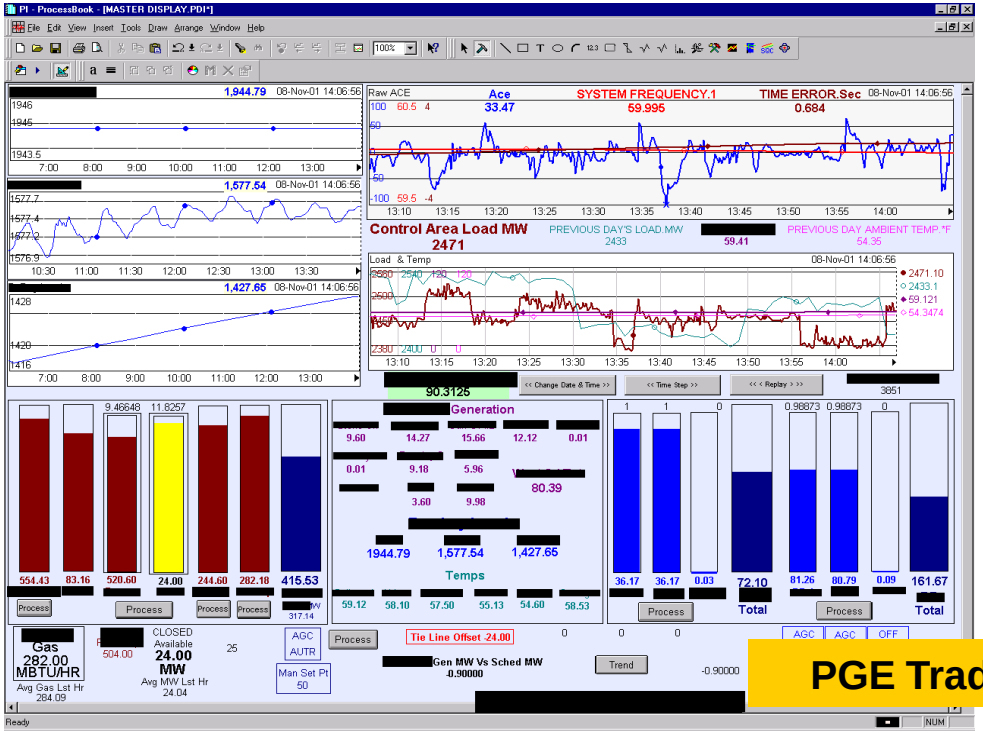
Operations Planning / Tieline Control

Transformer Loading



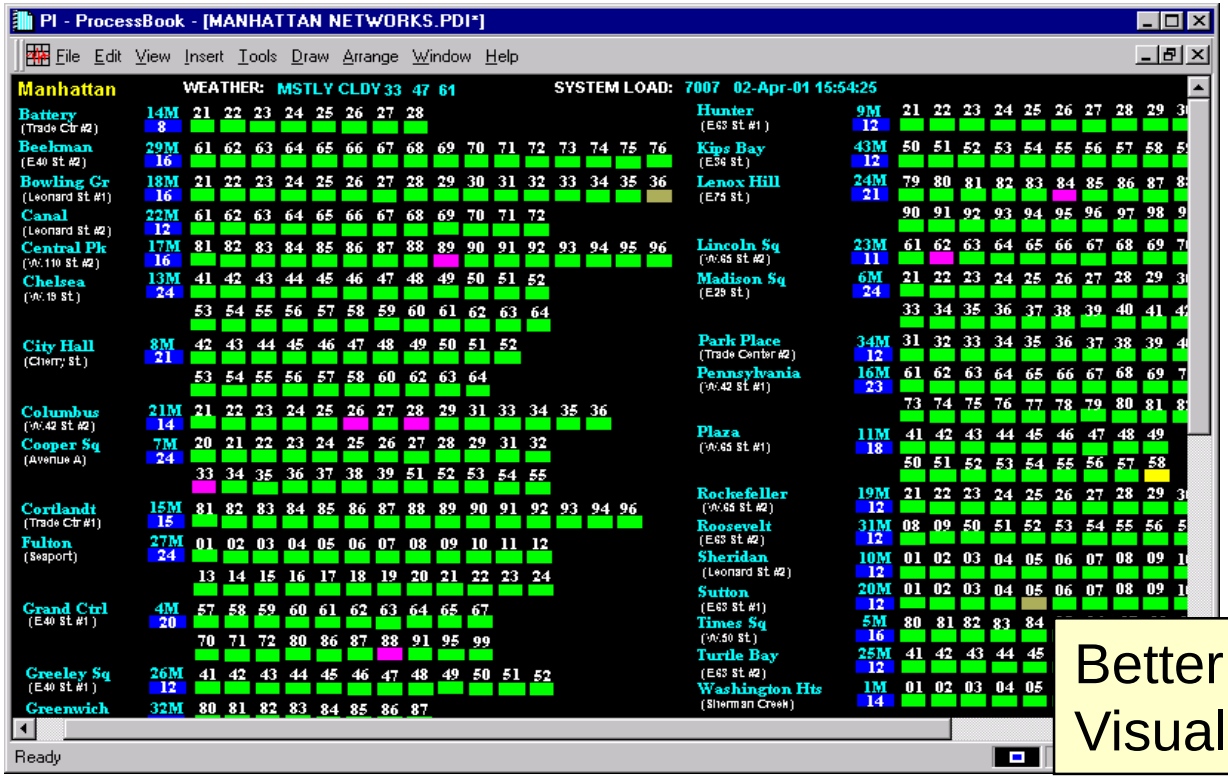
Real-Time Dynamic
Tieline/Transformer Loading

Trading



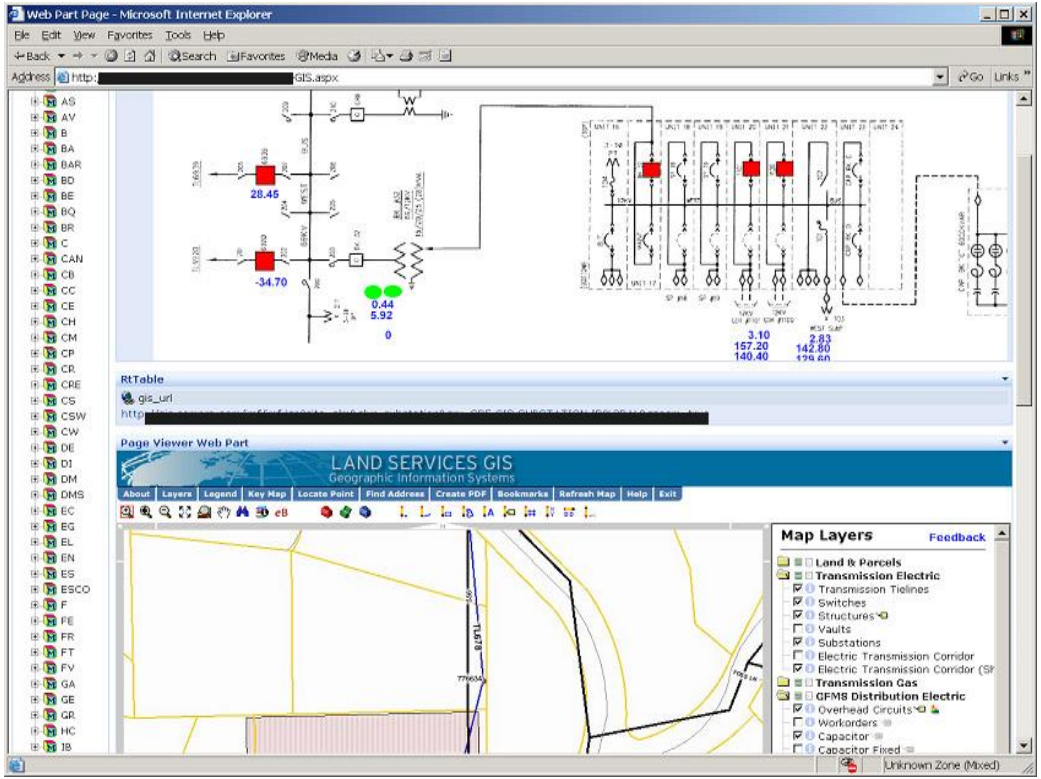
PGE Trading Floor Wall Screen

Substation Overview

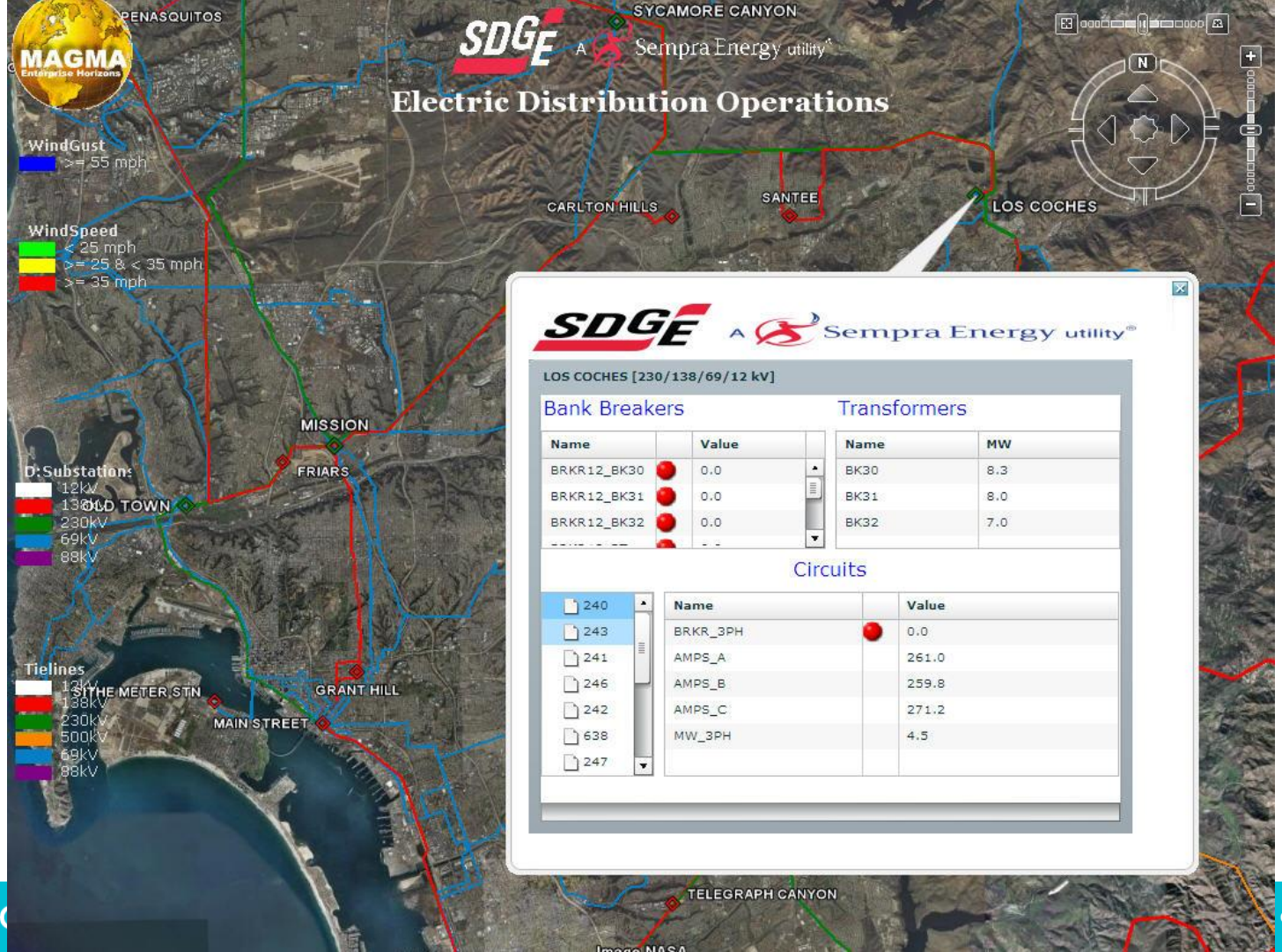


Better Visualization

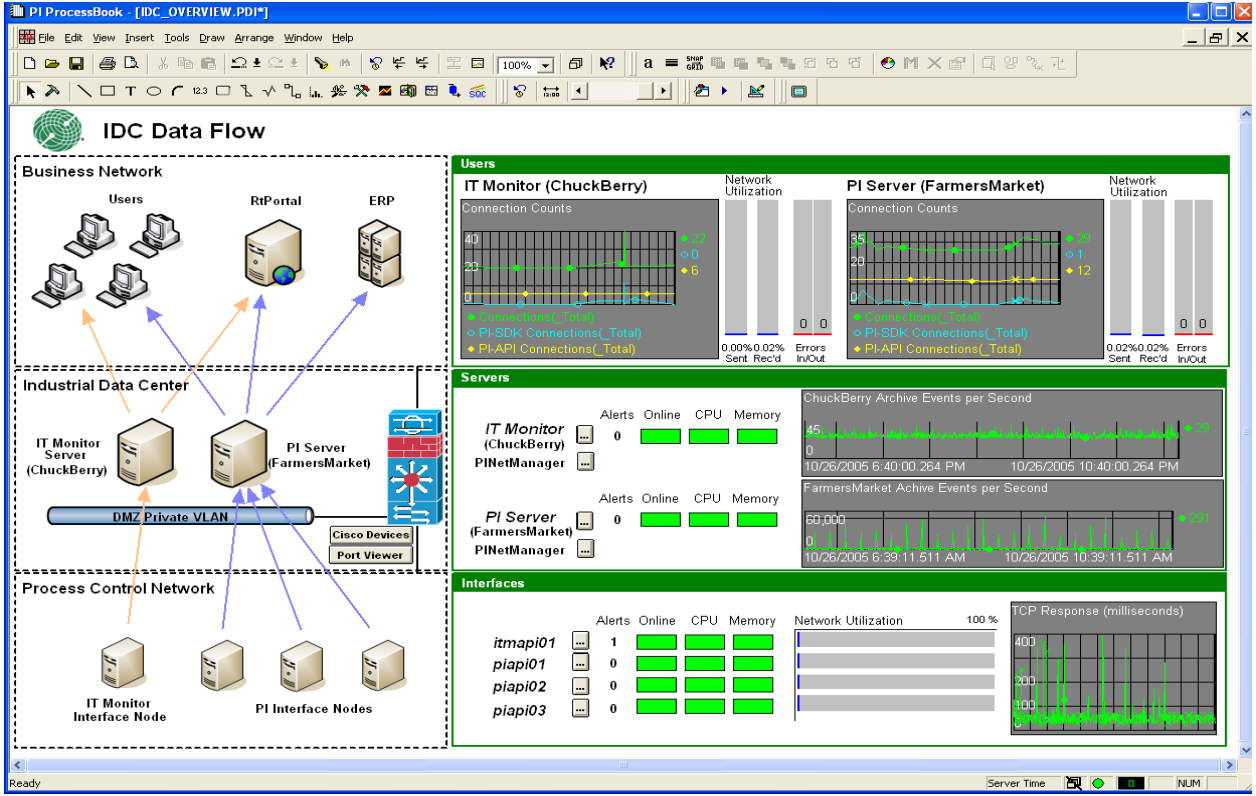
Integration of Geospatial Information



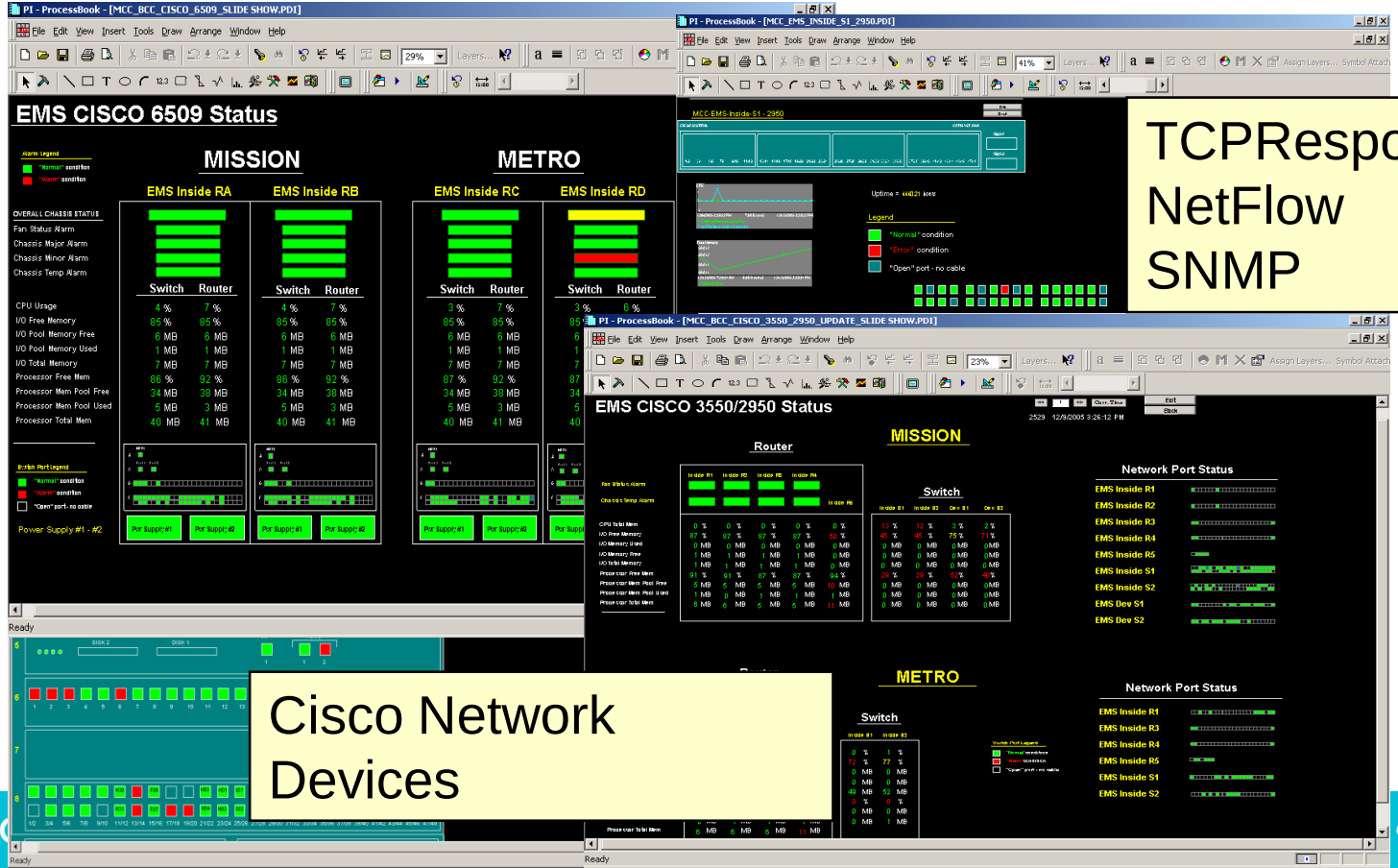
CALIFORNIA ISO


PENASQUITOS
MAGMA
Enterprise Horizons
SDGE
A Sempra Energy utility
Electric Distribution Operations
SYCAMORE CANYON
WindGust
>= 55 mph
WindSpeed
< 25 mph
>= 25 & < 35 mph
>= 35 mph
CARLTON HILLS
SANTEE
LOS COCHES
MISSION
FRIARS
OLD TOWN
Substations
12kV
138kV
230kV
69kV
88kV
Tielines
12kV
138kV
230kV
500kV
69kV
88kV
SILVETHE METER STN
GRANT HILL
MAIN STREET
TELEGRAPH CANYON
N
SDGE
A Sempra Energy utility
LOS COCHES [230/138/69/12 kV]
Bank Breakers
Name
Value
BRKR12_BK30
0.0
BRKR12_BK31
0.0
BRKR12_BK32
0.0
Transformers
Name
MW
BK30
8.3
BK31
8.0
BK32
7.0
Circuits
240
243
241
246
242
638
247
Name
Value
BRKR_3PH
0.0
AMPS_A
261.0
AMPS_B
259.8
AMPS_C
271.2
MW_3PH
4.5

Industrial Data Center and IT Monitor



Monitor and Protect Networks



Enterprise Integration

CAISO – Operator Console

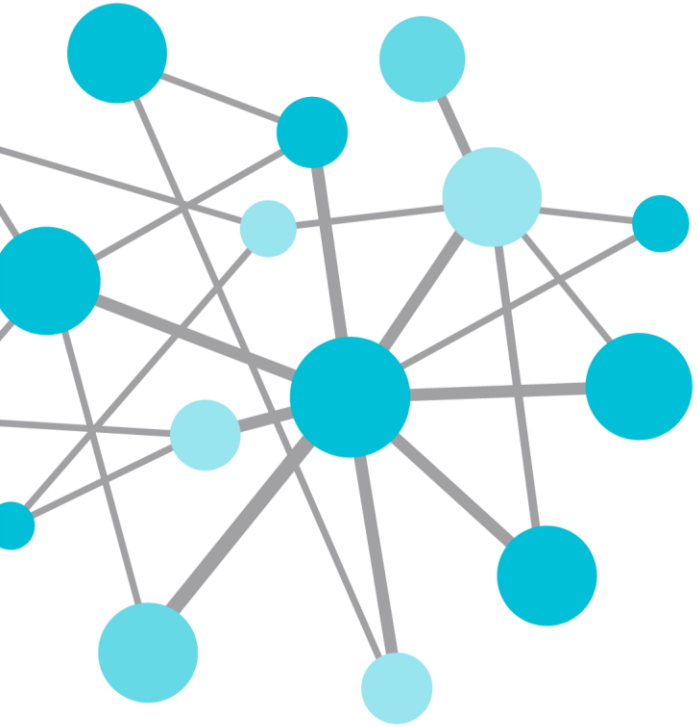
Enterprise Integration

PJM Transmission Video Wall

California ISO: Governor's visit

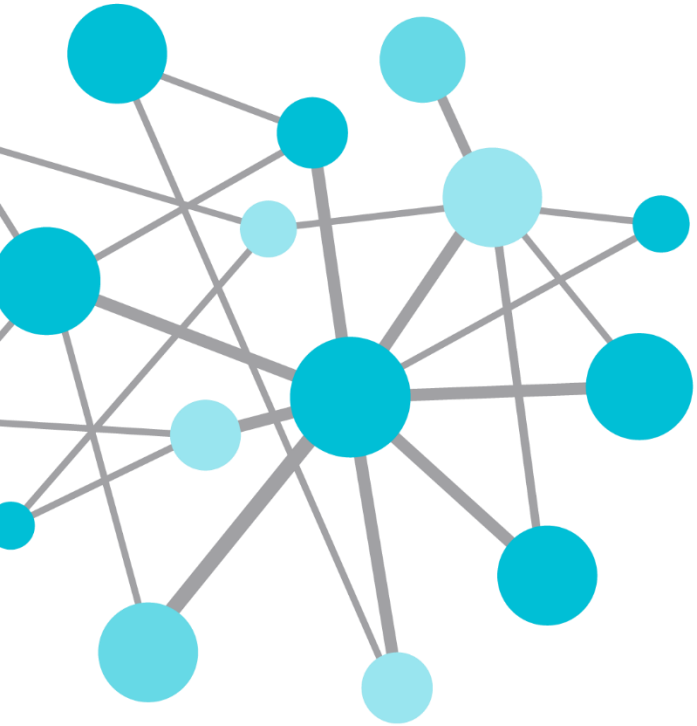
Summary

- What?
  - Infrastructure that
    - Creates an integration platform to all islands
    - Connects your plant floor data into the business management system
    - Supports Integrated Operations (Fleet Mentality)
- Why?
  - Foundation for Business and Operational Improvement Initiatives
    - Improved Business Agility – real-time decision making
    - Standardization - One version of truth
    - Collaboration – Everyone works with the same data, rules & tools
    - Protection of existing and future investment
    - Low Risk & Quick option
- How?
  - Build the Foundation first
    - Infrastructure first, followed by applications supporting Performance Improvement Initiatives



THANK YOU

Brought to you by OSIsoft.



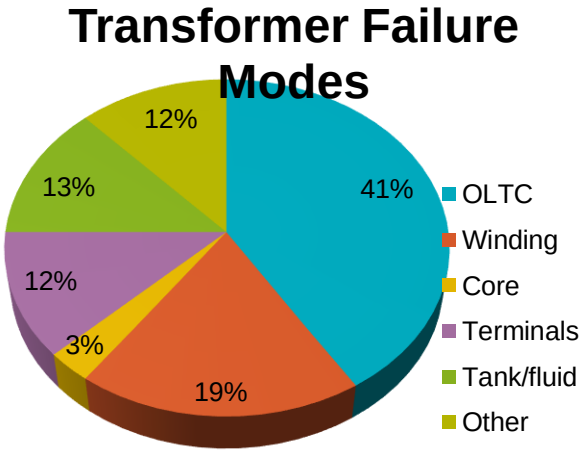
Examples for Leveraging the Value of PI in Operations & Maintenance

Transformer Condition Based Monitoring

Example: Transformer Condition Monitoring

Failure Modes

- Transformer Condition Monitoring
  - OLTC Monitoring
  - Dissolved Gas Analysis (DGA)
  - Transofrmer Temperature
  - Cooling System Monitoring
- The two most probable failure modes on a Transformer are
  - Load Tap Changer
  - Windings (including insulation)
- These are 60% of total



MIN. AVGERAGE LOAD CURRENT
APPARENT POWER, MVA
HOTTEST-SPOT ON WINDING
INSULATION AGING RATE
WATER CONTENT
STEADY LOAD
DYNAMIC OVERLOAD
COOLING EFFICIENCY
ETC WEIGHTED TEMP. DIFFERENCE

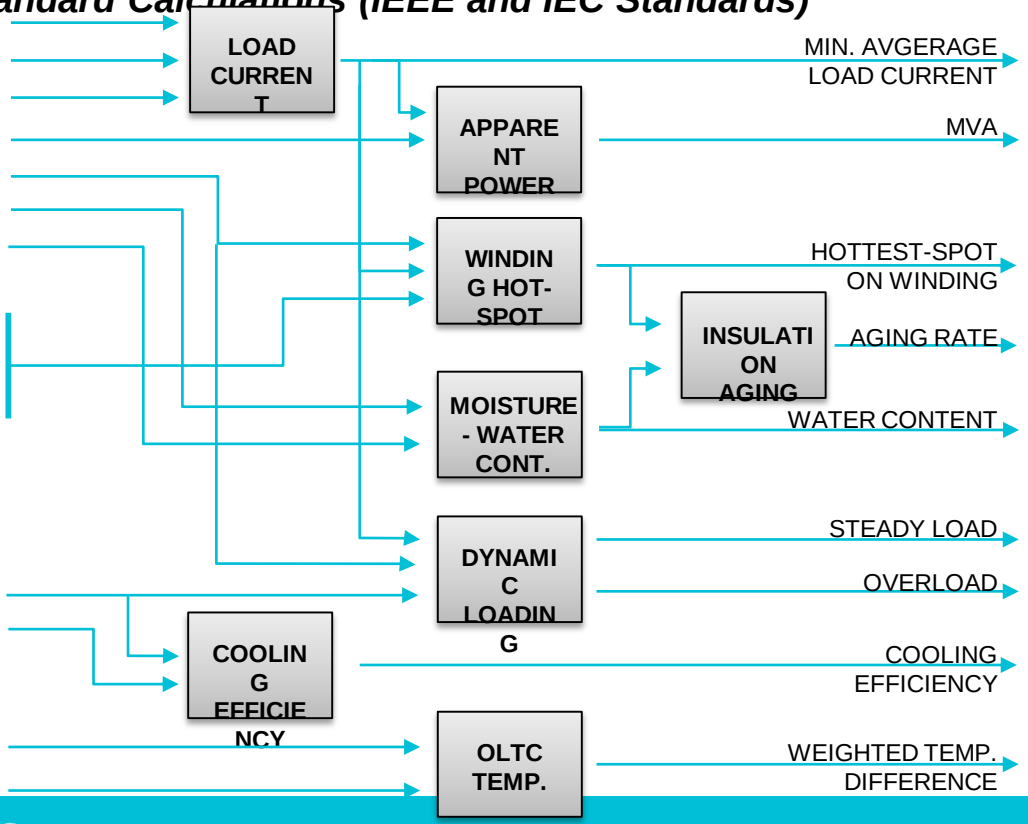
Example: Transformer Condition Monitoring

Standard Calculations (IEEE and IEC Standards)

- H winding current
- X winding current
- Y winding current
- H winding voltage
- Top oil temperature
- Moisture reading
- Moisture sensor temp

- Rated HST rise
- Rated load
- Winding Characterist.

- Ambient temperature
- Cooling stage status
- Tap Changer temp



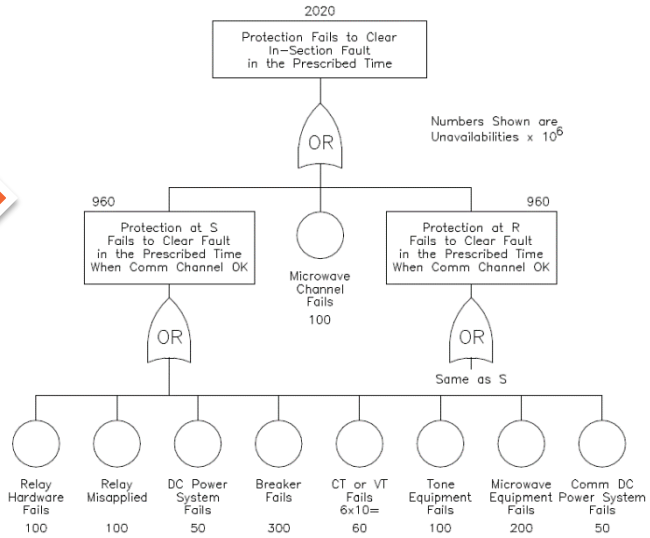
Example: Transformer Condition Monitoring

Root Cause Analysiy (RCA) and FMEA / FMECA

Root Cause Analysis

Fault Tree

(FMEA, RCA)



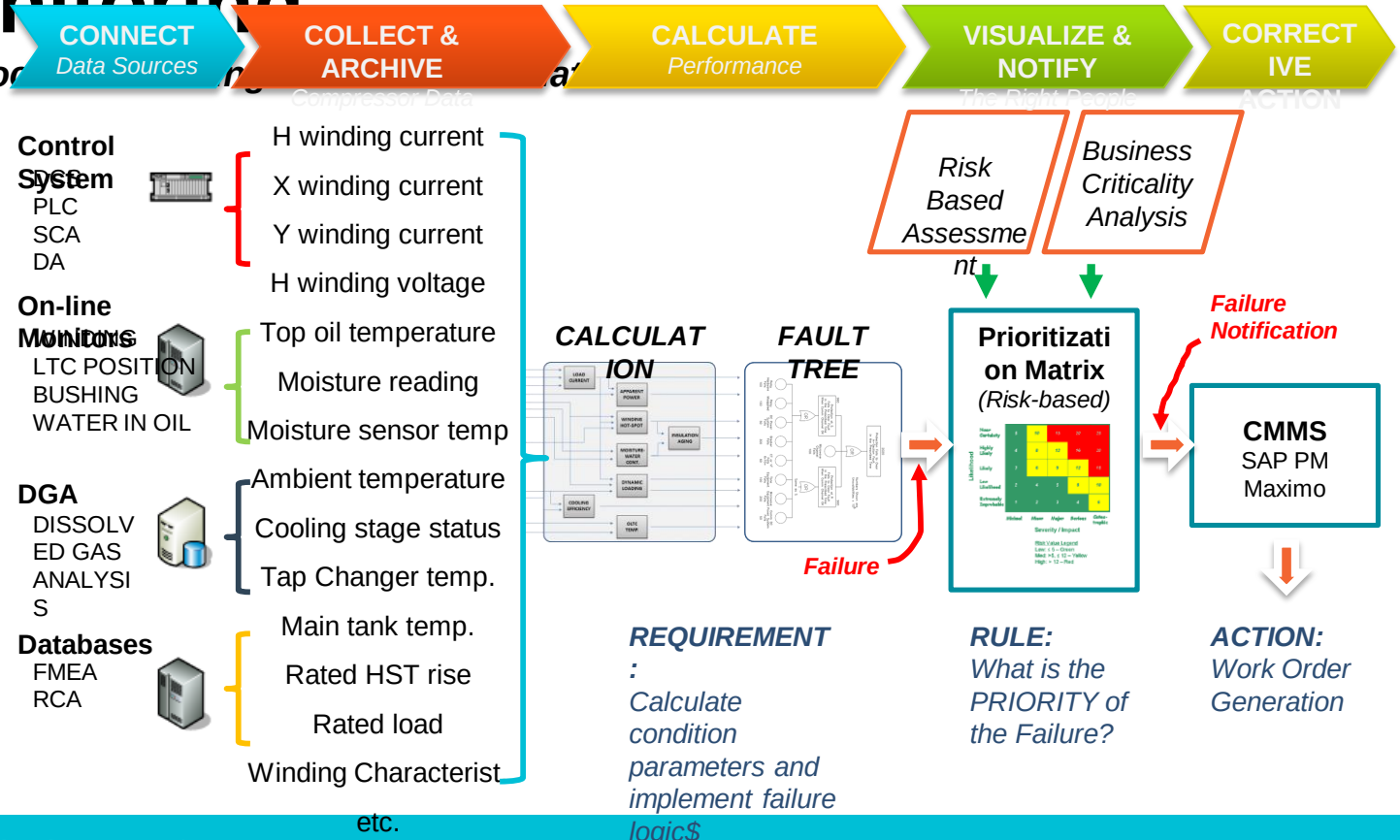
Top Event
FAILURE

Logic

Basic Event
SYMPTOM

Example: Transformer Condition Monitoring

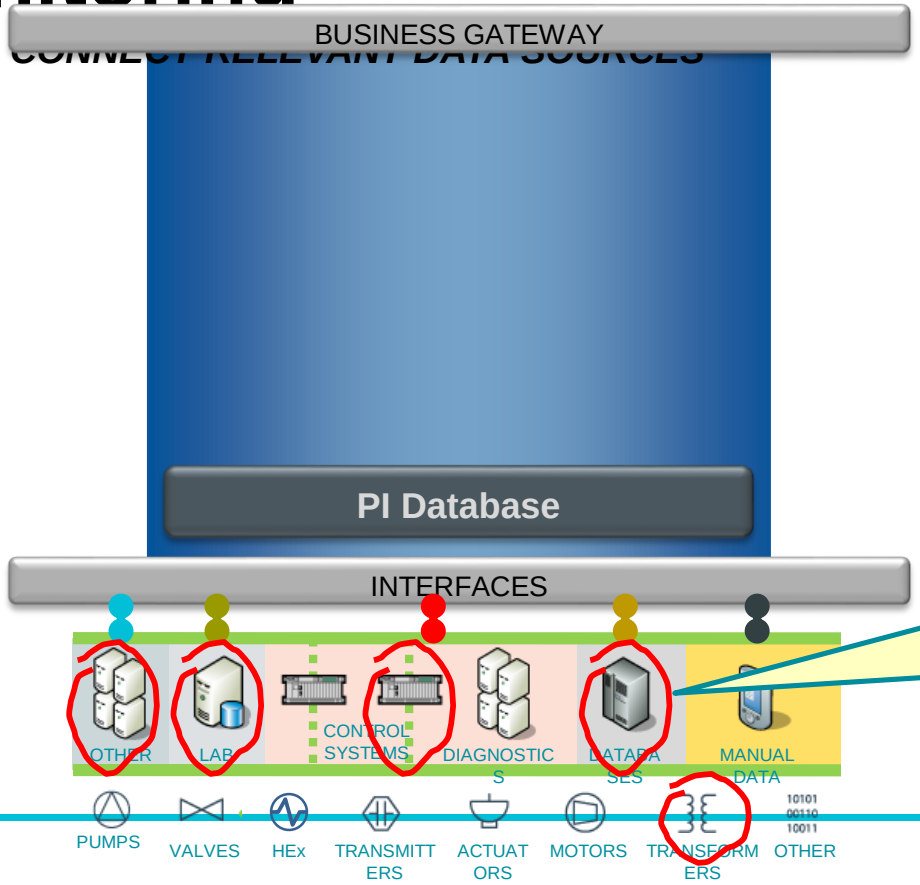
The proc… …g… …a…



Example: Transformer Condition Based Monitoring

STEP 1: CONNECT RELEVANT DATA SOURCES

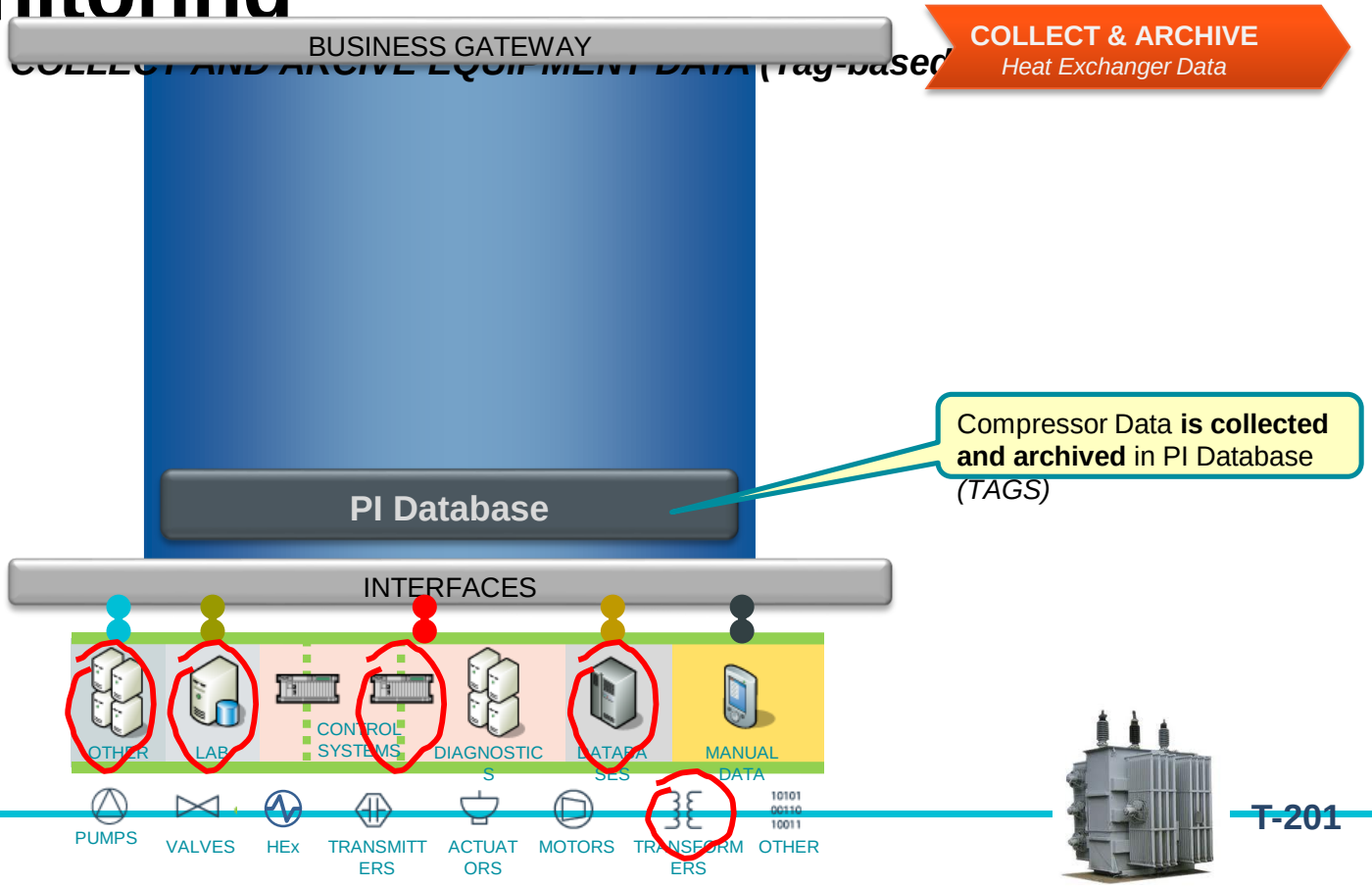
CONNECT
Data Sources



Transformer **Data appears in different systems** (data sources):
- Control System
- On-line Monitors
- DGA
- Databases

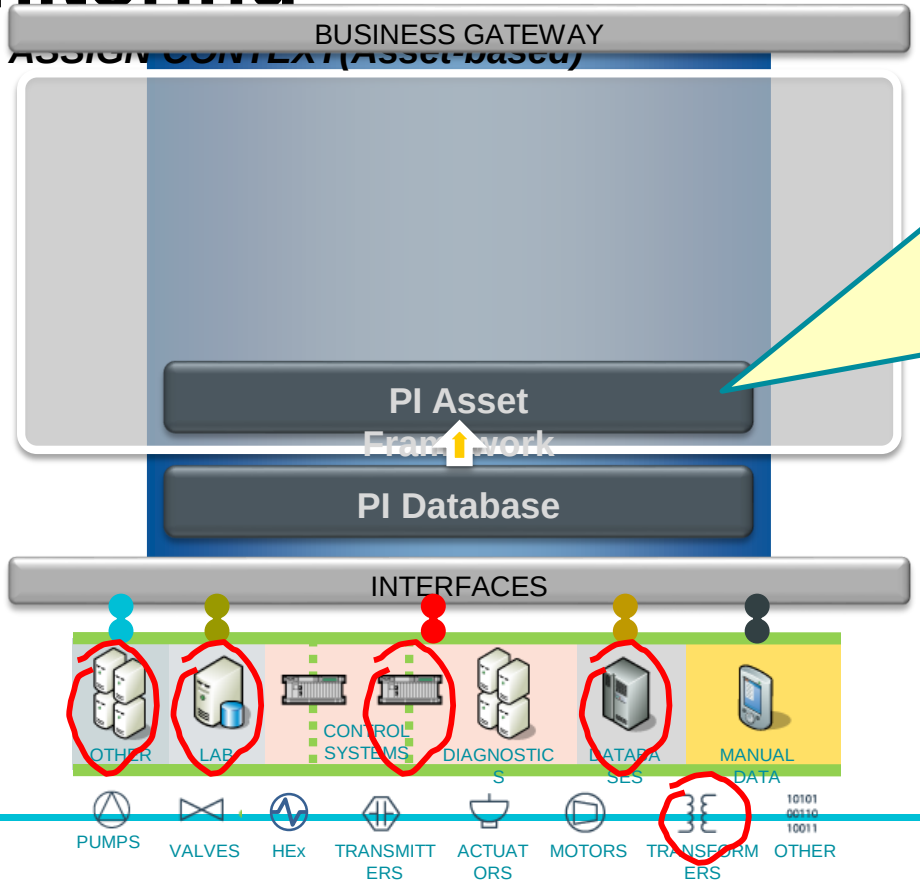
Example: Transformer Condition Monitoring

STEP 2: COLLECT AND ARCHIVE EQUIPMENT DATA (Tag-based)



Example: Transformer Condition Monitoring

STEP 3: ASSIGN CONTEXT (Asset-based)



COLLECT & ARCHIVE
Heat Exchanger Data

Data is assigned to an individual equipment (Transformer 201):

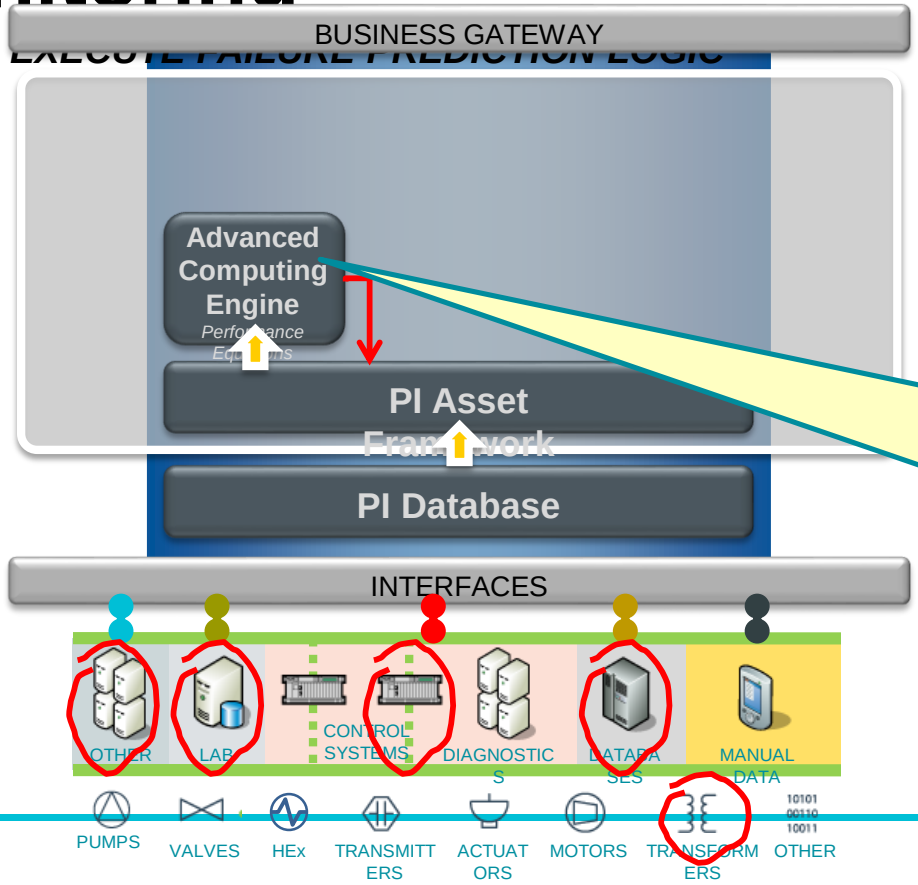
- **Asset-centric** representation of data. **Model driven** measurements
- Asset model complies with **IEC61970/68 CIM**
- Integration & synchronisation with SAP PI ture

T-201

T-201

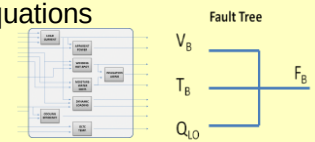
Example: Transformer Condition Monitoring

STEP 4: EXECUTE FAILURE PREDICTION LOGIC



CALCULATE *Performance*

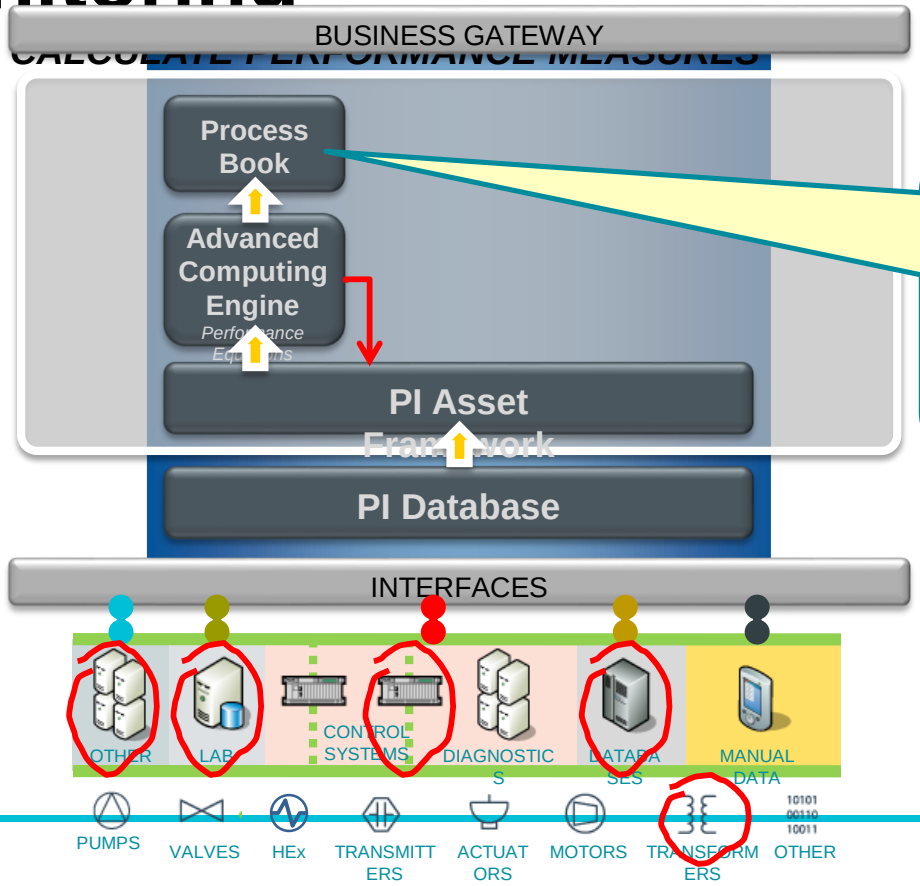
Calculation and Fault tree is implemented in Performance Equations



Failure is recorded in PI Database as Event (Abnormal Situation)

Example: Tramsformer Condition Monitoring

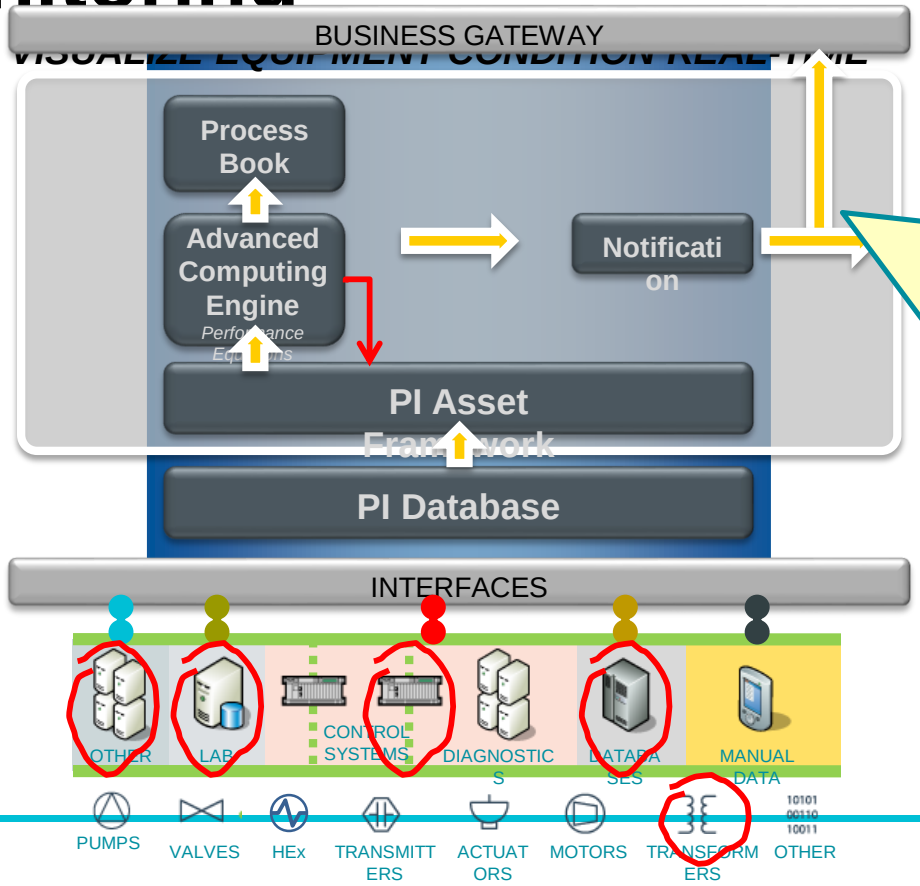
STEP 4: CALCULATE PERFORMANCE MEASURES



Trend and Visualize
Transformer condition

Example: Transformer Condition Monitoring

STEP 5: VISUALIZE EQUIPMENT CONDITION REAL-TIME

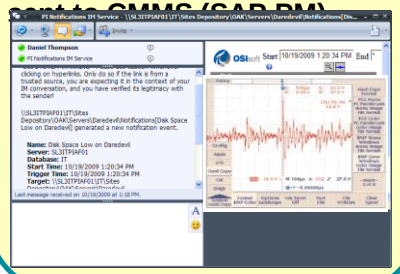


VISUALIZE & NOTIFY

The Right People

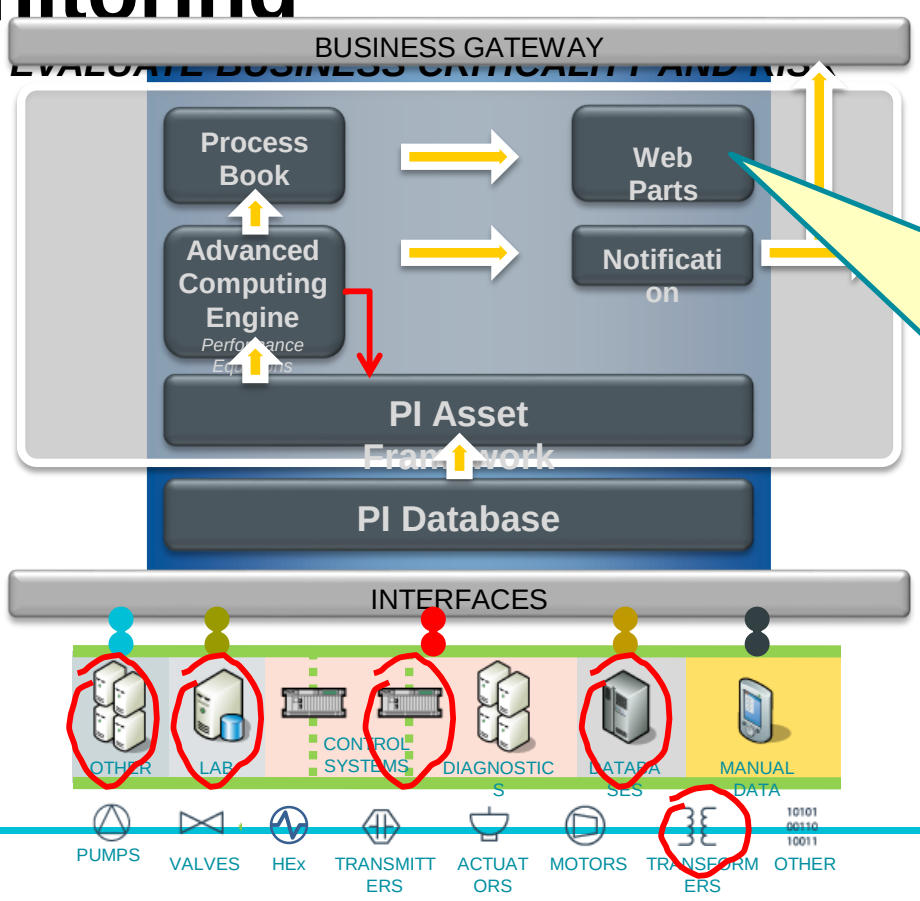
Notification is sent to shift operators and maintenance personnel, about:
TRANSFORMER LTCFAILURE

Maintenance Notification is sent to CMMS (SAP PM)



Example: Transformer Condition Monitoring

STEP 6: EVALUATE BUSINESS CRITICALITY AND RIS



VISUALIZE & NOTIFY

The Right People

Visualize maintenance priority matrix