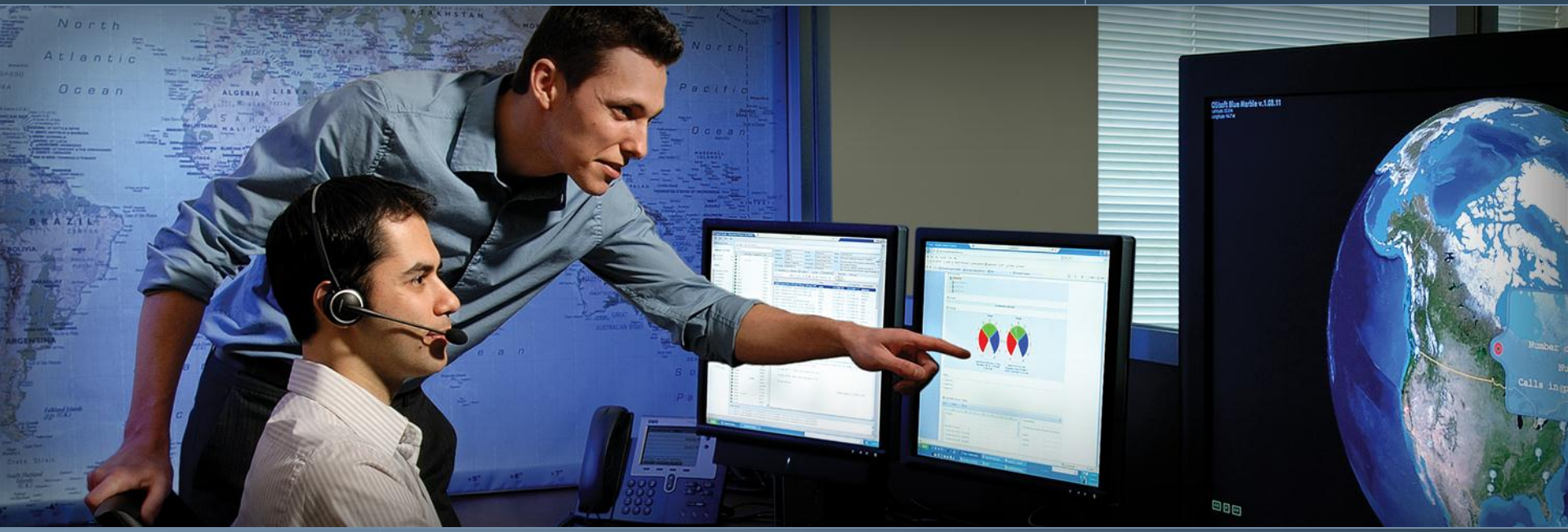
Regional Seminar
Boston



Condition-Based Maintenance (CBM) – PSE&G Case Study

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OSIsoft

November 2010

Empowering Business in Real Time.

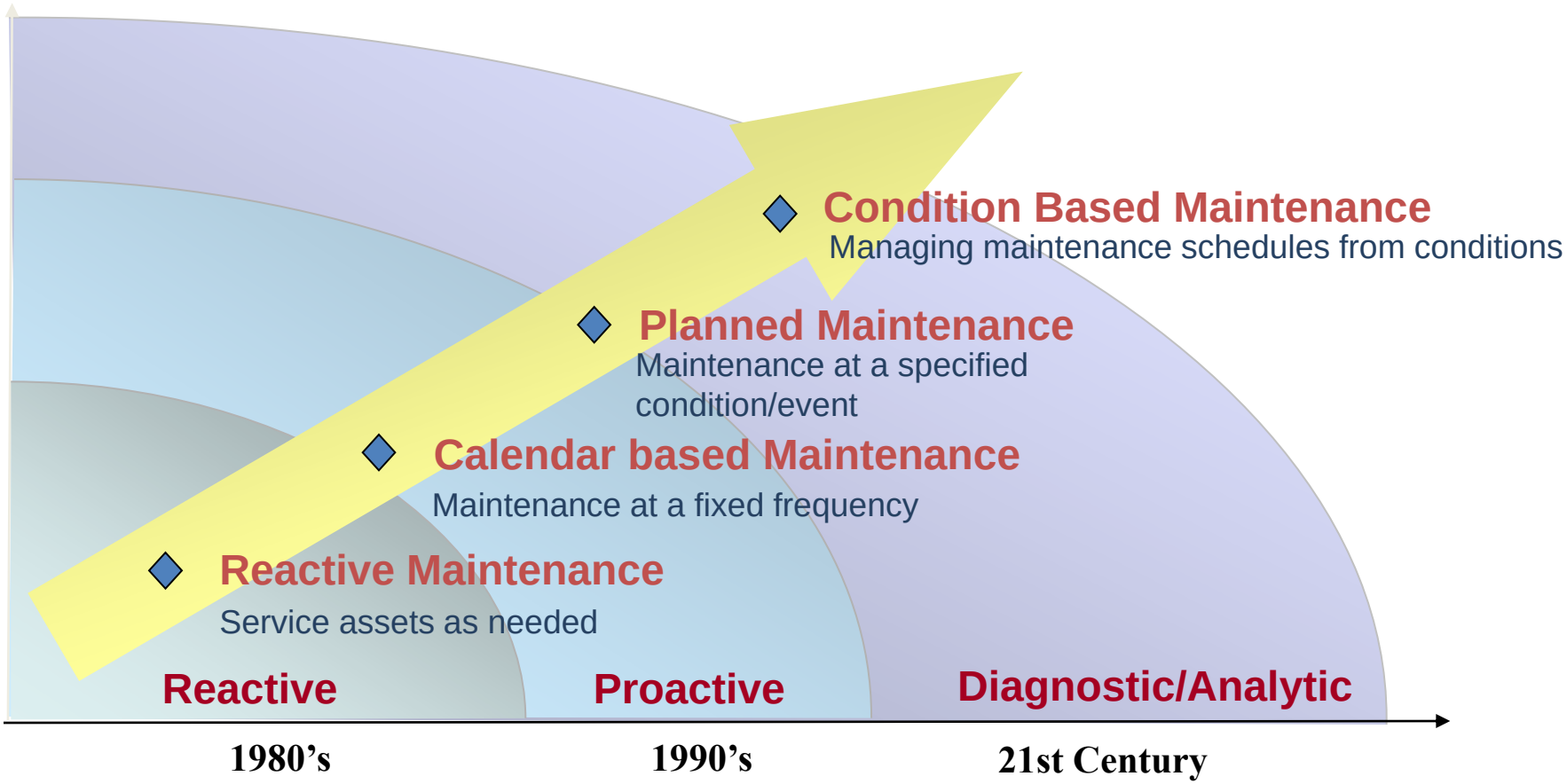
AGENDA

- CBM Background
- PSE&G Overview
- Motivating Factors & Background
- System Overview
- Condition Assessment
- Benefits
- Q&A

Condition-Based Maintenance

Definitions

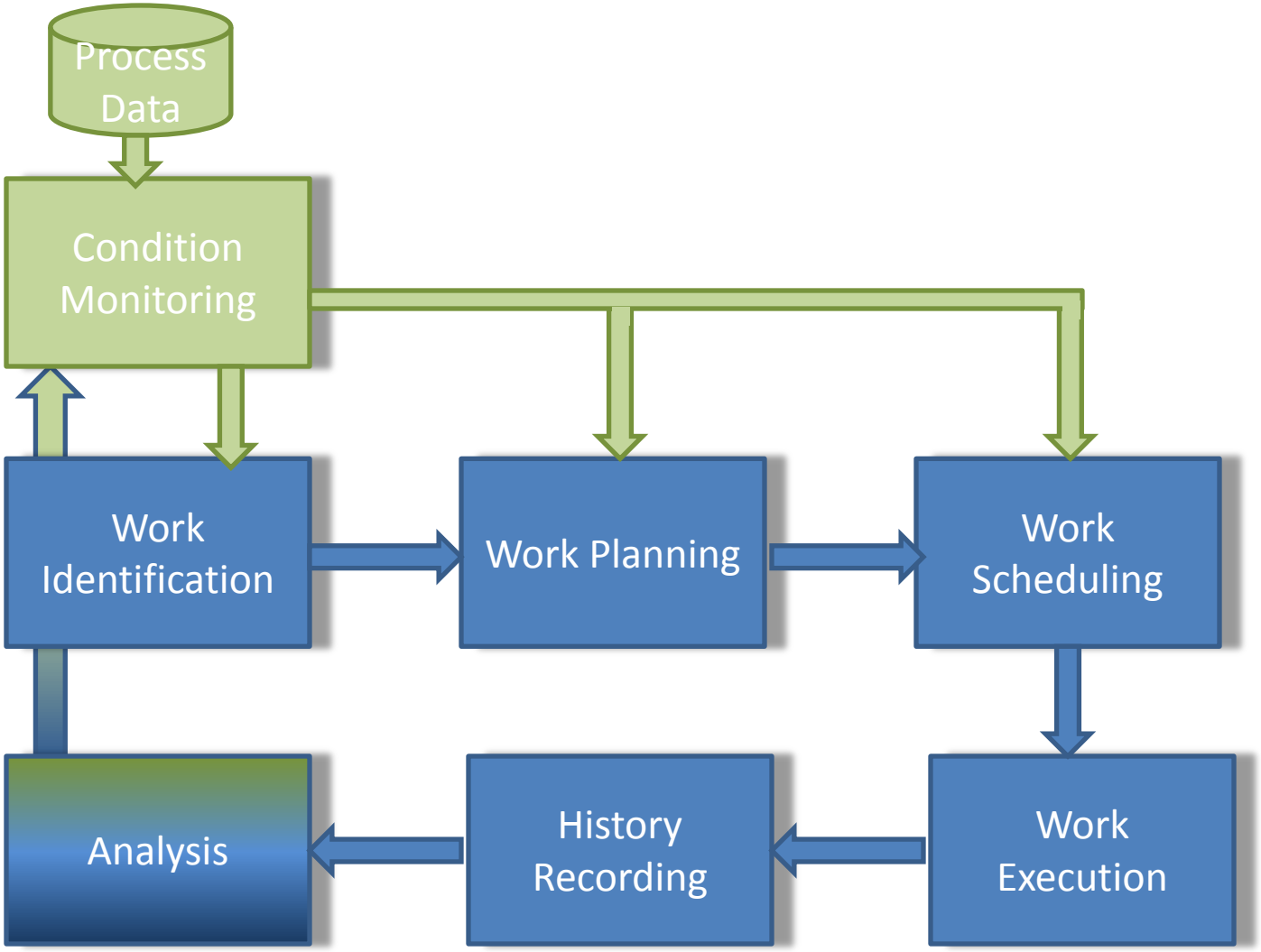
Maintenance Evolution - Reliability



Terms & Definitions

- Predictive Maintenance (PdM)- using a parameter to determine when an asset may fail
- Condition Monitoring (CM) – using a parameter or information about an asset to determine its condition (in regard to that specific parameter)
- Condition-Based Maintenance (CBM)- determining maintenance schedules based on condition type indicators
- Model-Driven Monitoring – based on optimal model for current conditions.
- Reliability Centered Maintenance (RCM) –includes processes to ensure assets perform as required – may involve all of the above plus ancillary functions (training, parts, etc.)

CBM & Maintenance Process



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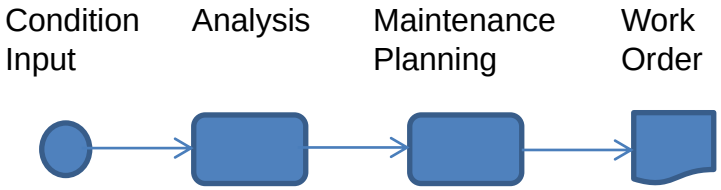
Condition-Based Maintenance (CBM)

- Maintenance Plan Fundamentals
  - Quantitative
  - Qualitative

- Requirements
  - Indicative Data
  - Integration with Work Management



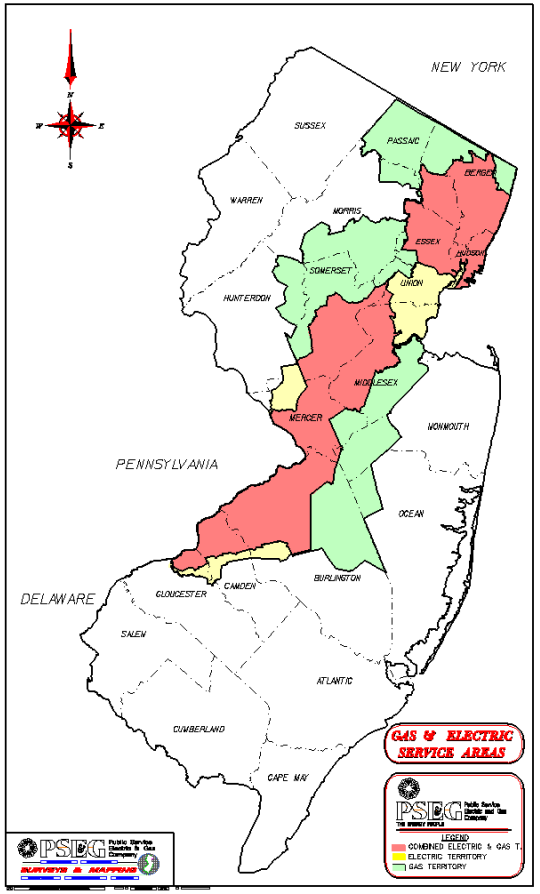
- Implementation Lifecycle
  - It's a journey – very easy to start small
  - Motivate Key Personnel
  - Change Management

PSE&G Customer Case Study

Condition-Based Maintenance at an Electric Utility

PSE&G

- Utility Overview
  - New Jersey Based
  - Total Assets ~ $14 Billion
  - Total Revenue ~ $7 Billion
- Service Territory
  - 70% of New Jersey's population
  - 2.0 million Electric customers
  - 1.6 million Gas customers
  - 2,600 Square Miles
- Delivery Implementation
  - 1999 – SAP
  - 2000 - OMS, GIS & CAD
  - 2002 - CMMS



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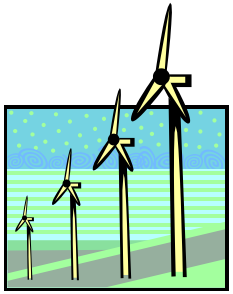
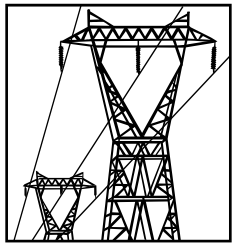
CBM Scope

- Focused on the electrical transmission and distribution (T&D) arm of the Delivery Organization
- Primary assets are large transformers and breakers

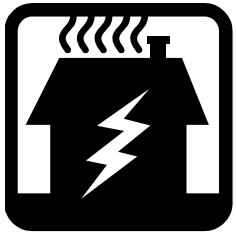


Generation

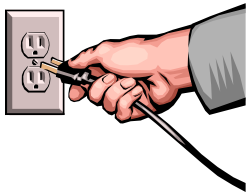


Transmission

Distribution



Household



Outlet

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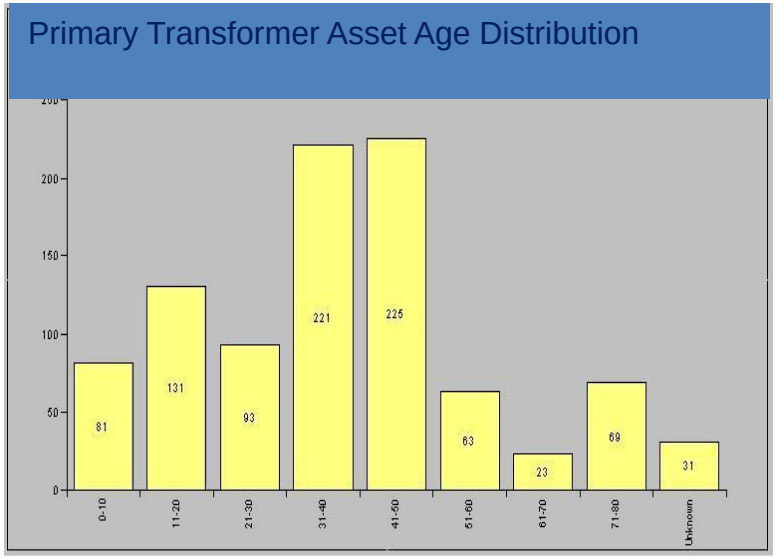
Business Challenge / Problems Addressed

Business Challenges

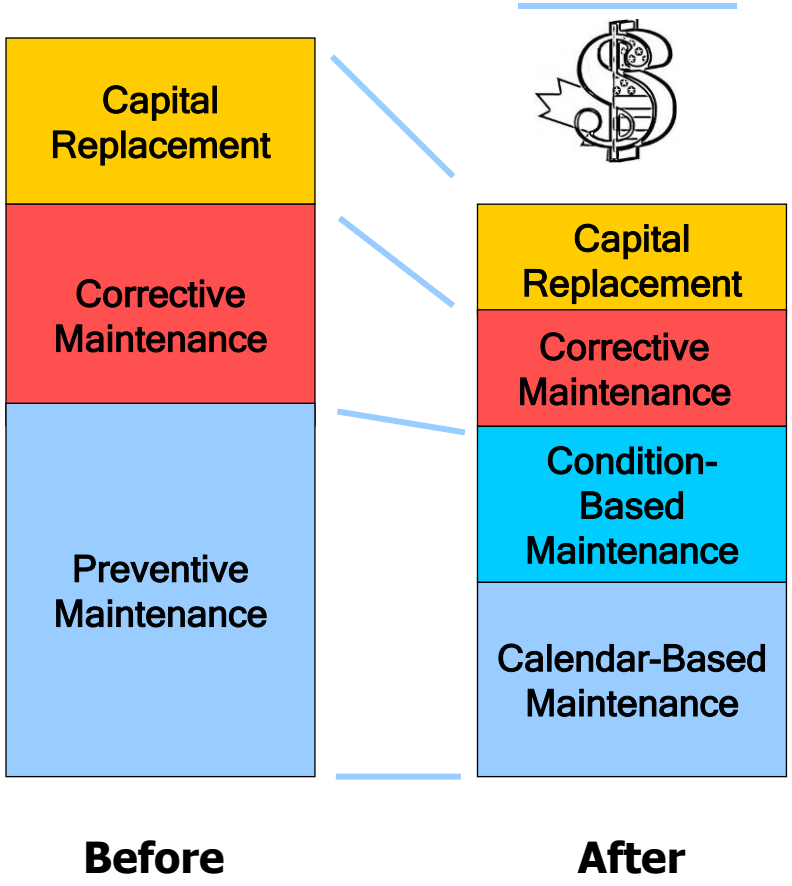
- Significant risk of system outage potential from old equipment vulnerable to failure
- No formal capital expenditure determination plan
- No formal preventive maintenance scheduling program



- Expensive Replacement Projects
- Loss of Expertise
- After an equipment failure, sufficient data collected to determine why - Asset Information in a variety of disparate systems
- Lots of features & functions in SAP PM
- Upgrades & Enhancements in Work Management, Outage Management, Distribution Operations, etc.

Business Targets

- Reduce risks of business interruption
  - Fewer outages
  - Fewer induced errors
  - More focused work effort
- Condition-based maintenance (CBM)
  - Less PM, Less CM
  - More targeted Capital Expenditures
- Work prioritization
  - Focus on the assets in the most need and the most critical
- Capital replacement strategies
  - Target worst performing assets
- Data/information organization and visualization
  - Faster issue resolution
  - Root cause failure analysis
- Platform to support decision support solutions based on the assets and available data
  - Circuit analysis
  - Grid conservation



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Project Success Factors

- Determination of health indicator to focus asset management activities
  - Determine condition health indicators – use existing information
  - Normalize indicator across asset type and family
- Provide an analysis platform for engineering activities
  - Integrate data from various disparate systems
  - Simple, consistent tools for analysis
- Perform condition-based maintenance
  - Visualize condition health
  - Integrate with SAP PM
- ROI in < 3 years

Project Scope

- Asset Scope - T&D Substation
  - Transformers
  - Breakers
  - Related Equipment (Compressors, LTC, etc.)
- Work Process Scope
  - Substation Inspections
  - Diagnostic Data Collection
  - Preventive Maintenance Prioritization
  - Asset Health Review
  - Capital Replacement Determination

Technical Components

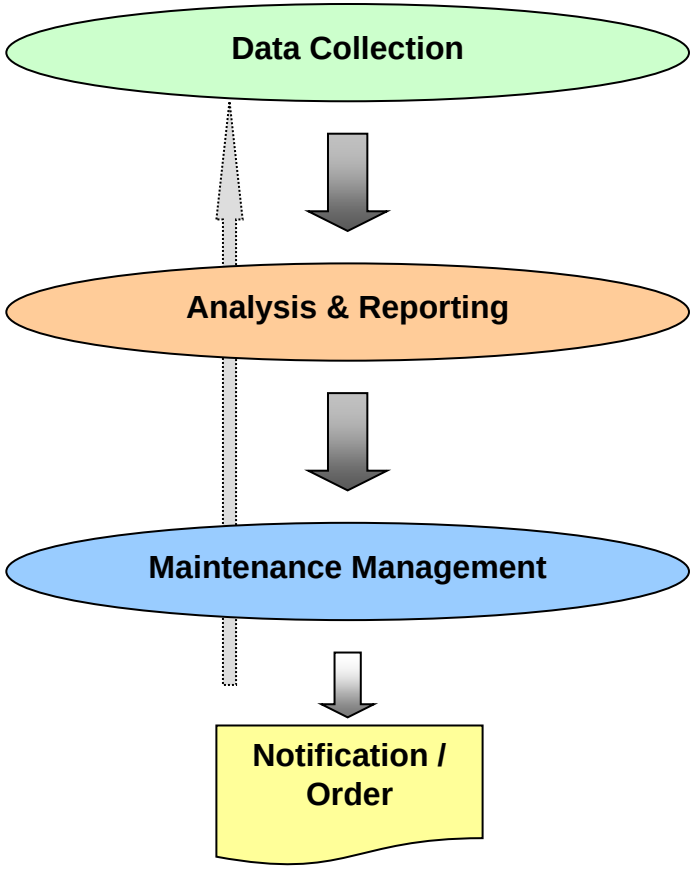
- System Interfaces
  - SAP PM historical data
  - SAP PM measurement documents (RLINK)
  - Transmission SCADA (PI-to-PI)
  - Distribution SCADA (ETL & PI BatchFile)
  - MV-90 Load Monitoring (ETL & PI BatchFile)
  - Lab Systems – DeltaX & Doble (ETL & PI BatchFile)
- Condition Assessment
  - Equation Builder
  - Diagnostic Displays

Condition-Based Maintenance

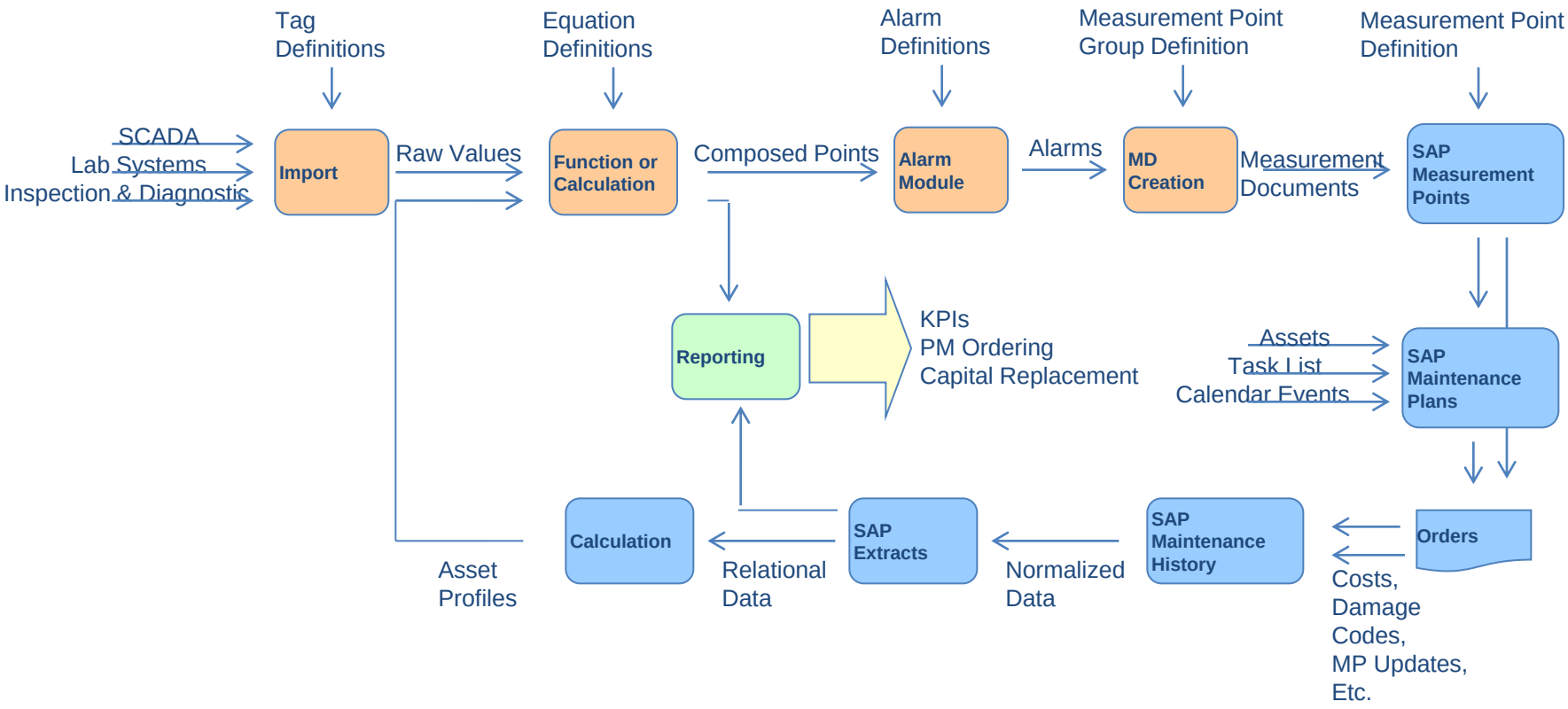
System Overview

Functional Areas

- Data Collection
  - SAP Asset Information
  - Time-Series Data Collection Application
  - Diagnostic and Inspection Data
- Asset Analysis and Reporting
  - Condition Assessment
  - Work Prioritization
  - Alerts / Notifications
- Maintenance Management
  - Measurement Points
  - Maintenance Plan Modifications
  - Notifications



System Model



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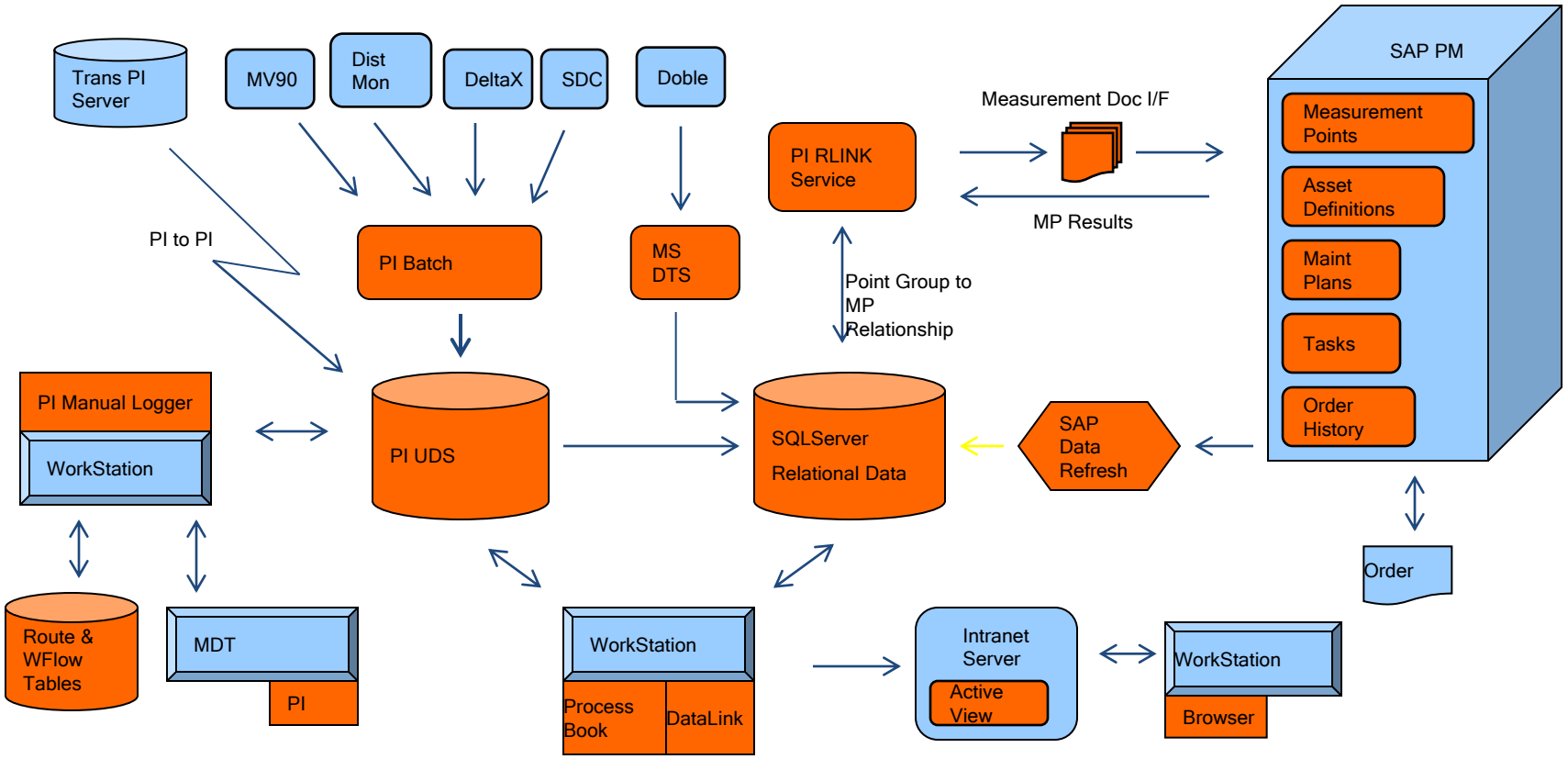
Conceptual Design



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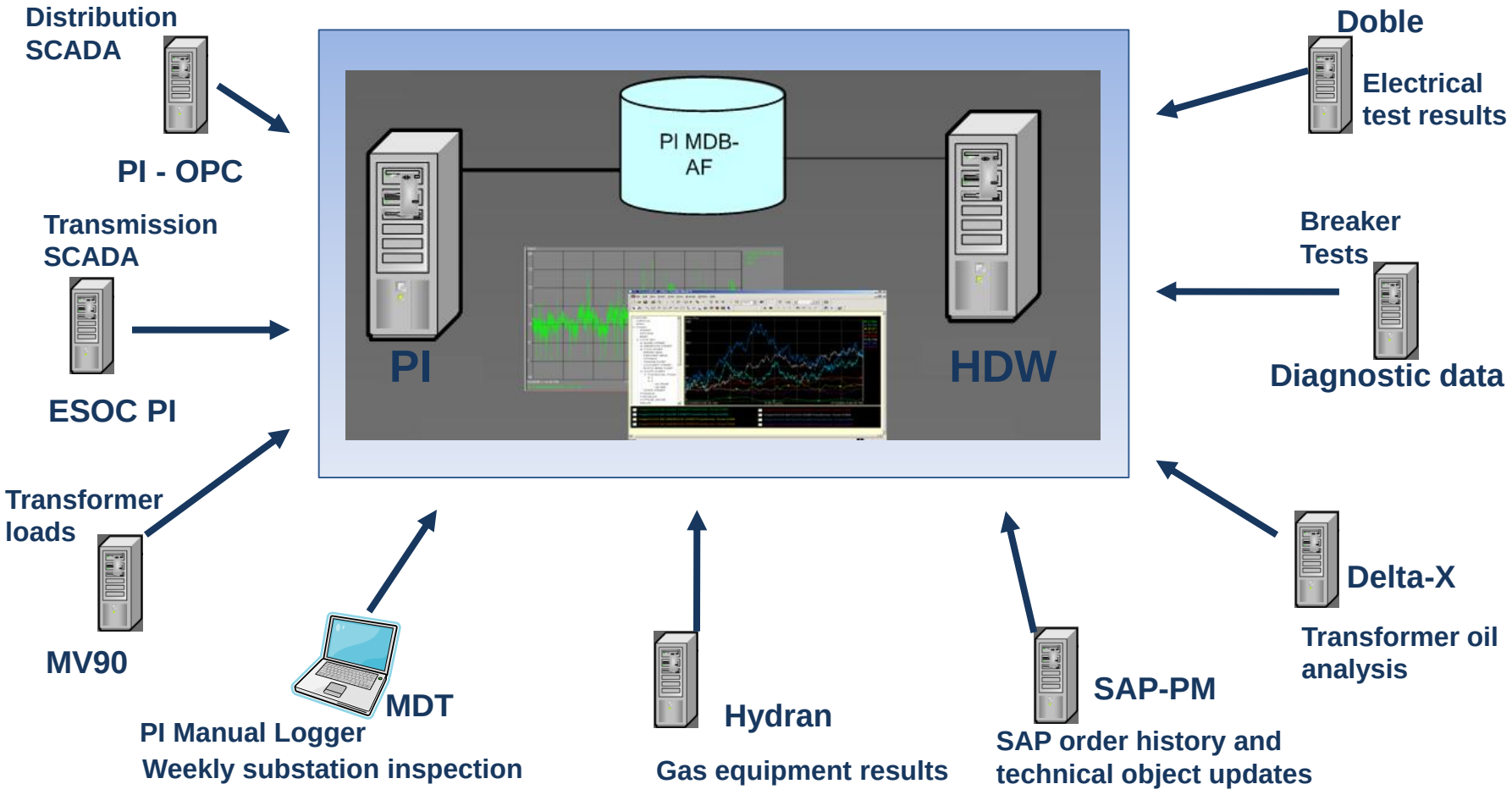
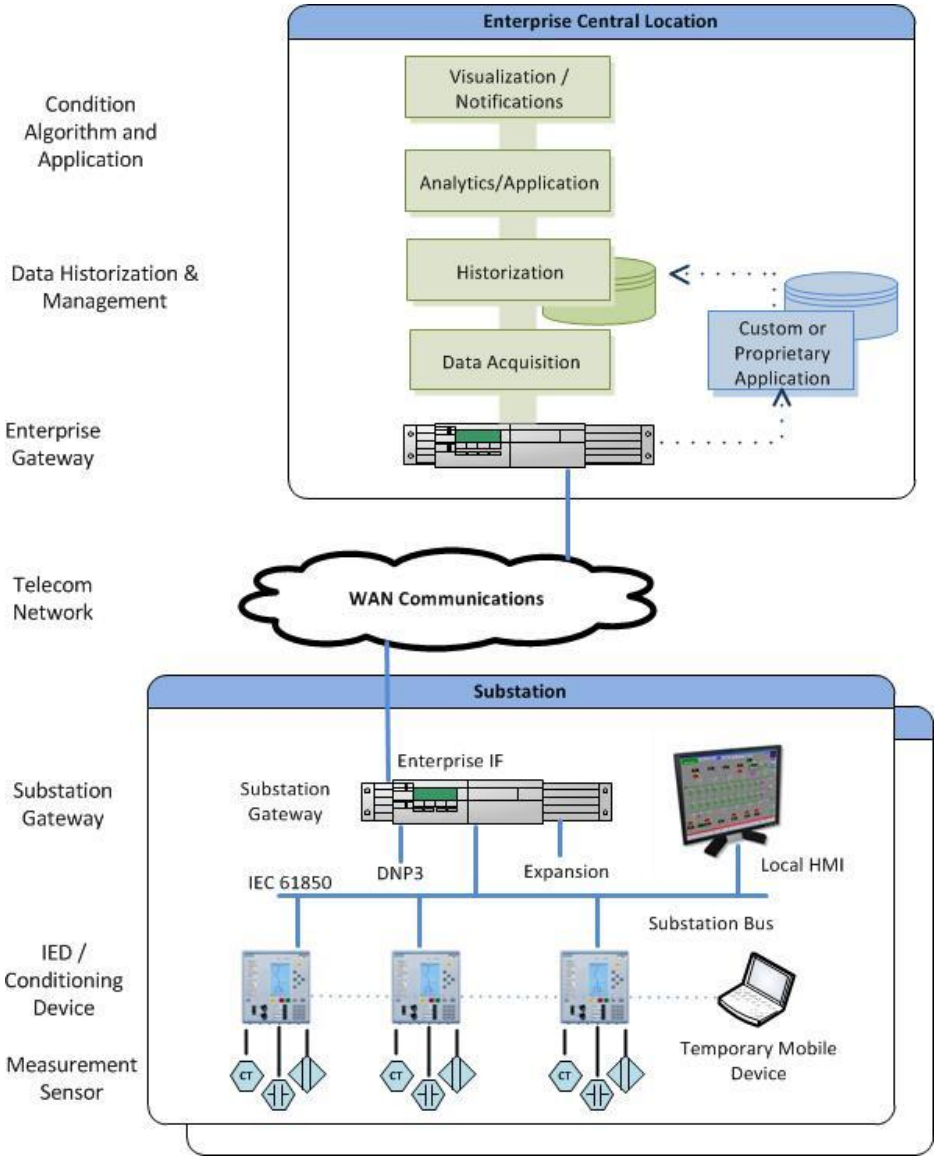
System Integration



More Modern Substation



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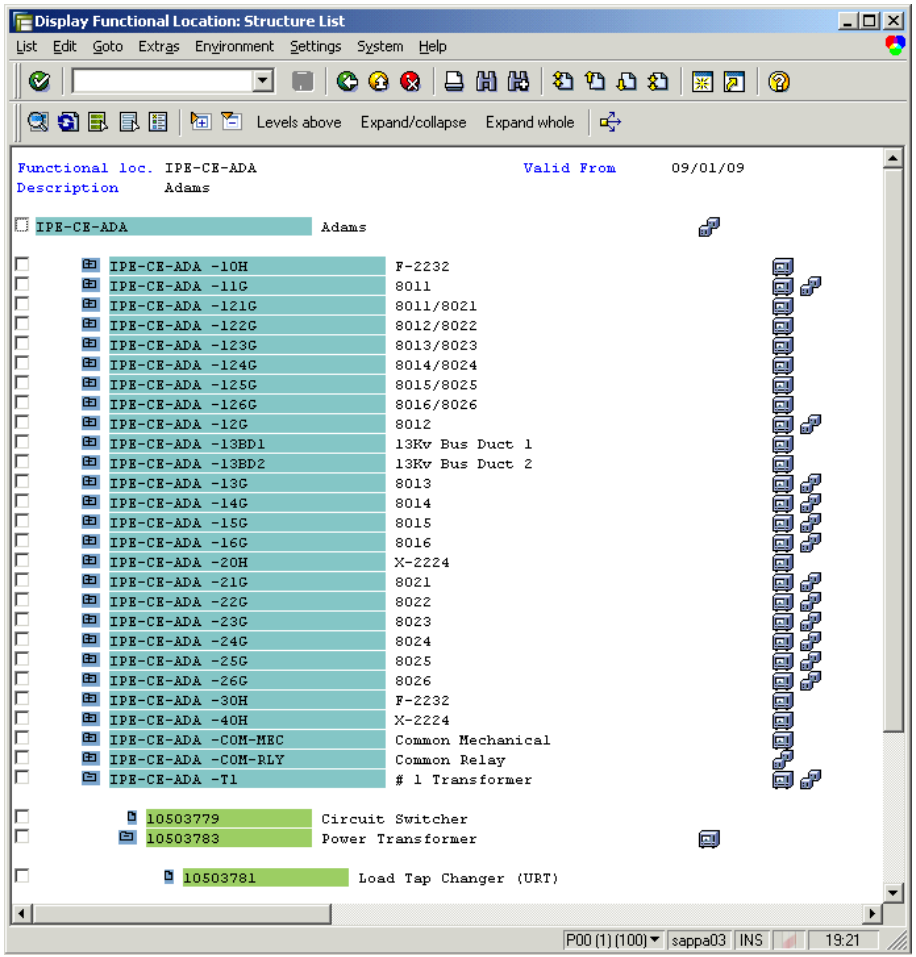
SAP PM for PSE&G Electric Delivery

- Equipment & Locations
  - Class and Characteristics
  - Nameplate
- Maintenance Plans (56k Plans)
  - Calendar-based
  - Counter-based
  - Condition-based
- Notifications
  - Damage and Cause Codes grouped by Equipment
- Equipment Visibility
  - PM Plan Cost/Hours vs. Actual
  - CM Cost



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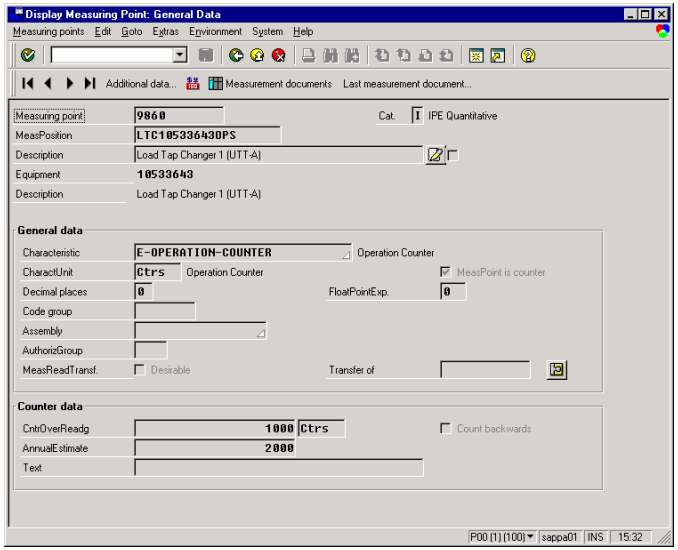
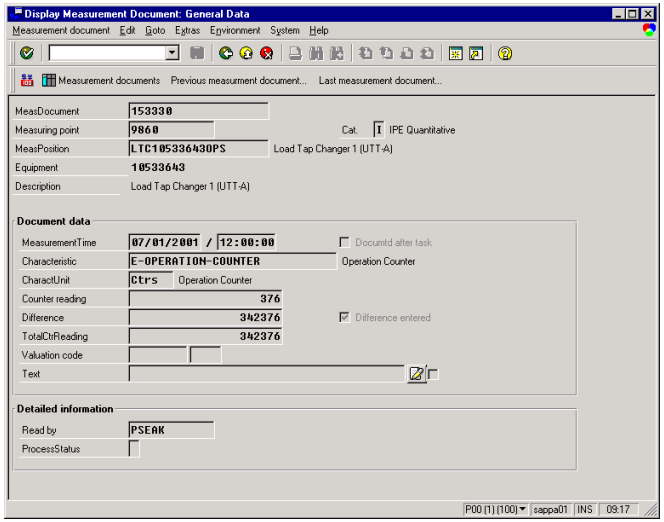
Measurement Points

- Measurement Point Types
  - Qualitative (“Real Hot”)
  - Quantitative (> 220°F)
- Measurement Document
  - Absolute vs. Differential
  - Notification Generation
- Functional Uses
  - Counter Readings
  - LTC Movements
  - Runtime Hours
  - Breaker not operating
  - LTC not crossing neutral
  - Rate of Change





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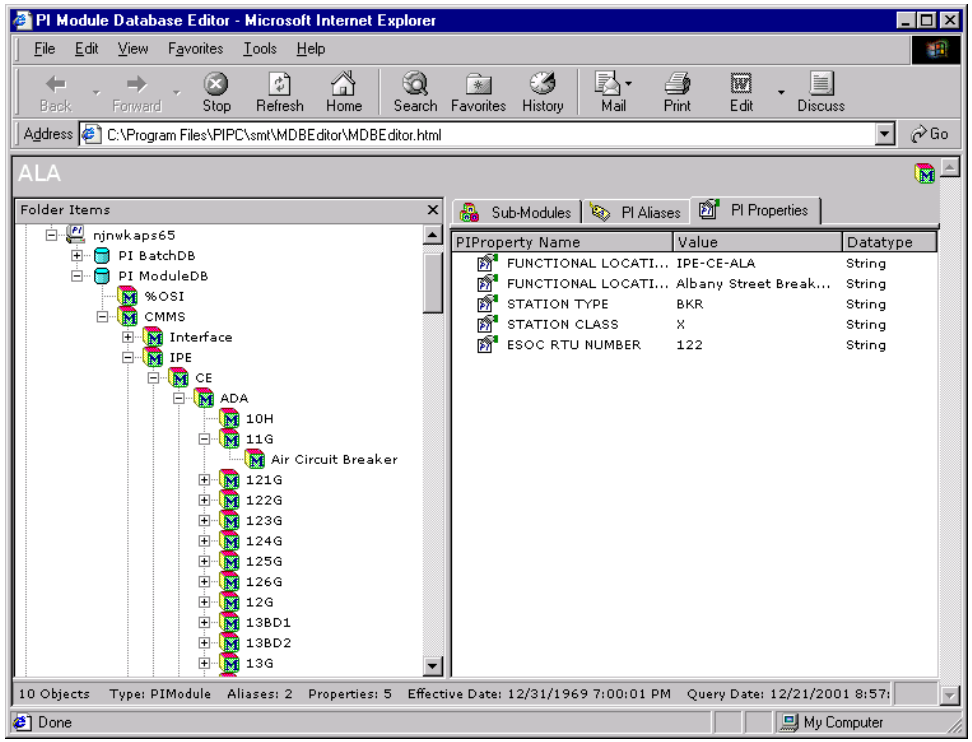
PI AF/MDB Definitions

- Define Module Taxonomy
  - Define Hierarchies
  - Each level has a parent-child relationship
  - Any module can appear many times in the hierarchy
  - Load the hierarchies
  - Provides context to displays and data



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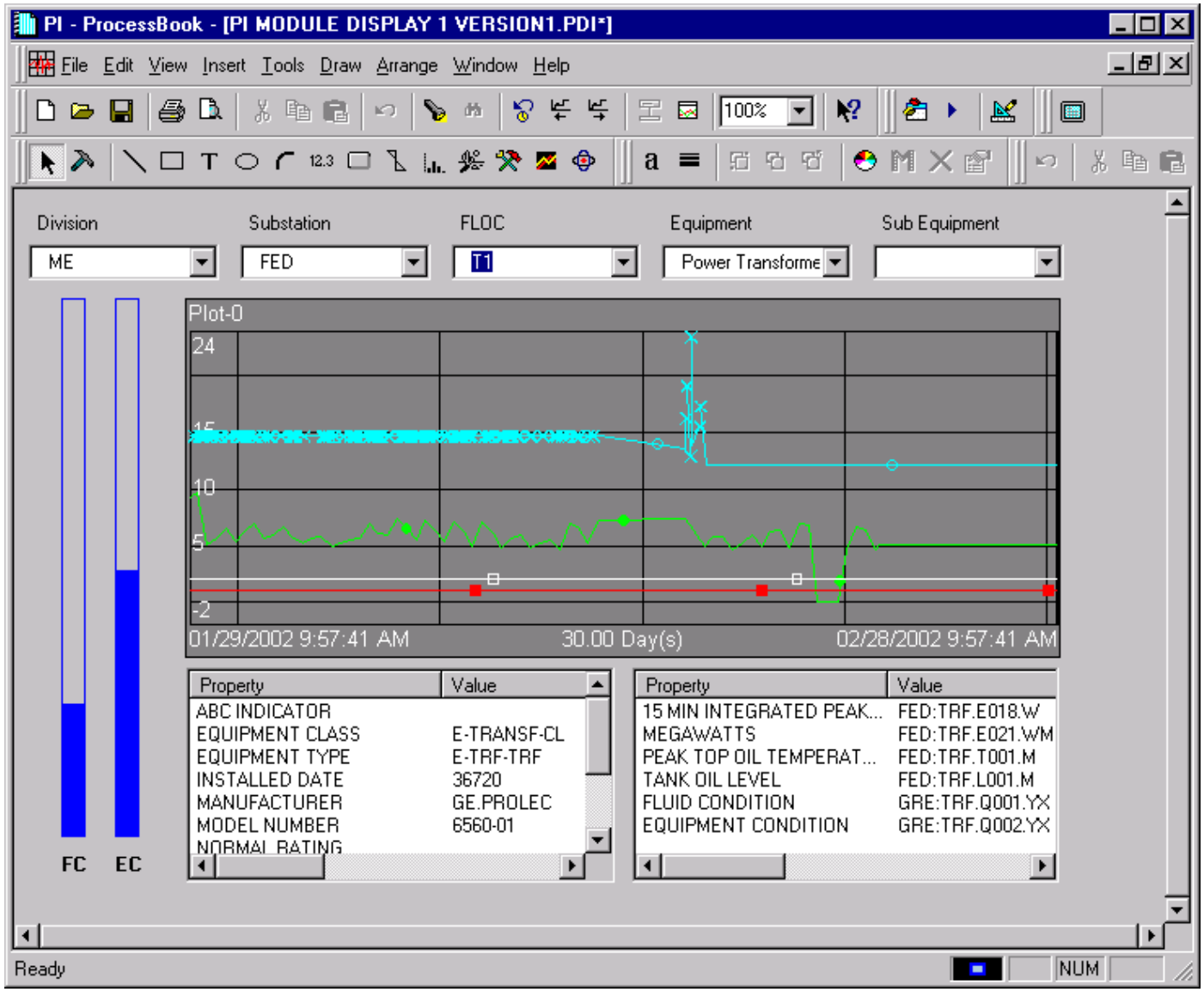
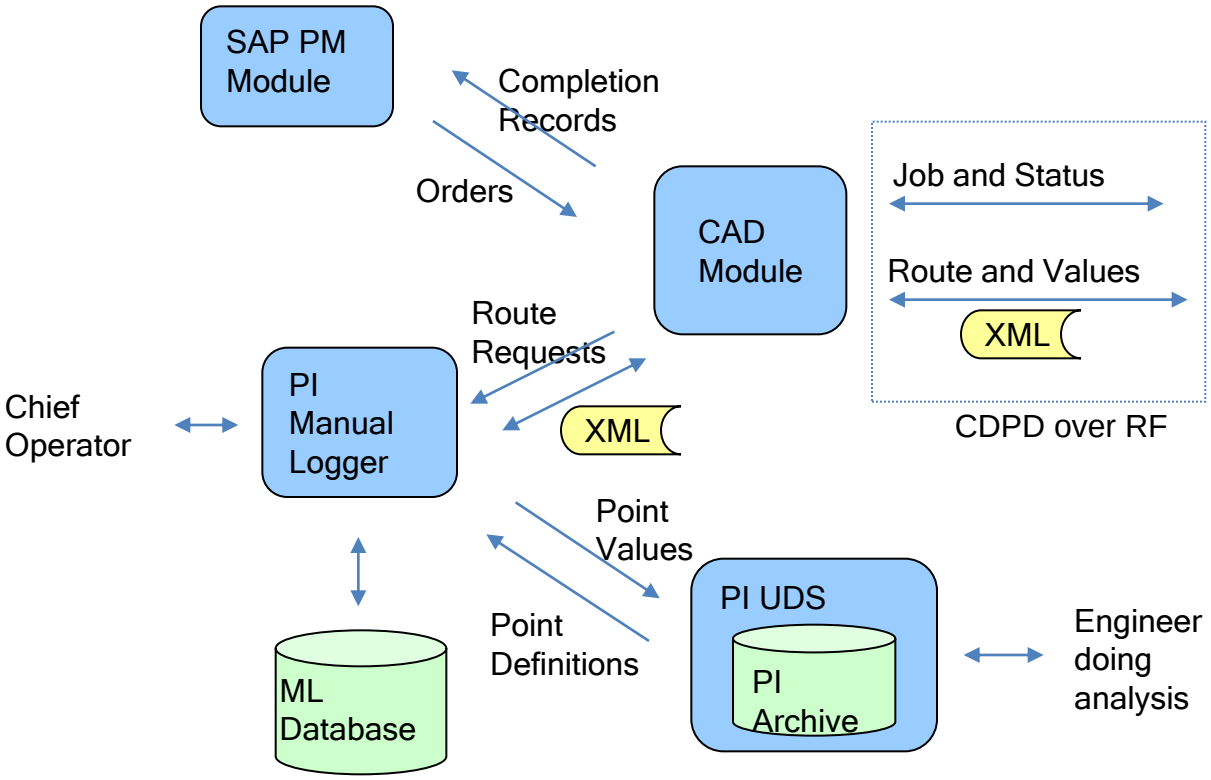
PI MDB Enabled Displays



PI Manual Logger

- Substation Inspections
- 300 Substations – Weekly and Peak Inspections
- 20 – 500 points per station
- Scheduled in SAP PM
- Dispatched using CAD Dispatch over RF and CDPD
- XML file transfers of tour definition and data
- Equipment Oriented Point Collection

Inspection Design Overview



1. Create SAP Order
2. Create CAD job
3. Get PI-ML Tour
4. Send Job to MDT
5. Accept Job
6. Send Tour
7. Conduct Tour
8. Send Tour to CAD
9. Complete order in SAP
10. Send Tour to PI-ML
11. Update PI UDS

PSE&G Customer Case Study

Condition Assessment Overview

Calculation Structure

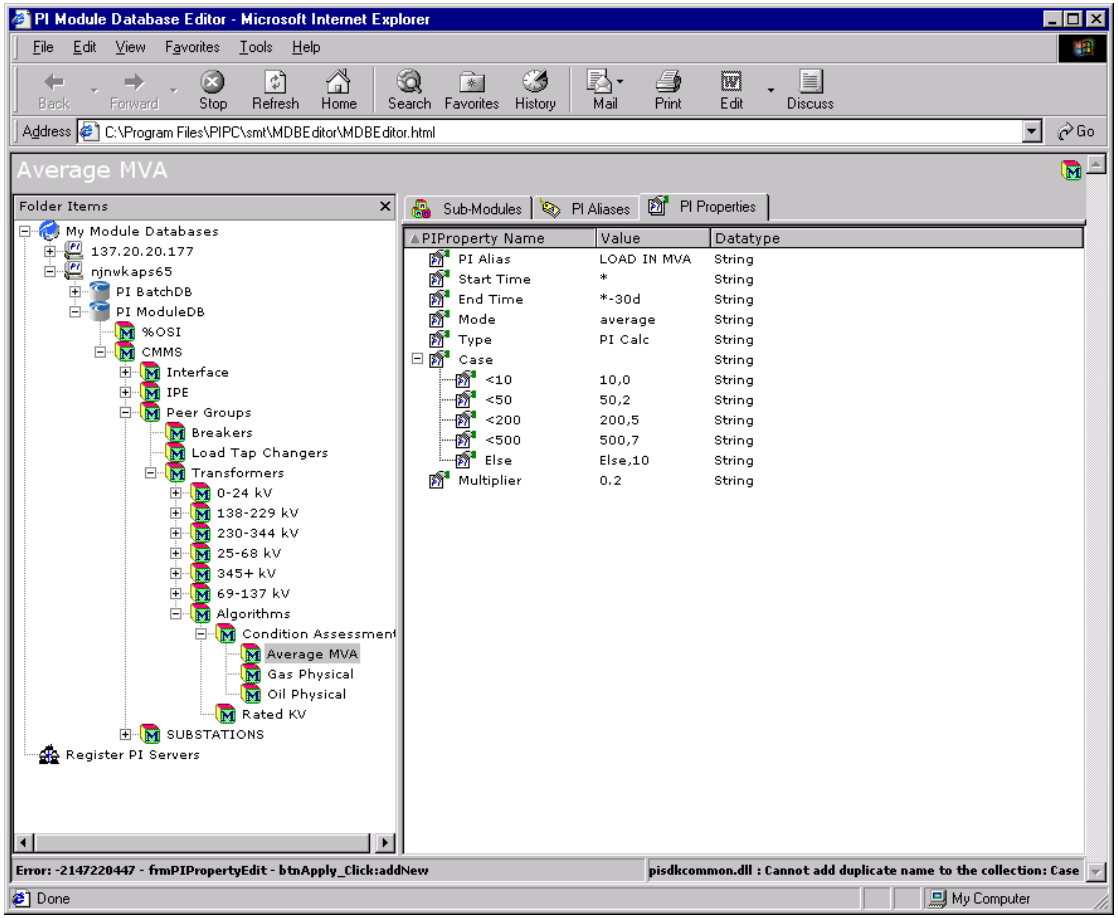
- Equations
  - $CA = F_1(M_1) + F_2(M_2) + F_3(M_3) + \ldots$
- Example factor types include:
  - Average Load over time period
  - Last oil test results (SQL Query)
  - Maintenance cost data
  - Number of operations
- Factor components dependent on peer group
  - Apply calculations by peer group
  - Voltage, Class, Type
  - Example Groups:
    - 26KV – 69KV GCB
    - 138KV+ Power Transformer
    - LTC Vacuum Tanks

Condition Structure & Maintenance

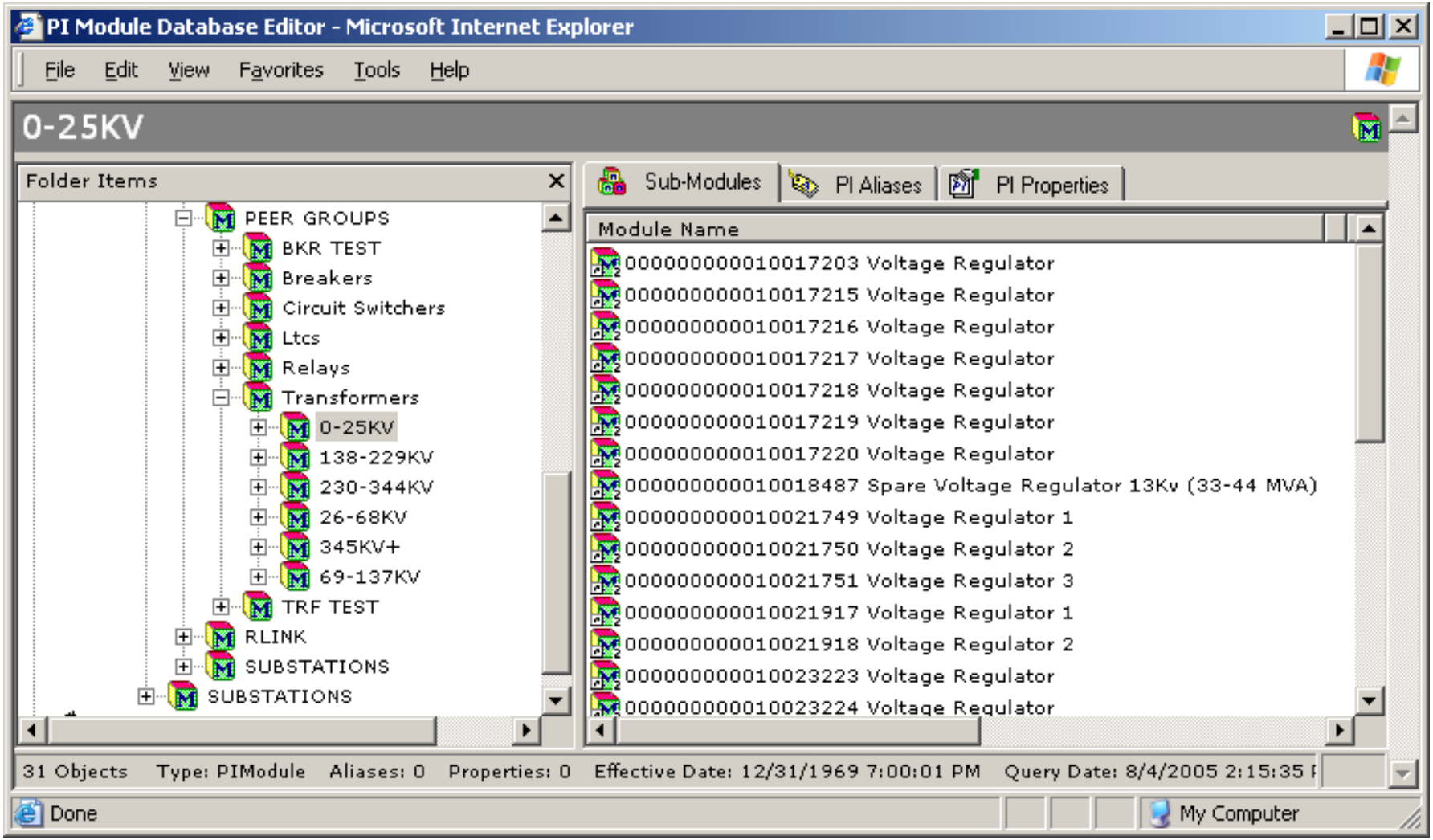
- Use of PI Module DataBase (MDB/AF)
  - Module for each level of the SAP PM hierarchy and installed functional locations and equipment
  - Defined peer groups and installed equipment modules
  - Defined factor types and equation groups
  - Created Module for each equation and for each equation factor
  - Developed displays using PI Module Database

Factor Example

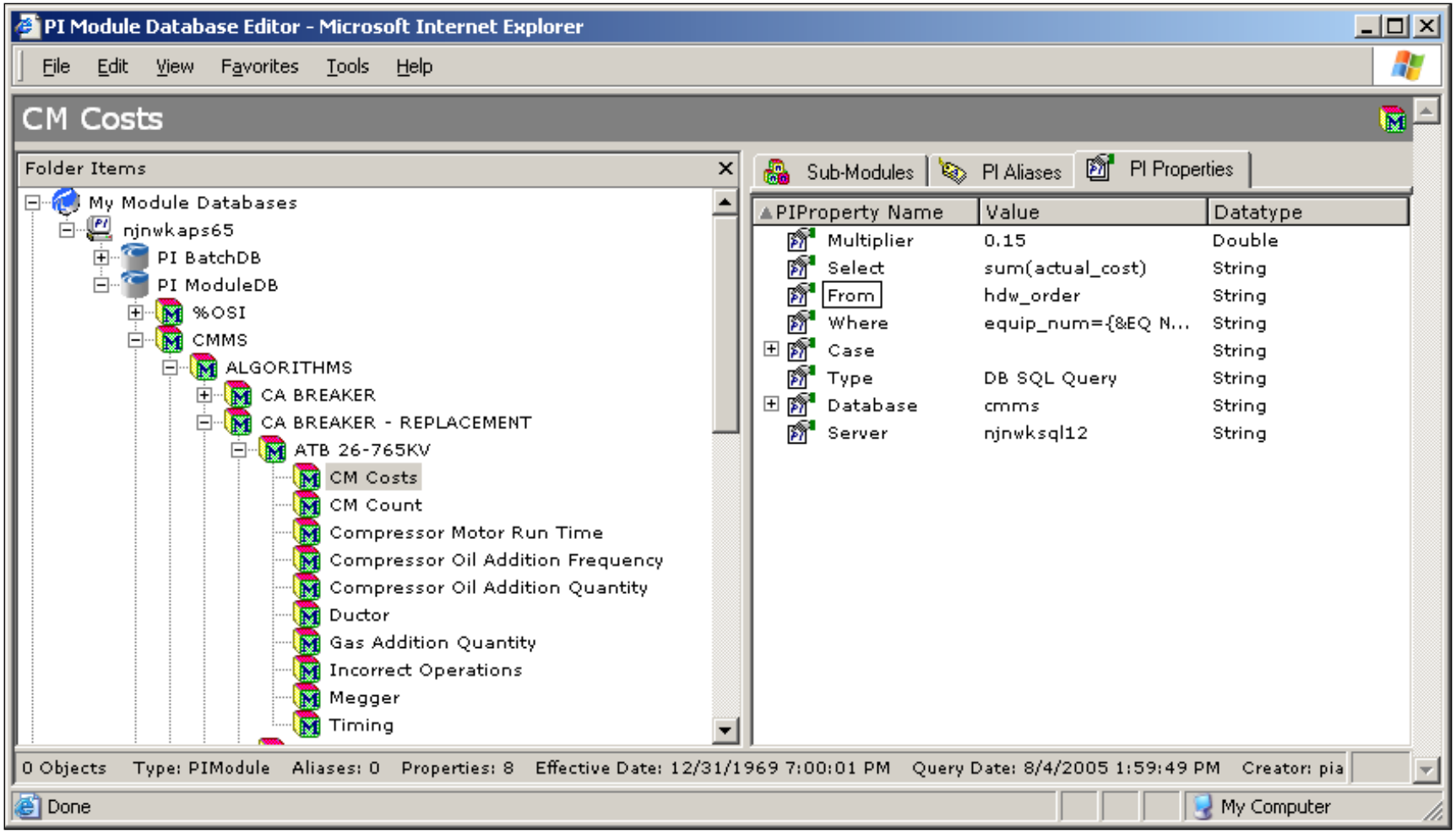
- Average MVA (load) factor
  - Type: PI Calc
  - Alias: Load in MVA
  - Start Time = *
  - End Time = *-30d
  - Mode: Average
  - Case: Assign value to factor
  - Multiplier = 0.2



Assets in PI



Calculation Models in PI



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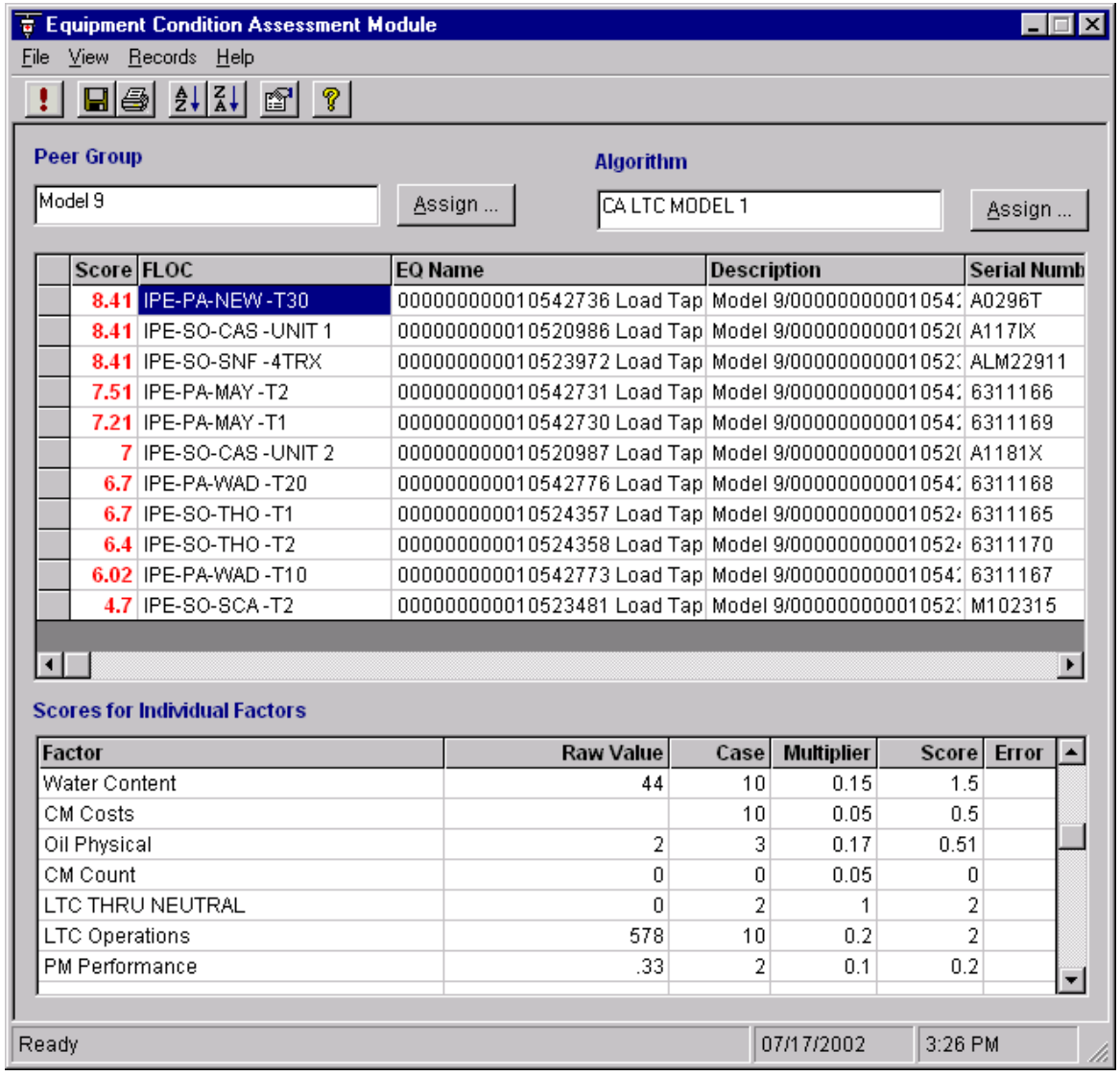
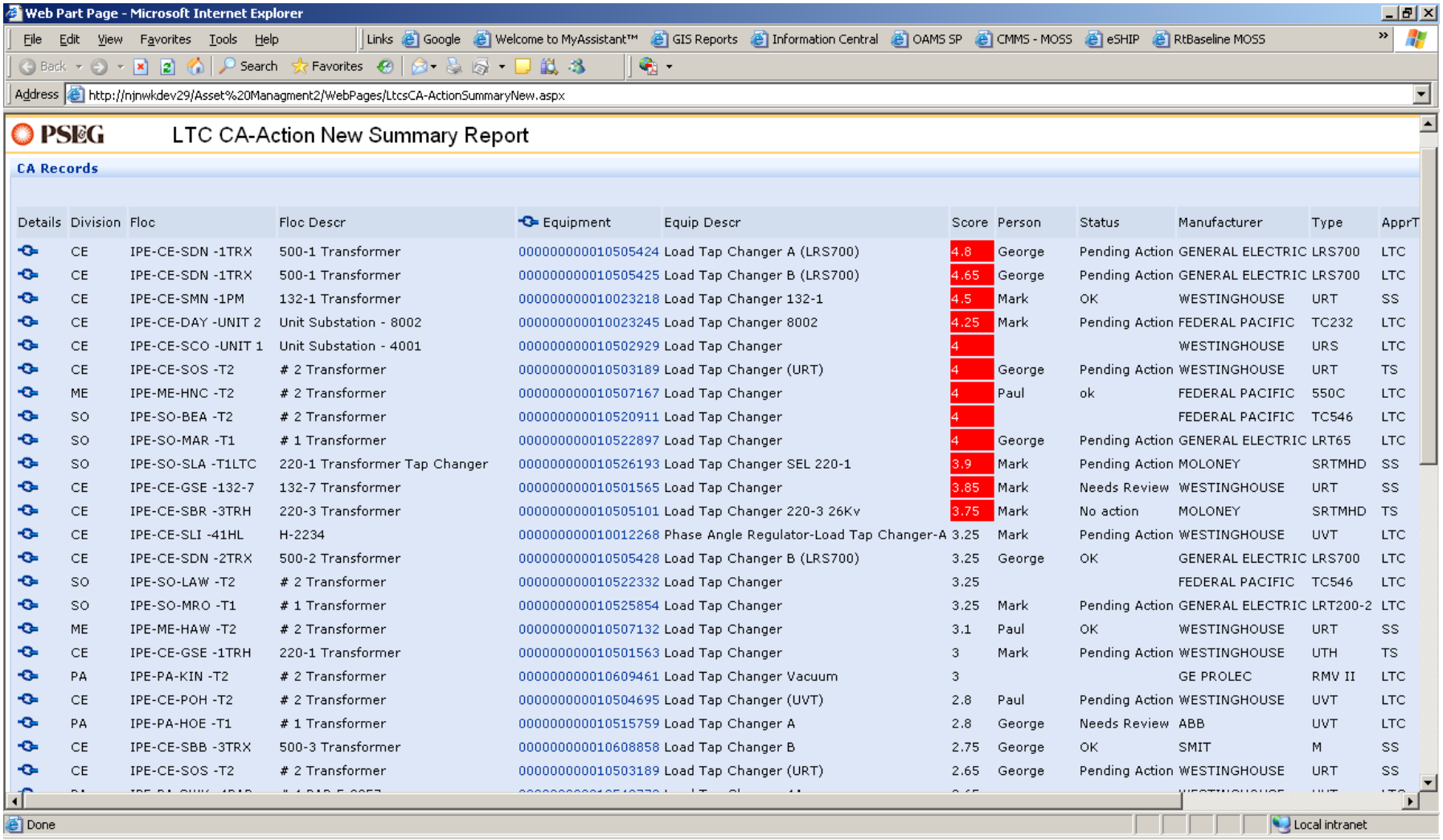
Condition Assessment



PSE&G Visualization



Details	Division	Floc	Floc Descr	Equipment	Equip Descr	Score	Person	Status	Manufacturer	Type	ApprT
	CE	IPE-CE-SDN -1TRX	500-1 Transformer	000000000010505424	Load Tap Changer A (LRS700)	4.8	George	Pending Action	GENERAL ELECTRIC	LRS700	LTC
	CE	IPE-CE-SDN -1TRX	500-1 Transformer	000000000010505425	Load Tap Changer B (LRS700)	4.65	George	Pending Action	GENERAL ELECTRIC	LRS700	LTC
	CE	IPE-CE-SMN -1PM	132-1 Transformer	000000000010023218	Load Tap Changer 132-1	4.5	Mark	OK	WESTINGHOUSE	URT	SS
	CE	IPE-CE-DAY -UNIT 2	Unit Substation - 8002	000000000010023245	Load Tap Changer 8002	4.25	Mark	Pending Action	FEDERAL PACIFIC	TC232	LTC
	CE	IPE-CE-SCO -UNIT 1	Unit Substation - 4001	000000000010502929	Load Tap Changer	4			WESTINGHOUSE	URS	LTC
	CE	IPE-CE-SOS -T2	# 2 Transformer	000000000010503189	Load Tap Changer (URT)	4	George	Pending Action	WESTINGHOUSE	URT	TS
	ME	IPE-ME-HNC -T2	# 2 Transformer	000000000010507167	Load Tap Changer	4	Paul	ok	FEDERAL PACIFIC	550C	LTC
	SO	IPE-SO-BEA -T2	# 2 Transformer	000000000010520911	Load Tap Changer	4			FEDERAL PACIFIC	TC546	LTC
	SO	IPE-SO-MAR -T1	# 1 Transformer	000000000010522897	Load Tap Changer	4	George	Pending Action	GENERAL ELECTRIC	LRT65	LTC
	SO	IPE-SO-SLA -T1LTC	220-1 Transformer Tap Changer	000000000010526193	Load Tap Changer SEL 220-1	3.9	Mark	Pending Action	MOLONEY	SRTMHD	SS
	CE	IPE-CE-GSE -132-7	132-7 Transformer	000000000010501565	Load Tap Changer	3.85	Mark	Needs Review	WESTINGHOUSE	URT	SS
	CE	IPE-CE-SBR -3TRH	220-3 Transformer	000000000010505101	Load Tap Changer 220-3 26Kv	3.75	Mark	No action	MOLONEY	SRTMHD	TS
	CE	IPE-CE-SLI -41HL	H-2234	000000000010012268	Phase Angle Regulator-Load Tap Changer-A	3.25	Mark	Pending Action	WESTINGHOUSE	UVT	LTC
	CE	IPE-CE-SDN -2TRX	500-2 Transformer	000000000010505428	Load Tap Changer B (LRS700)	3.25	George	OK	GENERAL ELECTRIC	LRS700	LTC
	SO	IPE-SO-LAW -T2	# 2 Transformer	000000000010522332	Load Tap Changer	3.25			FEDERAL PACIFIC	TC546	LTC
	SO	IPE-SO-MRO -T1	# 1 Transformer	000000000010525854	Load Tap Changer	3.25	Mark	Pending Action	GENERAL ELECTRIC	LRT200-2	LTC
	ME	IPE-ME-HAW -T2	# 2 Transformer	000000000010507132	Load Tap Changer	3.1	Paul	OK	WESTINGHOUSE	URT	SS
	CE	IPE-CE-GSE -1TRH	220-1 Transformer	000000000010501563	Load Tap Changer	3	Mark	Pending Action	WESTINGHOUSE	UTH	TS
	PA	IPE-PA-KIN -T2	# 2 Transformer	000000000010609461	Load Tap Changer Vacuum	3			GE PROLEC	RMV II	LTC
	CE	IPE-CE-POH -T2	# 2 Transformer	000000000010504695	Load Tap Changer (UVT)	2.8	Paul	Pending Action	WESTINGHOUSE	UVT	LTC
	PA	IPE-PA-HOE -T1	# 1 Transformer	000000000010515759	Load Tap Changer A	2.8	George	Needs Review	ABB	UVT	LTC
	CE	IPE-CE-SBB -3TRX	500-3 Transformer	000000000010608858	Load Tap Changer B	2.75	George	OK	SMIT	M	SS
	CE	IPE-CE-SOS -T2	# 2 Transformer	000000000010503189	Load Tap Changer (URT)	2.65	George	Pending Action	WESTINGHOUSE	URT	SS

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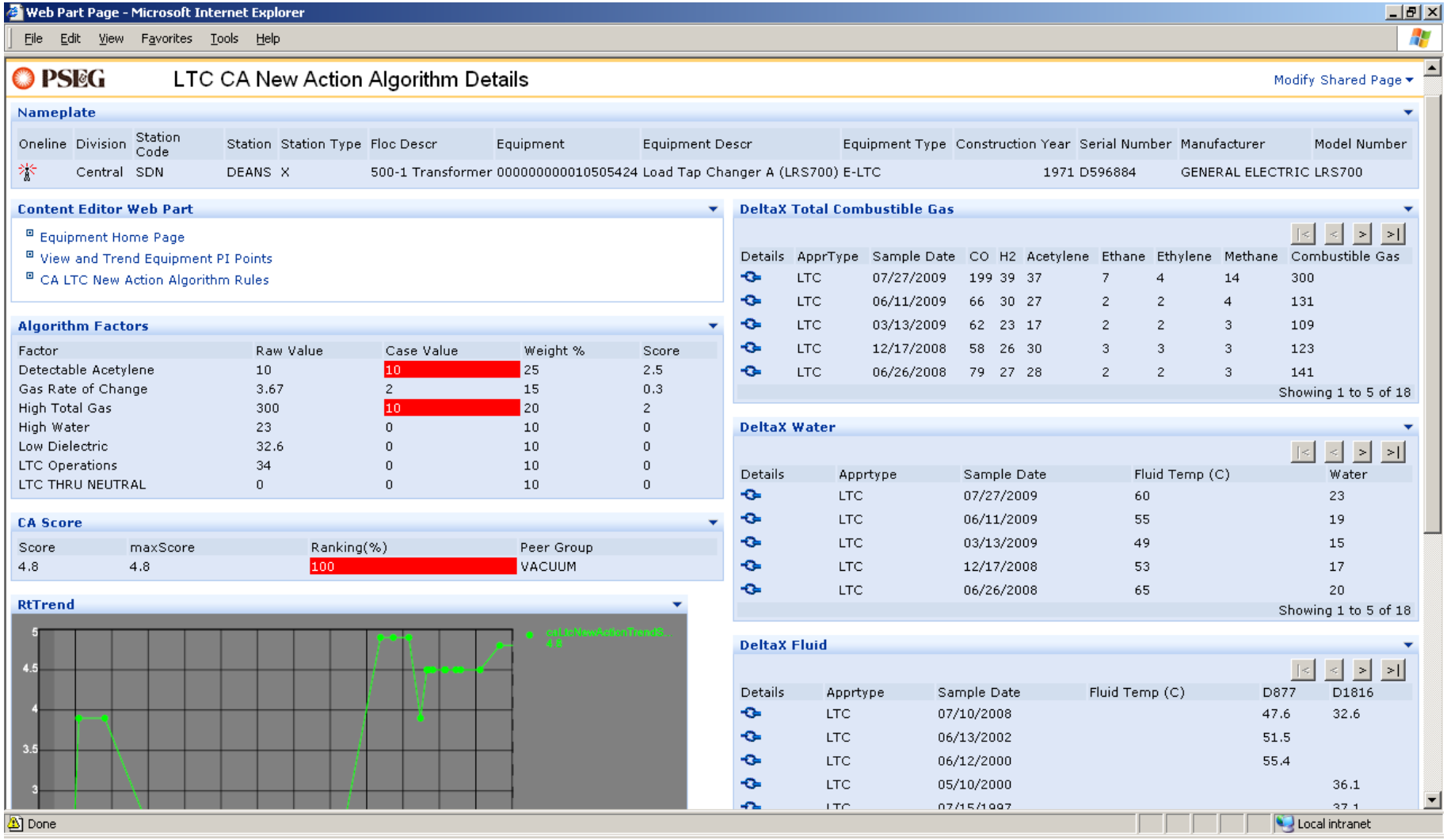
PSE&G Visualization



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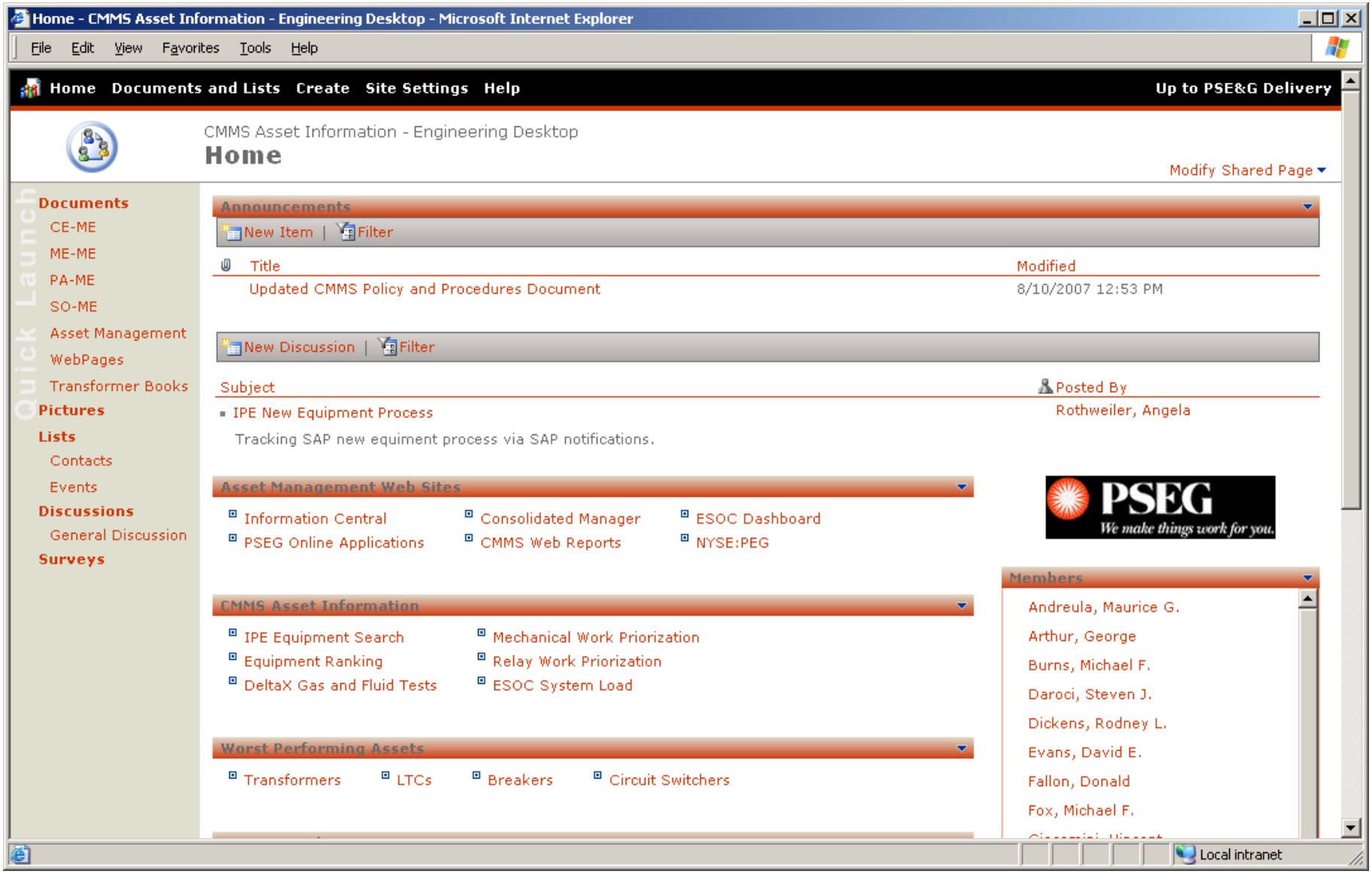
Engineering Desktop Home



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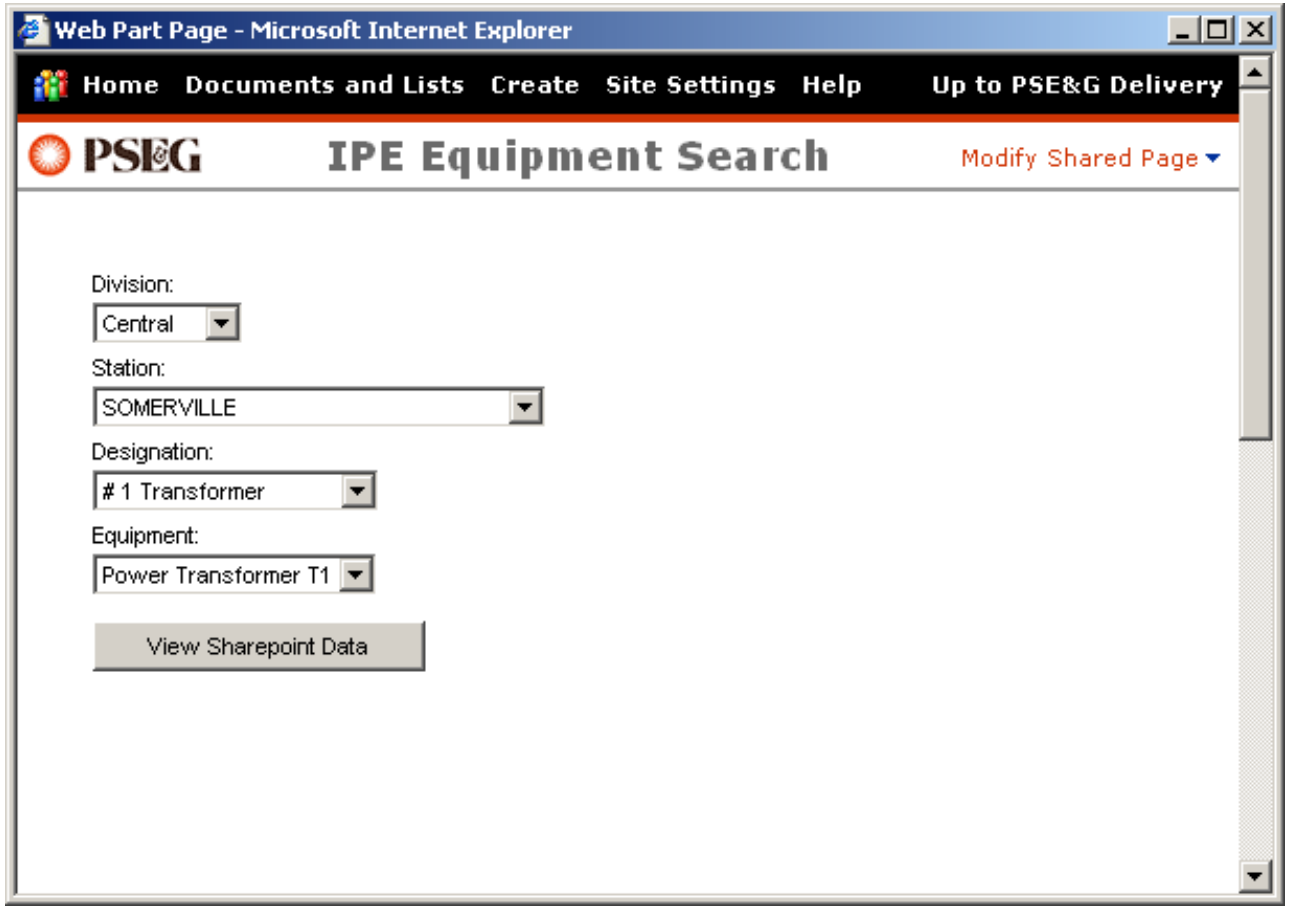
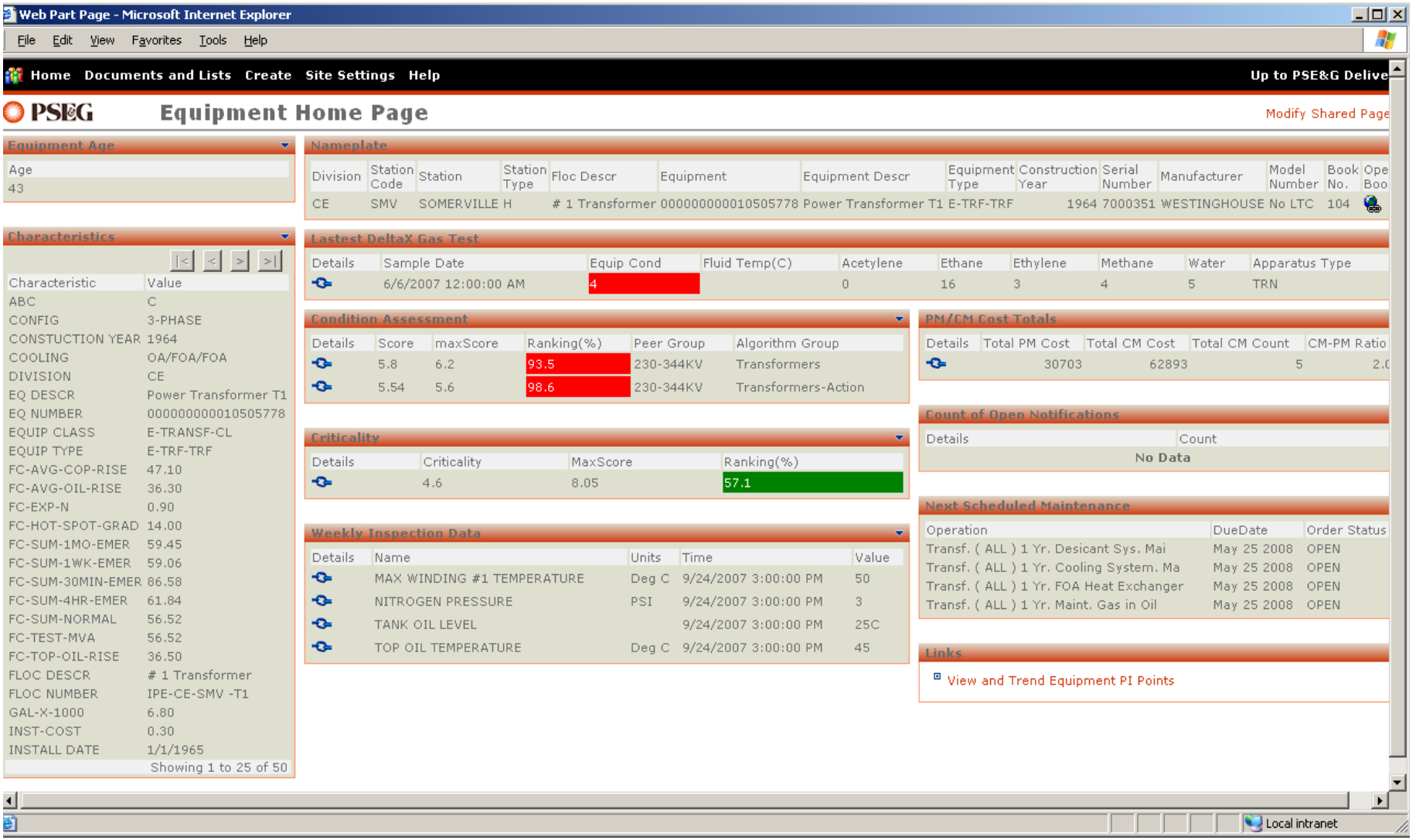
Asset Search

- Search By
  - Division
  - Substation
  - FLOC
  - Equipment



Asset Detail



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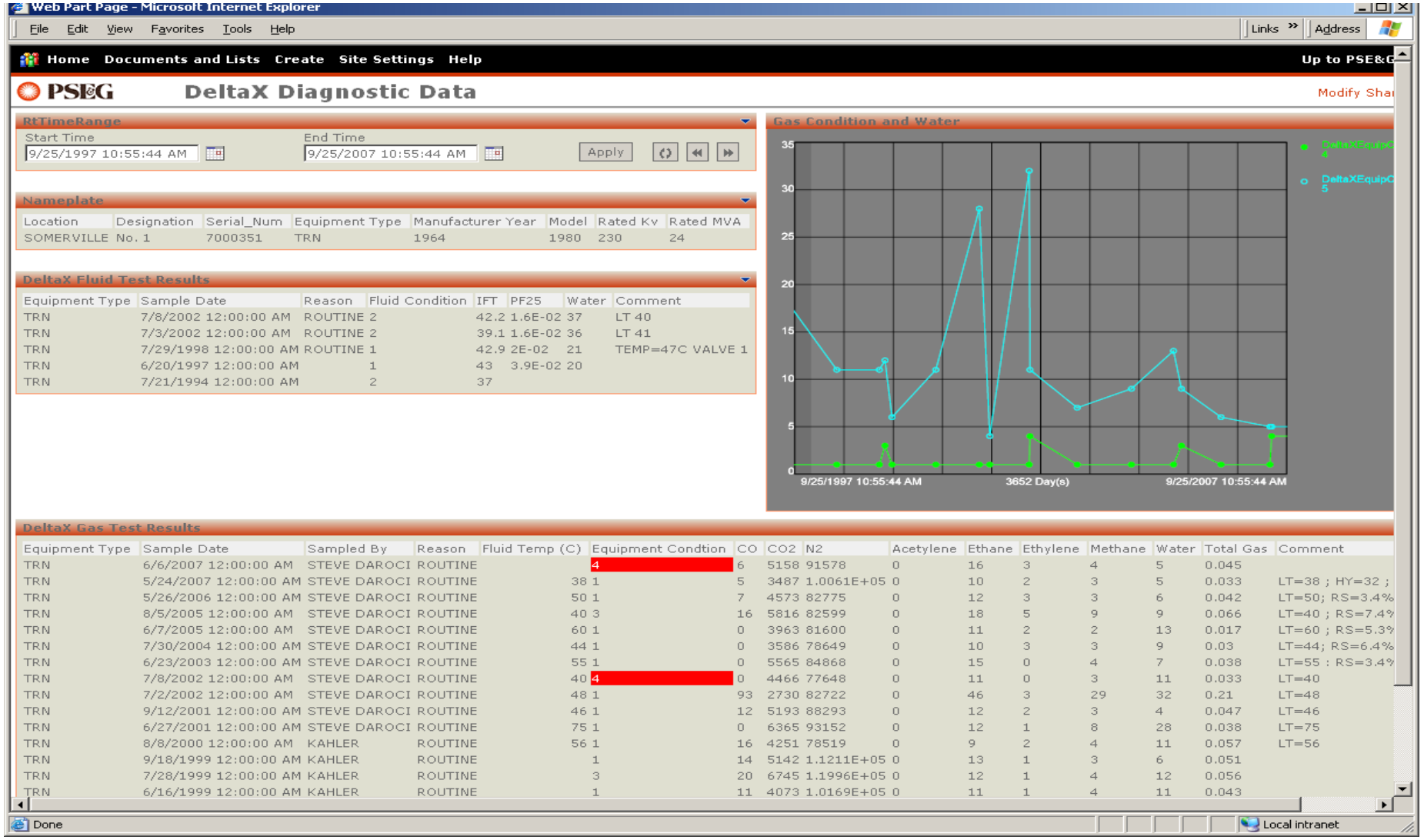
Condition Assessment Detail



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Results

Benefits

- Tangible
  - Annually document savings
  - First year savings!
  - 2005 – Approximately $3MM
    - Reduced Maintenance Costs
    - Failure avoidance
  - More targeted and reduced Capital Expenditures
- Intangible
  - Platform for many other analytic efforts
  - Used for limiting component determination for critical circuits
  - Used for Work Prioritization – ensuring the right work is performed – most PM's completed annually
  - Results in quicker failure analysis
  - Most reliable electric utility nationally, regionally for last 8 years (PA Consulting)

Thank you

777 Davis St., Suite 250 San Leandro, CA 94577