



让PI 系统发掘企业数据蕴藏的无限潜能

## **Asset Optimization and Condition-Based Maintenance (CBM)**

### **Improving Reliability and Quality**

**资产性能最优化  
及  
实时状态检修/维护  
提升可靠性 及 性能**

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策略事务开发总监

# Agenda议程

- Asset Management Issues and Trends  
(资产管理方面的问题和趋势)
- Utility Use Cases (电力公司应用案例)
  - PSE&G CMMS
  - SDG&E RtCBM
- Benefits and ROI (效益和投资回报)
- Summary and Q&A (结语和问题与答疑)

# 资产管理演化

## 1. 传统的资产管理方法

- *Issues*问题
- *Limitations*局限性

## 2. 维护实践演化

Past Present Future



- Interval based (基于时间间隔)
  - *Time based* (基于时间)
  - *Counter based* (基于操作次数)
- Condition based (基于状态)
- Real-time Condition based (基于实时状态)
- Future Asset Management Practice (面向未来资产管理策略)

**PSE&G**

**(Public Service Electric & Gas)**

**CMMS**

**(Computerized Maintenance Management System)**

电脑化的维修管理系统

# WHY? Asset Management

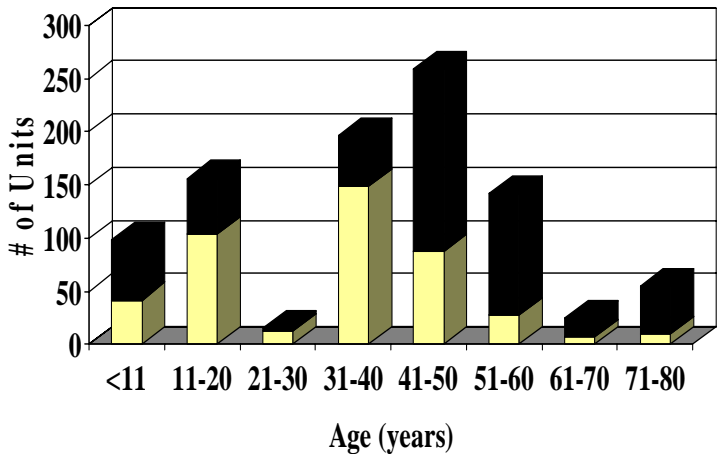
## - Inside Plant

### What do you do when...

- You have **\$1.5B** of installed plant with a replacement value of **\$5.4B**
- Average age of the assets exceeds **40** years
- All equipment is expected to be **used and useful** all the time, and
- Maintenance expenditures **erode earnings** and capital replacement provides for no new revenue?

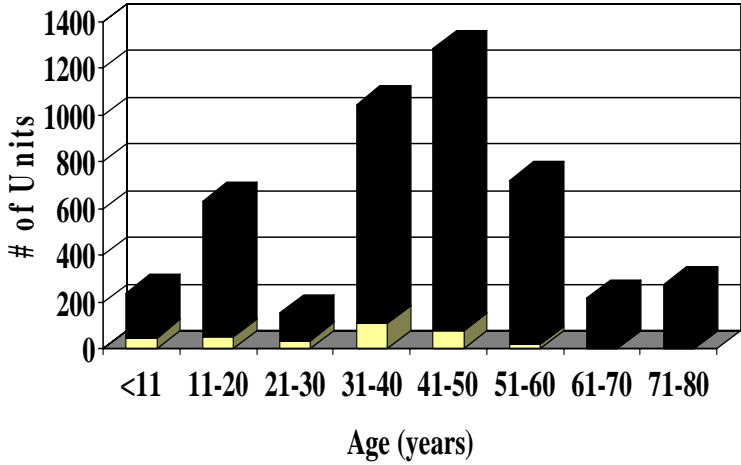
# Equipment Age Profile in Utility

Transformers 变压器  
Total - 955 units



Transmission Distribution

Breakers 断路器  
Total - 4578



Transmission Distribution

Average Age- **37.4** Years

Average Age- **40.6** Years

# The Mission 目标

To optimize the investment in assets while *Improving* the overall system *reliability* of Electric Delivery

以优化投资资产，同时提高整个电力输送系统的可靠性

# The Vision 远见

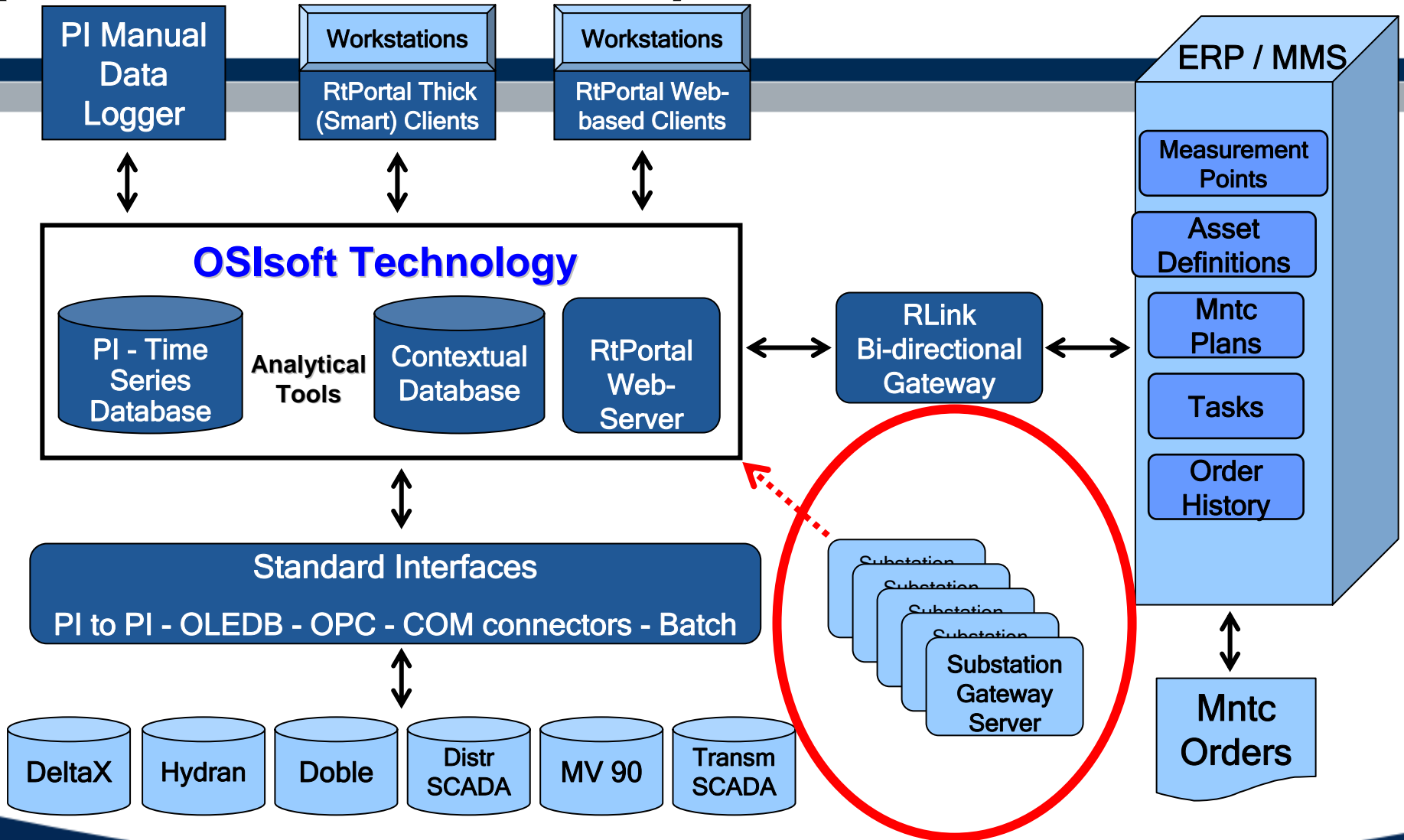
To perform the right maintenance  
at the right time, based on the  
***consistent*** analysis of ***data*** to  
ensure a safe, reliable, cost  
effective approach

基于一贯的数据分析, 以确保安全, 可靠,  
具成本效益的方法



# Implementation Overview

(典型的执行方式总览)



# Data Correlation(数据相关整合)

## Condition Assessment 状态评估

Score

Relational Attri

PI Module Database Editor - Microsoft Internet Explorer

00000000010503860 Power Transformer

Folder Items

- BAY
- BEN
  - COM-RLY
  - T1
  - T2
    - 00000000010503860 Power Transformer
      - IPE-CE-BEN -T2 -7259
      - IPE-CE-BEN -T2 -7261
      - IPE-CE-BEN -T2 -7261M
      - IPE-CE-BEN -T2 -7262L
      - IPE-CE-BEN -T2 -7262V
  - BOU

PIProperty Name Value

- EQ NUMBER 000000
- EQ DESCR Power
- FLOC DESCR # 2 Tr
- FLOC NUMBER IPE-CE
- FC Summer Normal 51.19
- EC Summer Normal 33.80
- NORMAL RATING 24000
- Secondary Voltage 13
- TRF CONFIG 3-PHAS
- SERIAL NUMBER RAR66

1 Objects Type: PIModule Aliases: 5 Properties: 10 Effective Date: 12/31/1969 7:00:01 PM Query

Peer Group Model 9 Algorithm CA LTC MODEL 1

Score	FLOC	EQ Name	Description	Serial Num
8.41	IPE-PA-NEW -T30	000000000010542736 Load Tap	Model 9/00000000001054; A0296T	A0296T
8.41	IPE-SO-CAS -UNIT 1	000000000010520986 Load Tap	Model 9/00000000001052; A117IX	A117IX
8.41	IPE-SO-SNF -4TRX	000000000010523972 Load Tap	Model 9/00000000001052; ALM22911	ALM22911
7.51	IPE-PA-MAY -T2	000000000010542731 Load Tap	Model 9/00000000001054; 6311186	6311186
7.21	IPE-PA-MAY -T1	000000000010542730 Load Tap	Model 9/00000000001054; 6311169	6311169
7	IPE-SO-CAS -UNIT 2	000000000010520987 Load Tap	Model 9/00000000001052; A1181X	A1181X
6.7	IPE-PA-WAD -T20	000000000010542776 Load Tap	Model 9/00000000001054; 6311188	6311188
6.7	IPE-SO-THO -T1	000000000010524357 Load Tap	Model 9/00000000001052; 6311165	6311165
6.4	IPE-SO-THO -T2	000000000010524358 Load Tap	Model 9/00000000001052; 6311170	6311170
6.02	IPE-PA-WAD -T10	000000000010542773 Load Tap	Model 9/00000000001054; 6311167	6311167
4.7	IPE-SO-SCA -T2	000000000010523481 Load Tap	Model 9/00000000001052; M102315	M102315

Scores for Individual Factors

Factor	Raw Value	Case	Multiplier	Score	Error
Water Content	44	10	0.15	1.5	
CM Costs		10	0.05	0.5	
Oil Physical	2	3	0.17	0.51	
CM Count	0	0	0.05	0	
LTC THRU NEUTRAL	0	2	1	2	
LTC Operations	578	10	0.2	2	
PM Performance	.33	2	0.1	0.2	

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ies Points

Sub-Modules PI Aliases PI Properties

Alias Name	Tag Name	Server	Snapshot Va
ESOC LOAD IN MVA	BEN:TRF.E004.Q	rjnw.aps65	38.9892
MV90 KVAR IN	BEN:TRF.E011.Q	rjnw.aps65	0
MV90 KVAR OUT	BEN:TRF.E013.Q	rjnw.aps65	8960
MV90 KW	BEN:TRF.E017.W	rjnw.aps65	18060
MV90 VOLTS	BEN:TRF.E015.V	rjnw.aps65	120.476
OIL LEVEL	BEN:TRF.L002.M	rjnw.aps65	25C
MAX OIL TEMP	BEN:TRF.T003.M	rjnw.aps65	79
MAX WINDING TEMP	BEN:TRF.T004.M	rjnw.aps65	BROKEN
FLUID CONDITION	BEN:TRF.Q002.YX	rjnw.aps65	Pt Created
GAS CONDITION	BEN:TRF.Q004.YX	rjnw.aps65	Pt Created

12/31/1969 7:00:01 PM Query Date: 07/15/2002 11:49:22 AM

Condition Assessment =

$$f_1(m_1) + f_2(m_2) + f_3(m_3) \dots + f_n(m_n)$$

# Data Correlation (cont'd)

## Operational Data (运作数据)

PI Module Database Editor - Microsoft Internet Explorer

File Edit View Favorites Tools Help

00000000010047622 Power Transformer A

Folder Items

- SBB
  - 101H
  - 110X
  - 122X
  - 1T
  - 1TRX
    - 00000000010047622 Power Transformer A
    - 00000000010504816 Disconnect Switch Deluge System A
    - 00000000010504817 Disconnect Switch Deluge System C
    - 00000000010504818 Disconnect Switch Deluge System B
    - 00000000010504827 Disconnect Switch 500-1 230Kv Disc
    - 00000000010504828 Disconnect Switch 500-1 230Kv Grd
    - 00000000010504850 Disconnect Switch 500-1 BS 1
    - 00000000010504851 Circuit Switcher
    - 00000000010504852 Disconnect Switch Ground
    - 00000000010504853 Disconnect Switch Auto Ground
    - 00000000010504920 Power Transformer B
    - 00000000010504921 Power Transformer C
    - IPE-CE-SBB -1TRX -7259 Transformer Differential Relays
    - IPE-CE-SBB -1TRX -7261 BKR Trip Checks & Megger
    - IPE-CE-SBB -1TRX -7303 Transf. Tertiary Relays -
  - 230BS1
  - 230BS2
  - 230BS3
  - 230BS4

Sub-Modules PI Aliases PI Properties

PIAlias Name	Tag Name	Server	Snapshot Value
ESOC LOAD IN MVA	SBB:TRF.E003.Q	njnwaps65	498.7145
230KV MAX WINDING	SBB:TRF.T014.M	njnwaps65	65
500KV MAX WINDING	SBB:TRF.T004.M	njnwaps65	65
OIL TEMPERATURE	SBB:TRF.T032.M	njnwaps65	65
TANK OIL LEVEL	SBB:TRF.L001.M	njnwaps65	25C
TOP OIL TEMPERATU...	SBB:TRF.T001.M	njnwaps65	60
HYDRAN PPM	SBB:TRF.Q012.M	njnwaps65	37
HYDRAN ROC	SBB:TRF.Q012.N1	njnwaps65	0
220-1 GAS	SBR:TRF.Q014.M	njnwaps65	63
220-2A GAS	SBR::TRF.Q015.M	njnwaps65	142
500-1 PHASE A GAS	SBB:TRF.Q014.M	njnwaps65	118

1 Objects Type: PIModule Aliases: 11 Properties: 53 Effective Date: 12/31/1969 7:00:01 PM Query Date: 8/4/2005 1:35:49 PM Creator: piadmin ParentCount: 3

Done My Computer

# Data Correlation (cont'd)

## Characteristic Data (特性)

PI Module Database Editor - Microsoft Internet Explorer

File Edit View Favorites Tools Help

00000000010047622 Power Transformer A

Folder Items

- SBB
  - 101H
  - 110X
  - 122X
  - 1T
  - 1TRX
    - 00000000010047622 Power Transformer A
    - 00000000010504816 Disconnect Switch Deluge System A
    - 00000000010504817 Disconnect Switch Deluge System C
    - 00000000010504818 Disconnect Switch Deluge System B
    - 00000000010504827 Disconnect Switch 500-1 230Kv Disc
    - 00000000010504828 Disconnect Switch 500-1 230Kv Grd
    - 00000000010504850 Disconnect Switch 500-1 BS 1
    - 00000000010504851 Circuit Switcher
    - 00000000010504852 Disconnect Switch Ground
    - 00000000010504853 Disconnect Switch Auto Ground
    - 00000000010504920 Power Transformer B
    - 00000000010504921 Power Transformer C
    - IPE-CE-SBB -1TRX -7259 Transformer Differential Relays
    - IPE-CE-SBB -1TRX -7261 BKR Trip Checks & Megger
    - IPE-CE-SBB -1TRX -7303 Transf. Tertiary Relays -
  - 230BS1
  - 230BS2
  - 230BS3
  - 230BS4

Sub-Modules PI Aliases PI Properties

PIProperty Name	Value	Datatype
EQ NUMBER	00000000010047622	String
EQ DESCR	Power Transformer A	String
FLOC NUMBER	IPE-CE-SBB -1TRX	String
FLOC DESCR	500-1 Transformer	String
EQUIP CLASS	E-TRANSF-CL	String
EQUIP TYPE	E-TRF-TRF	String
MANUFACTURER	Smit	String
SERIAL NUMBER	220826	String
CONSTRUCTION YEAR	2004	String
INSTALL DATE	7/20/2004	String
SORT BY	1452	String
ABC	C	String
REPL-COST	2.80	String
INST-COST	0.70	String
TRANS-COST	2.10	String
FC-SUM-30MIN-EMER	560.19	String
FC-SUM-4HR-EMER	498.31	String
FC-SUM-24HR-EMER	461.10	String
FC-SUM-1WK-EMER	457.50	String
FC-SUM-1MO-EMER	449.70	String
FC-SUM-NORMAL	401.20	String
SC-SUM-24HR-EMER	285.70	String
FC-EXP-N	1.00	String
FC-HOT-SPOT-GRAD	21.80	String
FC-AVG-COP-RISE	39.50	String

1 Objects Type: PIModule Aliases: 11 Properties: 53 Effective Date: 12/31/1969 7:00:01 PM Query Date: 8/4/2005 1:35:49 PM Creator: piadmin ParentCount: 3

Done My Computer

# Algorithms (器算法)

PI Module Database Editor - Microsoft Internet Explorer

File Edit View Favorites Tools Help

## CM Costs

Folder Items

- My Module Databases
  - njnwks65
    - PI BatchDB
    - PI ModuleDB
      - %OSI
      - CMMS
        - ALGORITHMS
          - CA BREAKER
          - CA BREAKER - REPLACEMENT
            - ATB 26-765KV
              - CM Costs
              - CM Count
              - Compressor Motor Run Time
              - Compressor Oil Addition Frequency
              - Compressor Oil Addition Quantity
              - Ductor
              - Gas Addition Quantity
              - Incorrect Operations
              - Megger
              - Timing

Sub-Modules PI Aliases PI Properties

PIProperty Name	Value	Datatype
Multiplier	0.15	Double
Select	sum(actual_cost)	String
From	hdw_order	String
Where	equip_num={&EQ N...	String
Case		String
Type	DB SQL Query	String
Database	cmms	String
Server	njnwksql12	String

0 Objects Type: PIModule Aliases: 0 Properties: 8 Effective Date: 12/31/1969 7:00:01 PM Query Date: 8/4/2005 1:59:49 PM Creator: pia

# Score Generator (评分器)

**Equipment Condition Assessment Module**

File View Records Help

! Save Print Sort Asc Sort Desc Print Help

**Peer Group** BKR TEST  **Algorithm** GCB 26-69KV - ACTION

Score	FLOC	EQ Name	Description	Serial Number
2.1	IPE-PA-SBE -16FA	000000000010516999 Oil Circuit B	BKR TEST/000000000000	0139A7678-20
2.1	IPE-PA-SBE -8FB	000000000010517030 Oil Circuit B	BKR TEST/000000000000	0139A7637-20
0.9	IPE-PA-SBE -7FB	000000000010517027 Oil Circuit B	BKR TEST/000000000000	K-6566177-ZK
0.9	IPE-PA-SBE -14FA	000000000010516998 Oil Circuit B	BKR TEST/000000000000	K-6566177-WT
0.9	IPE-PA-SBE -7FA	000000000010517026 Oil Circuit B	BKR TEST/000000000000	K-6566177-ZK
0.9	IPE-PA-SBE -6FB	000000000010517024 Oil Circuit B	BKR TEST/000000000000	0141A3196-20
0	IPE-PA-SWK -41H	000000000010600558 Gas Circuit	BKR TEST/000000000000	B002910-11

**Scores for Individual Factors**

Factor	Raw Value	Case	Multiplier	Score	Error
Age	54	7	0.3	2.1	
Operations - 12m	6	0	0.35	0	
Operations - 6m	4	0	0.35	0	
Overall Score				2.1	

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# Work Prioritization (工作优先权)

Microsoft Excel - MECHworkPrioritybyDiv.xls

File Edit View Insert Format Tools Data Window PI P-SMT Help

A1 = orderNum

	A	B	C	E	G	H	I	K	L	M	N	Q	R
1	orderNum	workCenter	status	eqType	floc	desc	voltage	ca	criticality	daysLate	priority	eqRanking	
2	000100198305	PA-ME	OPEN	E-RECL	IPE-PA-RECL-ZSHOP	Pal. Recloser Control Inspection				424 B		50000.00	
3	000100307948	CE-ME	OPEN	E-BAT	IPE-CE-GED -COM-MEC	Cen. Battery (Transm.Dept.)				118 B		25000.00	
4	000100255900	PA-ME	OPEN	E-BAT	IPE-PA-MAL -COM-MEC	Pal. Battery (Dist.Dept.)				53 B		15000.00	
5	000100270059	CE-ME	OPEN	E-RECL	IPE-CE-RECL-MIN24F -13F	Cen. Recloser Control Inspection				-22 B		5000.00	
6	000100294817	PA-ME	OPEN	E-BAT	IPE-PA-SWK -COM-MEC	Pal. Battery (Transm.Dept.)				-162 B		5000.00	
7	000100283073	PA-ME	OPEN	E-BAT	IPE-PA-SER -M1	Pal. Battery (Transm.Dept.)				-122 B		5000.00	
8	000100279368	PA-ME	OPEN	E-BAT	IPE-PA-SER -COM-MEC	Pal. Battery (Transm.Dept.)				-100 B		5000.00	
9	000100246821	ME-ME	OPEN	E-BATCHG	IPE-ME-SNVV -COM-MEC	Met. Battery Charger ( Transm.Dept.				118 1		2500.00	
10	000100246822	ME-ME	OPEN	E-BATCHG	IPE-ME-SNVV -COM-MEC	Met. Battery Charger ( Transm.Dept.				118 1		2500.00	
11	000100246625	PA-ME	OPEN	E-BATCHG	IPE-PA-MAL -COM-MEC	Pal. Battery Charger ( Dist.Dept.)				130 1		2500.00	
12	000100168685	SO-ME	OPEN	E-BKR-OCB	IPE-SO-SNF -41X	So.GCB BKR 500 KV (12yr)	500.00	2.5	6.7	784 1		1675.00	
13	000100256197	PA-ME	OPEN	E-BKR-OCB	IPE-PA-SMA -2PM	Pal.OCB BKR 138 KV (Transm. Dept.)	138.00	2.9	5.5	405 1		1595.00	
14	000100251300	ME-ME	OPEN	E-BATCHG	IPE-ME-SES -COM-MEC	Met. Battery Charger ( Transm.Dept.				94 1		1500.00	
15	000100251301	ME-ME	OPEN	E-BATCHG	IPE-ME-SES -COM-MEC	Met. Battery Charger ( Transm.Dept.				94 1		1500.00	
16	000100255379	PA-ME	OPEN	E-EMGEN	IPE-PA-SNM -COM-MEC	Pal. Emerg. Gen. w/ drive (Trans.Dept.)				53 1		1500.00	
17	000100255375	PA-ME	OPEN	E-EMGEN	IPE-PA-SWK -COM-MEC	Pal. Emerg. Gen. w/ drive (Trans.Dept.)				53 1		1500.00	
18	000100194085	SO-ME	OPEN	E-TRF-UNT	IPE-SO-COL -UNIT 3	So. Transf.-4kv -69KV (10yr)	26-4	4.1	3.4	467 1		1394.00	
19	000100188794	SO-ME	OPEN	E-TRF-TRF	IPE-SO-WRVY -T3	So. Transf.-4KV-26KV (10yr)	26-4	3.46	3.4	473 1		1176.40	
20	000100193118	SO-ME	OPEN	E-TRF-TRF	IPE-SO-AUD -T1	So. Transf.-4KV-26KV (10yr)	26-4	3.08	3	431 1		924.00	
21	000100278943	CE-ME	OPEN	E-BKR-ATB	IPE-CE-SBB -41H	Cen. ATB BKR 138KV-500KV (Transm.Dept.)	230.00	4	6.05	95 1		726.00	
22	000100220487	PA-ME	OPEN	E-BKR-OCB	IPE-PA-RFL -230BS3-4	Pal.GCB BKR 138 KV (Transm. Dept.)	230.00	1.75	5.85	260 1		716.63	
23	000100296359	ME-ME	OPEN	E-TRF-TRF	IPE-ME-GRE -T2	Met. Transf.-4KV-69KV (Dist.Dept.)	26-4	3.92	3.4	102 1		666.40	
24	000100015768	PA-ME	OPEN	E-CKTSWR	IPE-PA-SHU -20H90	Pal.Circuit Sw.-138KV-500KV(Transm.Dept)	230.00	6.5		1744 1		650.00	
25	000100255820	PA-ME	OPEN	E-TRF-TRF	IPE-PA-MAYL -T2	Pal. Transf.-138kv -500KV (Transm.Dept.)	230-13	4.44	4.4	62 1		586.00	
26	000100027784	CE-ME	OPEN	E-LTC	IPE-CE-WFL -UNIT2	Cen. Load Tap Changers 1 Yr. & 4 Yr	13	5.8		1836 1		580.00	
27	000100246700	PA-ME	OPEN	E-BKR-OCB	IPE-PA-SWK -12V	Pal.GCB BKR 138 KV (Transm. Dept.)	345.00	1.85	6.2	121 1		573.50	
28	000100126105	PA-ME	OPEN	E-BKR-OCB	IPE-PA-SBE -90P	Pal.GCB BKR 138 KV (Transm. Dept.)	138.00	0	5.65	1202 1		565.00	
29	000100246374	ME-ME	OPEN	E-TRF-TRF	IPE-ME-SAT -132-2	Met. Transf.-138kv -500KV (Transm.Dept.)	138-26-11	3.1	3.6	107 1		558.00	
30	000100255739	PA-ME	OPEN	E-TRF-TRF	IPE-PA-MAYL -T3	Pal. Transf.-138kv -500KV (Transm.Dept.)	230-13	4.4	4.2	53 1		554.40	
31	000100278945	CE-ME	OPEN	E-BKR-ATB	IPE-CE-SBB -72H	Cen. ATB BKR 138KV-500KV (Transm.Dept.)	230.00	3.05	6.05	95 1		553.58	
32	000100193561	CE-ME	OPEN	E-BKR-OCB	IPE-CE-RAH -L1	Cen.GCB BKR-4KV-69KV (Dist.Dept.)	26.00	4	4.6	453 3		552.00	
33	000100002469	CE-ME	OPEN	E-BKR-OCB	IPE-CE-SLI -86F	Cen.GCB BKR-4KV-69KV (Dist.Dept.)	26.00	4	4.6	1256 3		552.00	
34	000100252609	PA-ME	OPEN	E-BKR-OCB	IPE-PA-SMA -3TR	Pal.OCB BKR 138 KV (Transm. Dept.)	138.00	0	5.4	405 1		540.00	
35	000100239563	SO-ME	OPEN	E-TRF-TRF	IPE-SO-CLN -T2	So. Transf.-4KV-69KV (Dist.Dept.)	26-4	3.12	3.4	143 1		530.40	
36	000100246400	ME-ME	OPEN	E-TRF-TRF	IPE-ME-SAT -132-3	Met. Transf.-138kv -500KV (Transm.Dept.)	138-26-11	2.92	3.6	107 1		525.60	
37	000100239477	SO-ME	OPEN	E-TRF-TRF	IPE-SO-BOR -T1	So. Transf.-4KV-69KV (Dist.Dept.)	26-4	3.08	3.4	156 1		523.60	
38	000100239574	SO-ME	OPEN	E-TRF-TRF	IPE-SO-LIB -T2	So. Transf.-4KV-69KV (Dist.Dept.)	26-4	3.08	3.4	143 1		523.60	
39	000100251265	ME-ME	OPEN	E-BKR-OCB	IPE-ME-SES -20H	Met.GCB BKR 138 KV (Transm. Dept.)	230.00	2.75	6.3	83 1		519.75	
40	000100251133	CE-ME	OPEN	E-BKR-OCB	IPE-CE-SBB -92X	Cen.GCB BKR 138 KV (Transm. Dept.)	500.00	2.5	6.8	97 1		510.00	
41	000100224948	SO-ME	OPEN	E-BKR-OCB	IPE-SO-GSA -30X	So.GCB BKR 500 KV (12yr)	500.00	0	7.25	263 1		507.50	
42	000100274255	CE-ME	OPEN	E-FHYD	IPE-CE-SBR -COM-MEC	Cen. Misc.Fire Fight Equip(Trans.Dept.)				-73 1		500.00	

Ready CAPS NUM

# ACE (Advanced Computing Engine)

## 高级计算引擎

- Groups equipment by aliases in PI Module
- Apply set of equations to groups of equipment
- Generate email notifications or trigger for transfer of measurement docs or creation of notifications
- Event-based and periodic calculations
- Easily turn on or off equations for individual equipment
- 55 class modules and over 6000 contexts



# Notification Calculations

## 自动通知报告的计算

- Hydran PPM Rate of Change
- Excessive LTC Operations
- Excessive Runtime Readings
- High Breaker Temperatures
- Breaker Filling Pressure
- High or Low Transformer Oil Levels
- Low Transformer Nitrogen Cylinder Pressure
- Low Transformer Nitrogen Pressure

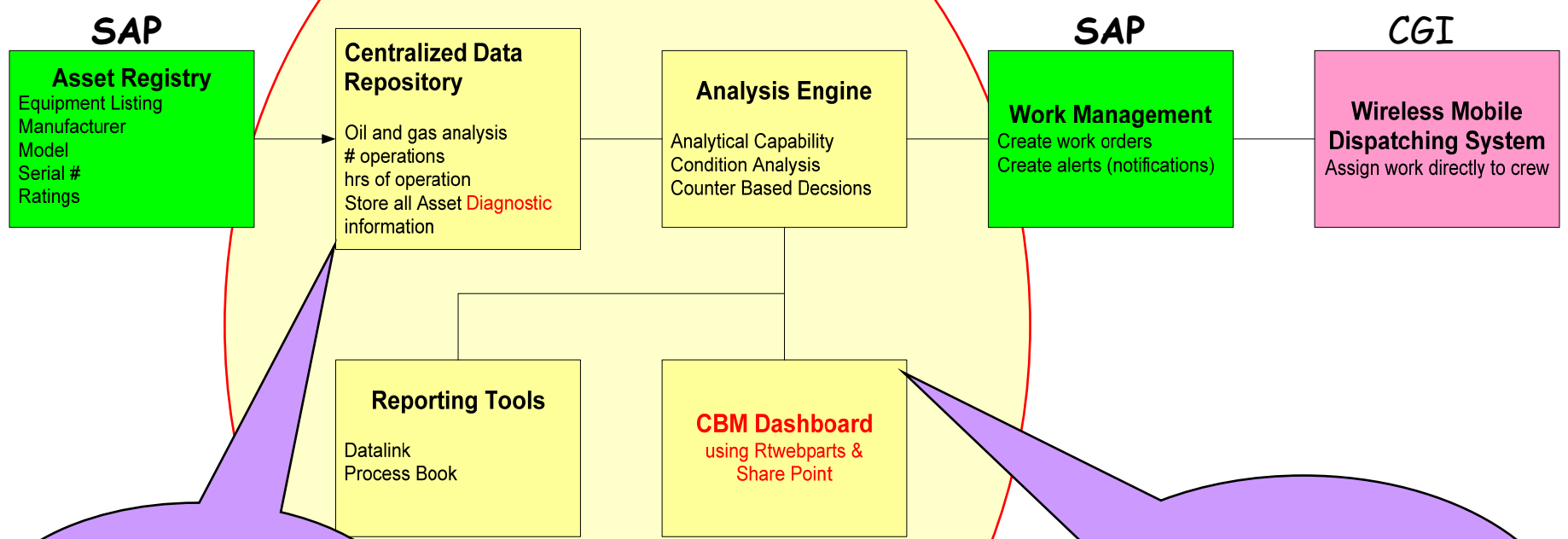
# Interfacing with Data Sources

## (各方数据来源的集成)

- SAP PM Module
- Lab Systems – DeltaX & Doble
- Breaker Diagnostic Data Web Pages
- Transmission SCADA
- Distribution SCADA
- MV-90 13kv Transformer Load Data
- SDC 4-26kv Metering
- Hydran Transformer PPM Monitoring
- SAP PM Measurement Documents

# Configuration (配置)

## The PI System



**Enterprise License**

**RtWebParts Drill down capability**  
技能导航性能

**OSIsoft**

# CA Tangible Results

## 状态评估有形的效果

- 2003 石油诊断信息目标为16 LTC's, 5个有联系问题
  - Estimated Cost Saving ~ **\$300,000**
- 2004 目标为10个LTC's, 1个有导致主要故障的潜在可能
- 2004 目标为5个变压器, 2个被确定为有重要问题
  - Estimated Cost Saving > **\$1.2M**
- 2005 Cost Savings > **\$2M**

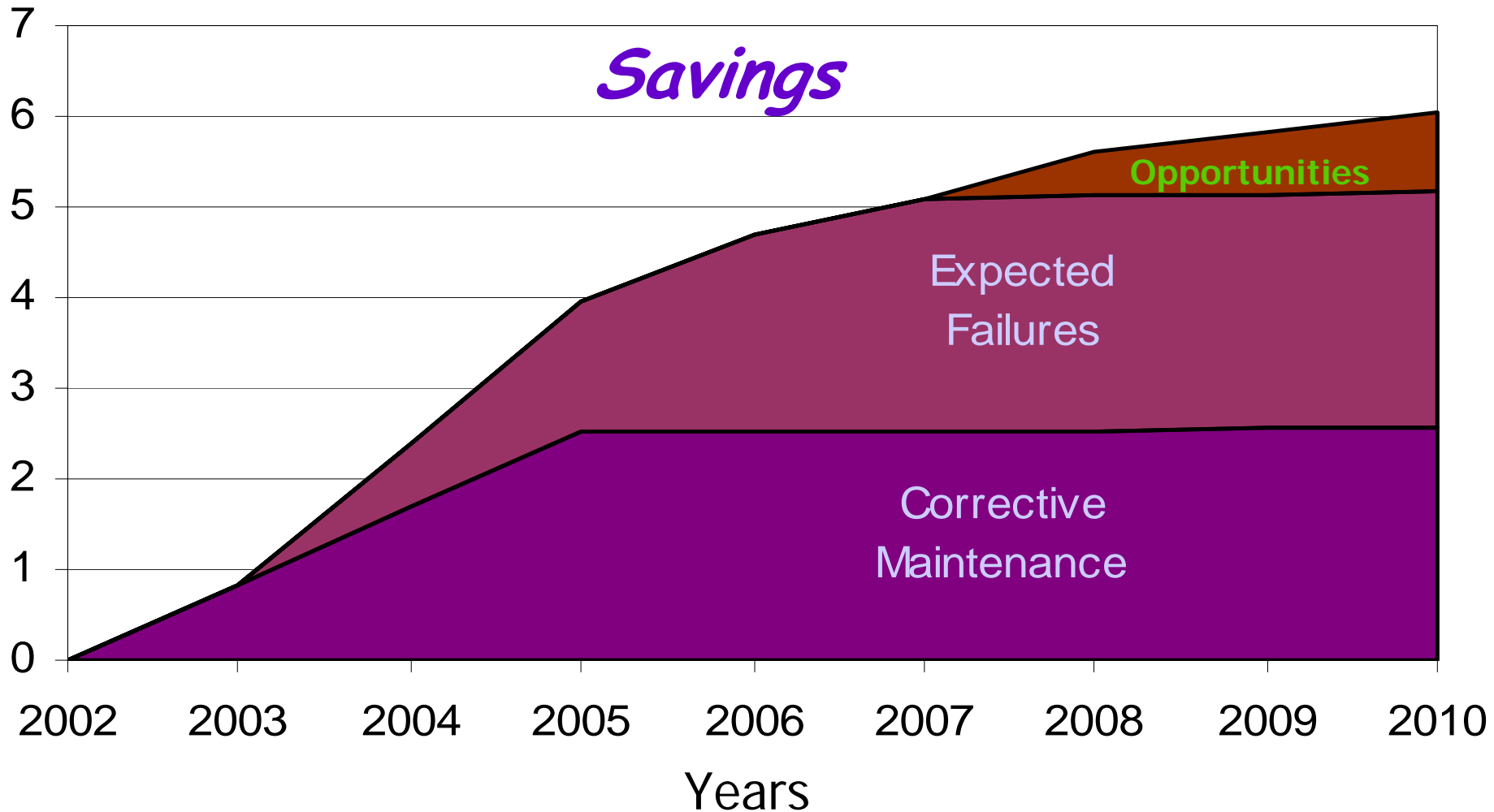
# Notification Tangible Results

## 通知报告有形的效果

- Problems discovered from CMMS Notifications
  - Controls out of Calibration
  - Leaky Blast Values
  - Incorrect CMV Setting
  - Defective Controls on older LTC
  - Defective Counters
  - Low Oil Levels
  - Cylinder Leaks
  - Hydran PPM
- 2003 Estimated Cost savings for 9 LTC's and 2 GCB's is **\$264,600**
- 2004 Estimated Cost saving for 5 Transformers is **\$800,000**
- **2005 Cost Savings > \$1M**

# Conclusion: Proactive Approach Enables:

\$ (Million)



# Dashboard

Home Documents and Lists Create Site Settings Help

**PSEG Equipment Dashboard** Modify Shared Page

**Equipment Age**

Age: 39

---

**Order Cost History**

Details	Total PM Cost	Total CM Cost	Total CM Count
	41502	19020	27

---

**Equipment Nameplate**

Details	Nameplate	Value
	CONSTRUCTION YEAR	1067
	MANUFACTURER	Highhouse
	MODEL NUMBER	URT
	OPER-KV	230-13
	RATING	24000.00
	SERIAL NUMBER	RAR66902

**DeltaX Information**

Details	Location	Desig	Serial Num	Sample Date	Temp(C)	Acetylene	Ethane	Ethylene	Methane	Water
	ADAMS	No. 1 TS	RAR66902	6/30/2006		8403	402	4322	1702	54
	ADAMS	No. 1	RAR66902	6/30/2006		0	13	2	6	11
	ADAMS	No. 1 SS	RAR66902	6/30/2006		0	196	194	74	40

---

**Open Order Information**

Details	Order	Descr	Status	Planned Cost
	000100381836	Cen. Transf.-138kv -50	OPEN	1306.7

---

**Asset Load**

No. 2 Transformer = 9730.00 ;  
9/9/2006 5:15:00 AM

---

**Condition Assessment Score**

Details	Peer Group	Algorithm Group	Score	maxScore	Ranking(%)
	230-344KV	Transformers	4.36	6.38	68
	230-344KV	Transformers-Action	3.12	5.48	56

Details	Floc Number	Criticality	MaxScore	Ranking(%)
	IPE-CE-ADA -T1	5.85	8.2	71

---

**Weekly Inspection Points**

Details	Name	Units	Time	Value
	GAS LEVEL	ppm	9/6/2006 3:00:00 PM	NOT EXIST
	HYDRAN PPM	ppm	9/6/2006 3:00:00 PM	NOT EXIST
	MAX WINDING #1 TEMPERATURE	Deg C	9/6/2006 3:00:00 PM	60
	NITROGEN CYLINDER PRESSURE	PSI	9/6/2006 3:00:00 PM	1500
	NITROGEN PRESSURE	PSI	9/6/2006 3:00:00 PM	3.3
	TANK OIL LEVEL		9/6/2006 3:00:00 PM	25C
	TOP OIL TEMPERATURE	Deg C	9/6/2006 3:00:00 PM	60

---

**Other PI Data Points**

Details	Name	Units	Source	Time	Value
	MV90 KVAR (IN)	KVAR	MV90	9/8/2006 11:45:00 PM	1010
	MV90 KVAR (OUT)	KVAR	MV90	9/8/2006 11:45:00 PM	0
	MV90 KW	KW	MV90	9/8/2006 11:45:00 PM	20580
	MV90 VOLTS	VOLTS	MV90	9/8/2006 11:45:00 PM	120
	T1 BUS VOLT	VOLTS	DAQ	9/13/2006 8:03:37 AM	122.6214
	T1 MVA	MVA	DAQ	9/13/2006 8:03:33 AM	-0.292968
	T1 MVAR	MVAR	DAQ	9/13/2006 8:02:33 AM	0.195312
	T1 MW	MW	DAQ	9/13/2006 8:01:13 AM	15.23434

**Criticality Score**

**Actual Loading**

**Condition Score**

# Drill down to details

PSEG
**PI Point Details**
Modify Shared Page ▾

---

**Archive Readings** ▾

Time	Status	Value
11/23/2005 10:00:00 AM	Good	28.0003
11/30/2005 5:00:00 PM	Good	30.0000
12/7/2005 12:00:00 PM	Good	27.0004
12/13/2005 1:00:00 PM	Good	24.0008
12/28/2005 4:00:00 PM	Good	39.9988
1/2/2006 11:00:00 AM	Good	30.0000
1/10/2006 9:00:00 AM	Good	49.9976
1/25/2006 12:00:00 PM	Good	49.9976
2/1/2006 10:00:00 AM	Good	46.9980
2/7/2006 11:00:00 AM	Good	44.9982
2/15/2006 11:00:00 AM	Good	44.9982
2/22/2006 3:00:00 PM	Good	39.9988
3/1/2006 10:00:00 AM	Good	27.0004
3/8/2006 8:00:00 AM	Good	26.0005
3/15/2006 4:00:00 PM	Good	25.0006
3/29/2006 9:00:00 AM	Good	30.0000
4/5/2006 4:00:00 PM	Good	39.9988
4/12/2006 12:00:00 PM	Good	39.9988
4/19/2006 10:00:00 AM	Good	49.9976
4/26/2006 9:00:00 AM	Good	52.9972
5/3/2006 1:00:00 PM	Good	34.9994
5/17/2006 1:00:00 PM	Good	54.9970
5/24/2006 11:00:00 AM	Good	42.9984
5/30/2006 1:00:00 PM	Good	51.9973
6/14/2006 12:00:00 PM	Good	60.0025
6/20/2006 1:00:00 PM	Good	51.9973
6/28/2006 9:00:00 AM	Good	60.0025
7/5/2006 12:00:00 PM	Good	80.0001
7/12/2006 10:00:00 AM	Good	60.0025
7/19/2006 8:00:00 AM	Good	49.9976
7/25/2006 11:00:00 AM	Good	54.9970
8/2/2006 8:00:00 AM	Good	89.9988
8/9/2006 8:00:00 AM	Good	57.0029
8/16/2006 9:00:00 AM	Good	58.0027
8/22/2006 8:00:00 AM	Good	56.0030
8/30/2006 9:00:00 AM	Good	49.9976
9/6/2006 3:00:00 PM	Good	60.0000

**Tag Properties** ▾

TagName	Descriptor	Units	Source
ADA:TRF.T001.M	#1 TRF TOP OIL TMP	Deg C	Inspection

**RTTimeRange** ▾

Start Time:  End Time:

**RTTrend** ▾

● ADA:TRF.T001.M  
● #1 TRF TOP OIL TMP  
● Deg C

● #1 TRF TOP OIL TMP  
 11/17/2005 8:07:06 AM      299.96 Day(s)      9/13/2006 8:07:06 AM

**Max Reading** ▾

Time	Max
8/2/2006 8:00:00 AM	89.9988

**Min Reading** ▾

Time	Min
12/13/2005 1:00:00 PM	24.0008

**Average Reading** ▾

Time	Average
9/13/2006 8:07:06 AM	46.1394

**Standard Deviation** ▾

Time	Standard Deviation
9/13/2006 8:07:06 AM	13.6737



# Gas and Oil Results

## PS&G DeltaX Gas and Fluid History

Modify Shared Page

DeltaX Nameplate								
Location	Designation	Serial_Num	Equipment Type	Manufacturer Year	Model	Rated Kv	Rated MVA	
ADAMS	No. 1 SS	RAR66902	SS	1967	URT 3 Phase	230	40	
ADAMS	No. 1	RAR66902	TRN	1967	URT 3 phase	230	40	
ADAMS	No. 1 TS	RAR66902	TS	1967	URT 3 phase	230	40	

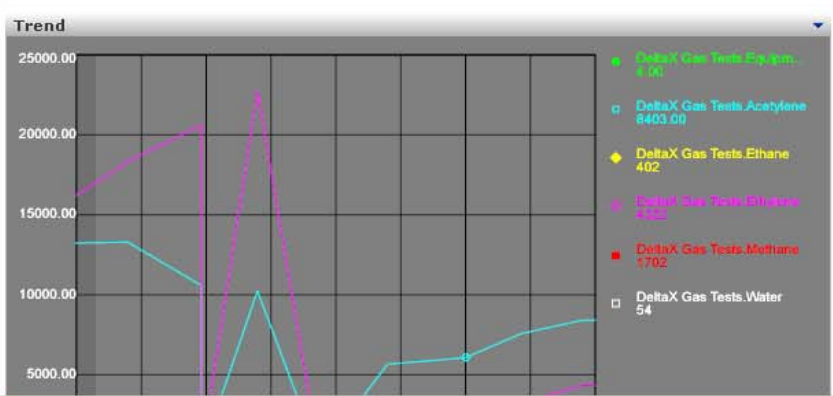
DeltaX Gas History												
Equipment Type	Sample Date	Sampled By	Reason	Fluid Temp (C)	Equipment Condition	Acetylene	Ethane	Ethylene	Methane	Water	Total Gas	Comment
SS	6/30/2006 12:00:00 AM	STEVE DAROCI	ROUTINE	55		4	0	196	194	74	40	0.93 LT=55; RS=19.4%
TRN	6/30/2006 12:00:00 AM	STEVE DAROCI	ROUTINE	55		1	0	13	2	6	11	0.021 LT=55; RS=5.3%
TS	6/30/2006 12:00:00 AM	STEVE DAROCI	ROUTINE	55		4	8403	402	4322	1702	54	22.315 LT=55; RS=26.3%
SS	7/25/2005 12:00:00 AM	STEVE DAROCI	ROUTINE	50		4	0	152	159	63	44	0.951 LT=50 ; RS=25.4%
TRN	7/25/2005 12:00:00 AM	STEVE DAROCI	ROUTINE	50		1	0	18	6	7	12	0.053 LT=50 ; RS=6.9%
TS	7/25/2005 12:00:00 AM	STEVE DAROCI	ROUTINE	50		4	7577	330	3302	1456	53	20.455 LT=50 ; RS=30.6%
SS	9/8/2004 12:00:00 AM	STEVE DAROCI	ROUTINE	85		4	0	173	173	62	43	0.927 LT=85 ; RS=8.3%
TRN	9/8/2004 12:00:00 AM	STEVE DAROCI	ROUTINE	50		1	0	21	22	7	33	0.084 LT=50 ; RS=19.0%
TS	9/8/2004 12:00:00 AM	STEVE DAROCI	ROUTINE	82		4	6058	267	2575	1136	56	17.712 LT=82 ; RS=11.8%
SS	7/1/2003 12:00:00 AM	STEVE DAROCI	ROUTINE	35		4	0	174	182	64	38	0.972 LT=35 ; RS=37.8%

Showing 1 to 10 of 30

DeltaX Fluid History								
Serial Number	Location	Designation	Equipment Type	Sample Date	Sampled By	Reason	Fluid Condition	Water
RAR66902	ADAMS	No. 1 SS	SS	6/11/2002 12:00:00 AM	KAHLER	DIAGNOSTIC	2	45
RAR66902	ADAMS	No. 1	TRN	6/11/2002 12:00:00 AM	KAHLER		2	34
RAR66902	ADAMS	No. 1 SS	SS	4/8/1994 12:00:00 AM	KAHLER	DIAGNOSTIC	2	
RAR66902	ADAMS	No. 1	TRN	4/8/1994 12:00:00 AM	KAHLER		1	

RTTimeRange

Start Time: 9/13/1998 8:11:50 AM End Time: 9/13/2006 8:11:50 AM [Apply] [Refresh] [Previous] [Next]



**SDG&E**

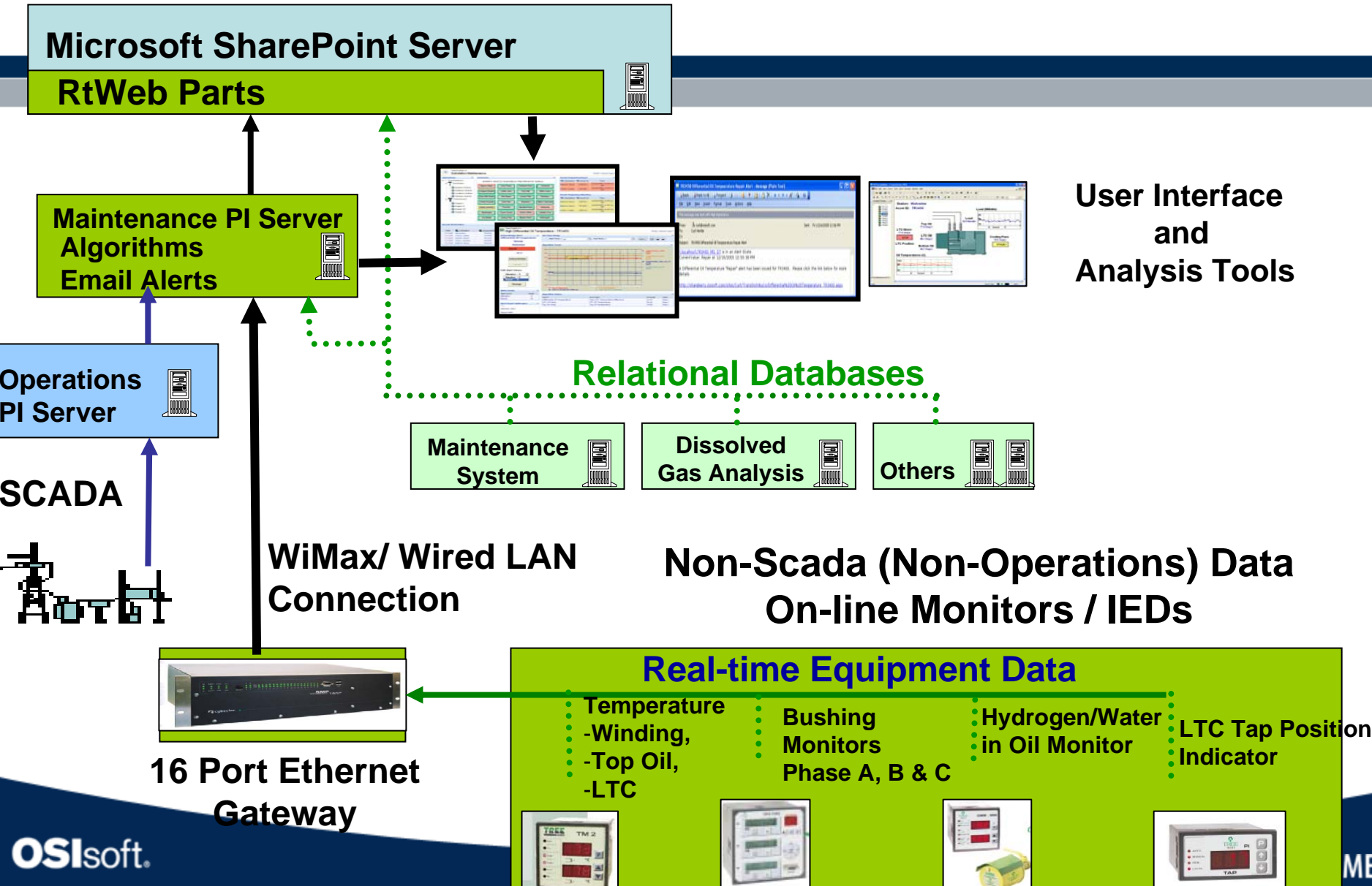
**(San Diego Gas & Electric)**

**RtCBM Program**

**(Real-time Condition Based Maintenance)**

**实时状态检修/维护**

# SDG&E RtCBM Architecture 架构



# RtCBM 数据集成

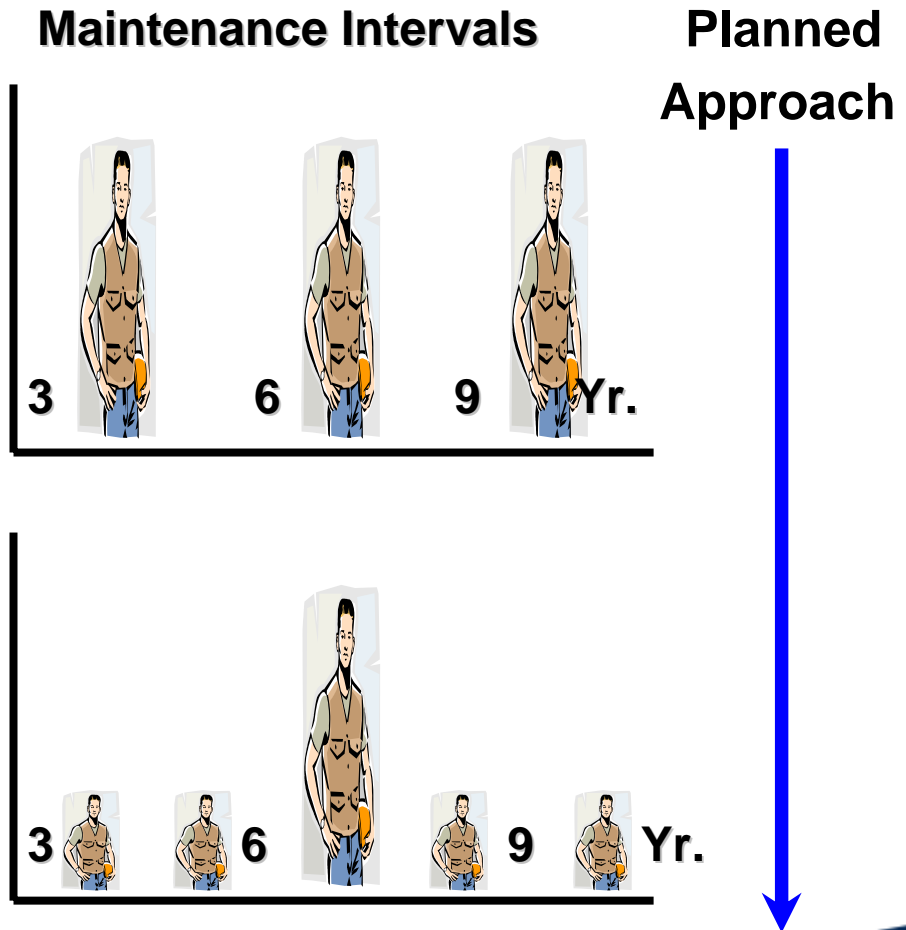
- Weekly general inspections 每周常规检查
  - LTC operations LTC操作
  - Alarms, temperature, visual 报警、温度、图像
- Monthly equipment inspections 每月设备检查
  - Operation counters 操作计数
  - Temperature, Pressure 温度、压力
  - Voltage 电压
  - Functional check 功能检查
- General Asset Data 普通资产数据
  - Rating 定额
  - Age, Type, Design 年限、类型、设计
  - Operating limits 操作限制
- Operational data 可操作数据
  - Relays & Digital fault recorders 继电器 & 数字错误记录
  - PQ Monitors PQ监控
- Specific Equipment Data 特定设备信息
  - Operating conditions 操作状态
  - Stress factors 压力因素
  - Trouble History 历史故障
  - Maintenance data 维护数据
  - Oil test data 石油测试数据
  - Electrical test data 电力测试数据
  - Operating speed 操作速度
- Real-time data 实时数据
  - Voltage & Current 电压 & 电流
  - Temperature 温度
  - Bushing On-line Power Factor 在线功率因数
  - Hydrogen in Oil 石油中氢含量
- Simulated data (modeling) 模拟数据 (模型)
- Other system & engineering data 其它系统 & 工程数据

# Time-based to RtCBM – Circuit Breakers

## 基于时间至 RtCBM- 断路器

### Data Available 数据有效性

- Weekly safety inspections 每周的安全检查
- Monthly equipment insp. 每月的设备检查
- Asset Data 资产数据
- Historical Data 历史数据
  - Operating conditions 操作状态
  - Stress factors 重点因素
  - Trouble 故障
  - Maintenance data 维护数据
  - Test data (insul & elec) 测试数据
- Operational data 可操作数据
  - Relays & Digital fault recorders 继电器 & 数字错误记录
  - PQ Monitors PQ (有/无功) 监控
- Real-time data 实时数据
  - Voltage & Current 电压 & 电流
  - I<sup>2</sup>T and Contact Wear I<sup>2</sup>T 以及接触磨损
  - Operations Counter 操作计数



# Circuit Breaker Operations

## 断路器操作

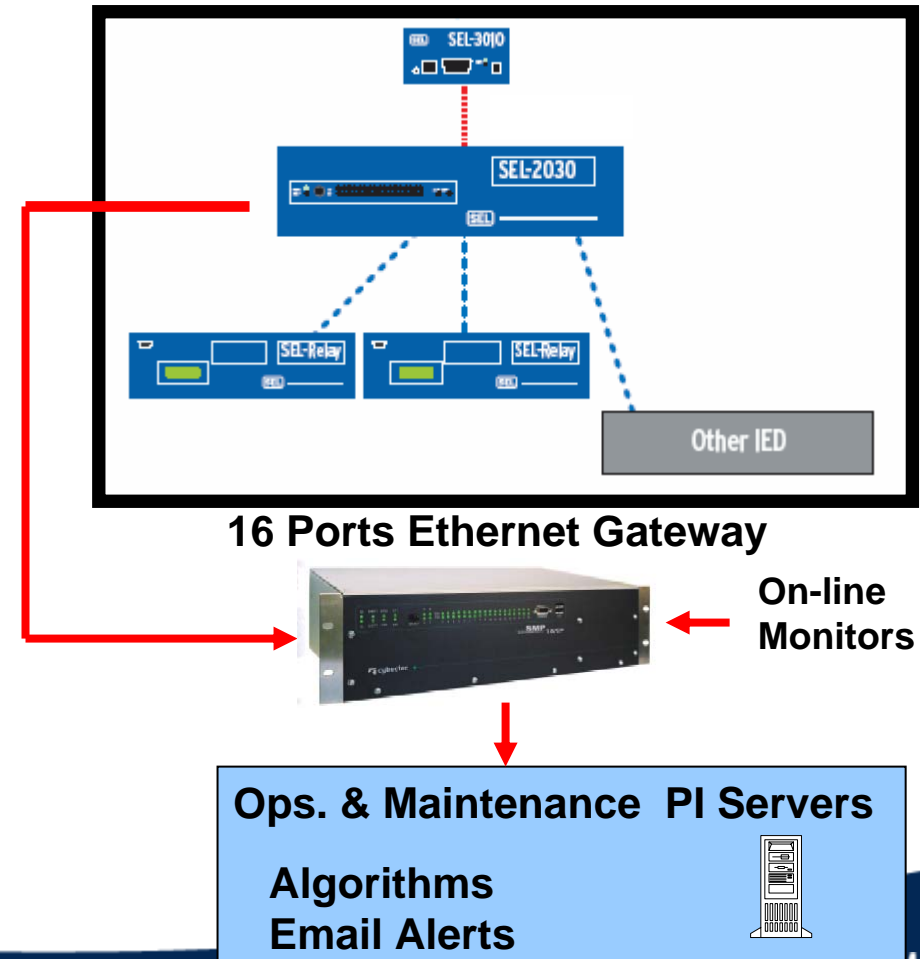
### 关注

- Proper fault clearing 适当的故障清除
- Fault testing with a circuit breaker 用断路器做故障测试

### 方案

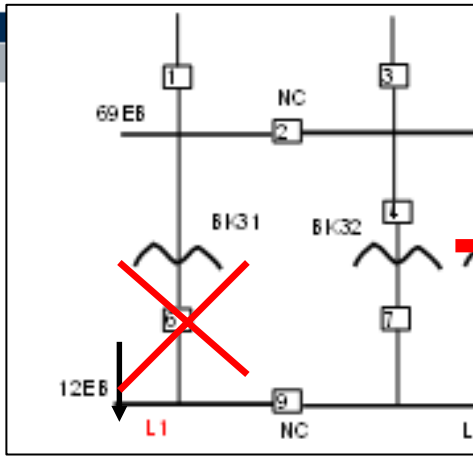
- **Verify the health of CB 检验CB的性能**
  - Contact wear 接触磨损
  - Insulation medium integrity 绝缘介质完整性
  - Bushings and accessories 套管及备件
  - Operating history 历史操作
- Use historic and real time contact wear data ( $I^2T$ ) to make a decision 使用历史和实时接触磨损数据( $I^2T$ ) 来做决策

### Substation Relays with Circuit Breaker Monitor



# Transformer at Emergency Rating

## 紧急状态等级的变压器



### 变压器性能检测

- **Insulation Power Factor** 功率因数
- **LTC Application & Design**  
LTC设计及应用
- **Oil Conditions** 变压器油状态
- **Bushing & Accessories** 套管和附件
- 操作记录及状态

### Paper Insulation Health

Location of Paper Sample	Degree of Polymerization (DP)
NLTC – Phase A	586
NLTC – Phase B	737
69kV Bushing C	688

**New Insulation Paper:**

**Middle Aged Insulation Paper:**

**Old Age Insulation Paper:**

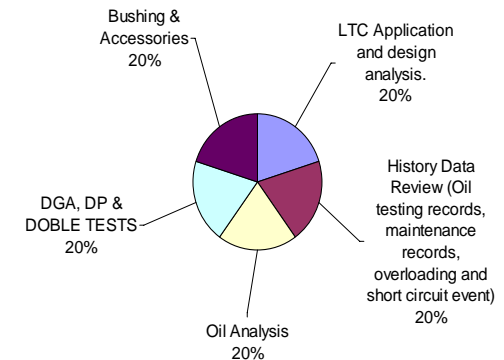
**Severely Degraded Insulation Paper:**

**1000 < DP<sub>v</sub> < 1300**

**DP<sub>v</sub> = 500**

**DP<sub>v</sub> < 251**

**DP<sub>v</sub> < 151**



# Transformer at Emergency Rating

## 紧急状态等级的变压器

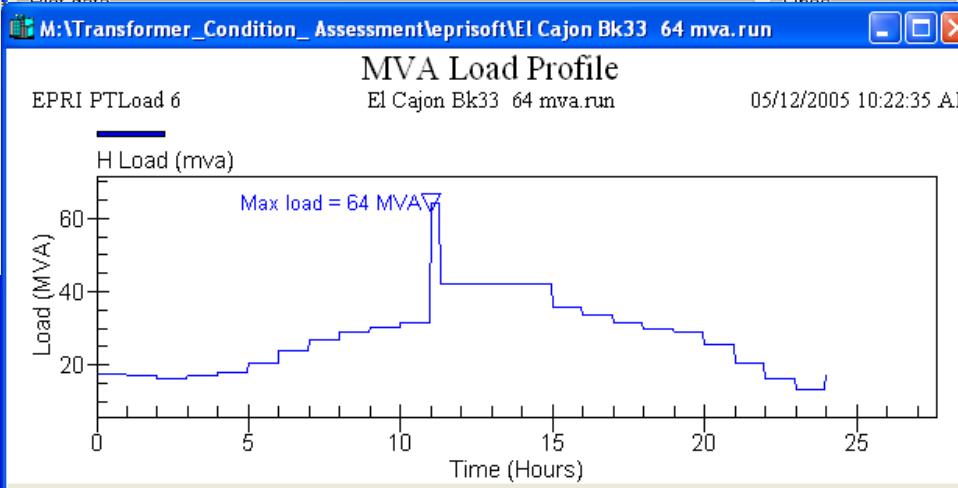
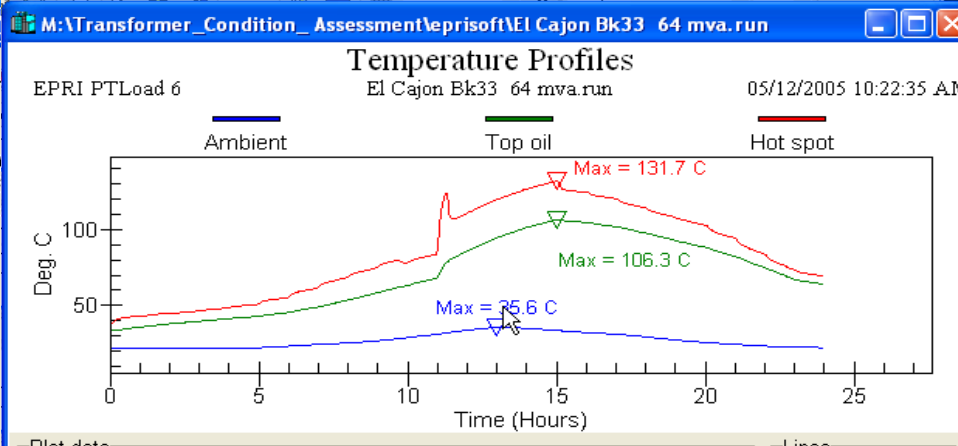
PTLOAD-Design - ...ion\_Assessment\eprisoft\El Cajon Bk33 64 mva.run

File Edit Tools Options Help

Transformer Cooling Ambient Load Bubbles Calc Results  
Cycle Cycle Type

**A. OUTPUT SUMMARY**  
 Date of Calculation = 05/12/2005 10:22:35 AM  
 Number Iterations = 6  
 Limiting factor = Fixed upper limit  
 Contingency Load (Amps) = 2963.145  
 Peak Load (MVA) = 64  
 Peak Load (Amps) = 2963.145  
 Peak Load (PU) = 2.285714  
 \*\* Warning: ratings in excess of 2.0 P.U. are not supported by IEEE guidelines and the results may be unreliable.  
 Max Hot Spot (Deg C) = 131.64  
 Max Top Oil (Deg C) = 106.19  
 Peak Age Accel Factor = 8.1068  
 Cumulative % Loss of Life = 0.01401  
 Max Bubble Risk (mmHg) = -799.5175

Bubbles are not likely to form given the temperature and load profile



### Comparison of hot spot rise over top oil simulated versus actual

	Top Oil	Hot Spot	LOL
IEEE	105	176	.149
Ptload	105	145	.039
Actual HS rise	106	131	.014

**Decision: Based on Transformer Unit Health and Real Time Conditions**

决定：取决于变压器的各部件性能和实时状态



# Summary of RtCBM Benefits

## RtCBM效益总览

- **Operations Benefits 操作效益**
  - *Avoid potential equipment failure 避免潜在的设备故障*
  - *Increase asset availabilities 加强资产可用性*
  - *Respond to equipment alarms according to priorities 根据优先权响应设备报警*
  - *Maximize asset loading capabilities 资产负载性能最大化*
- **Maintenance Benefits 维护效益**
  - *Early warning and indication to address conditions 早期告警并指示异常位置*
  - *Reduce overtime on reactive maintenance 减少反复维护次数*
  - *Minimize equipment outages 设备断电次数最小化*
- **Asset Planning Benefits 资产计划效益**
  - *Improve future equipment specification and application to maximize utilization and performance 提升未来设备指标，使设备效用及性能最大化*

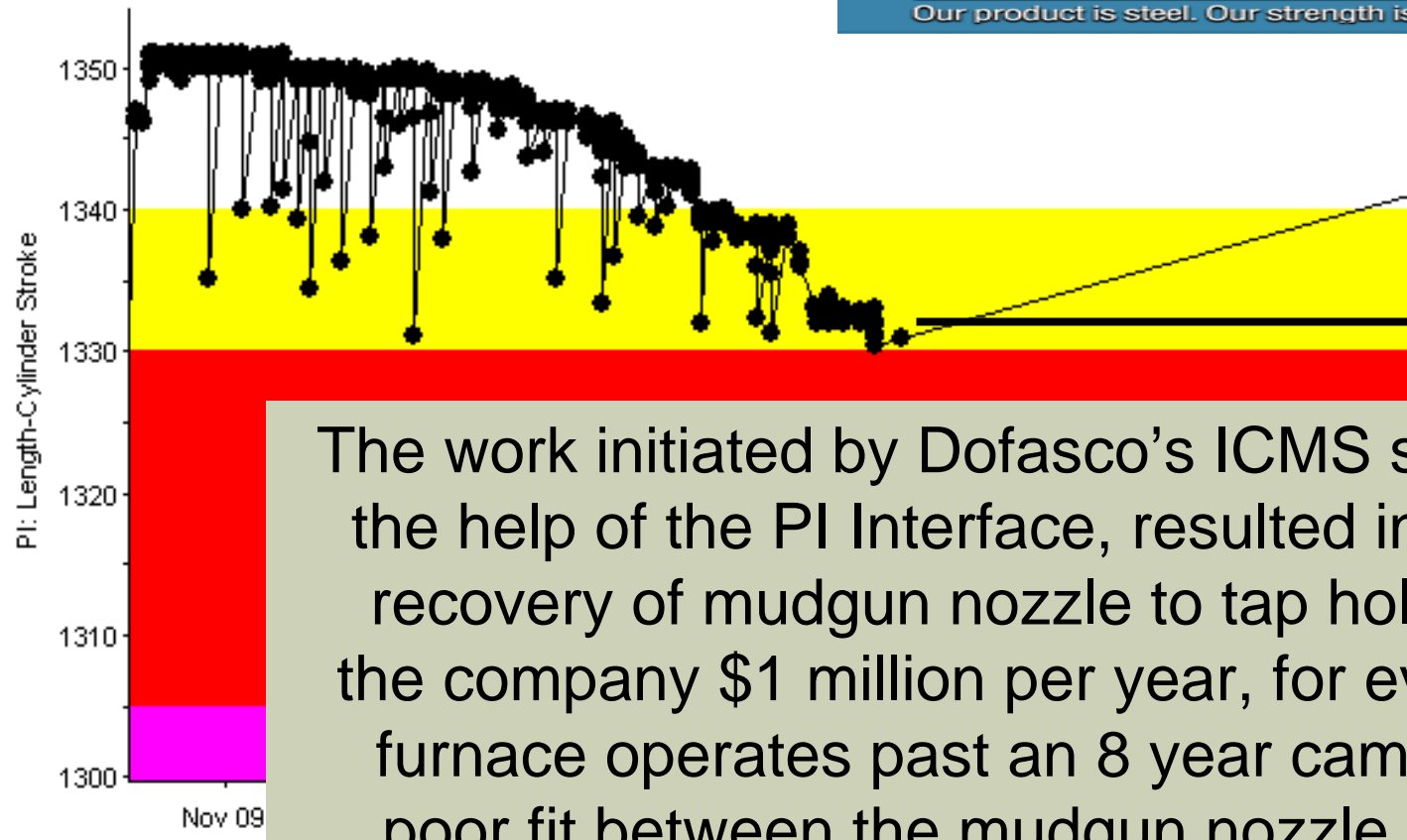
# More PI Customer Testimonials/ROI

更多 **PI** 系统用户的见证和投资回报

# Improve Control Center Operations

## 提升改善控制中心操作运行

Graph - BAYN.PROC.IRON.BF4.CAST.GUDR.EGUN.SWIN.CYL: PI: Length-Cylinder Stroke vs Date

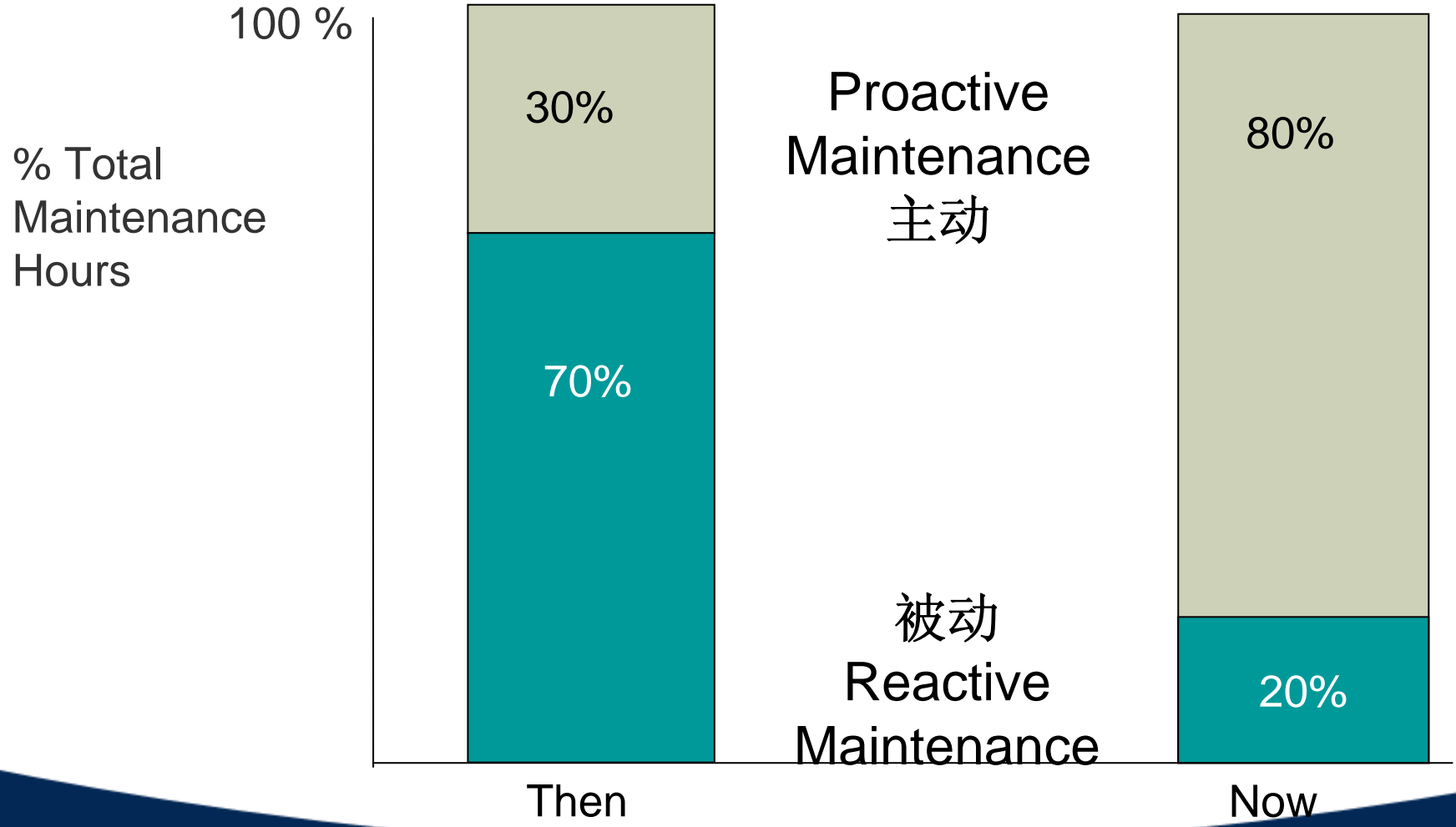


Savings:  
~\$1M/yr

The work initiated by Dofasco's ICMS system, with the help of the PI Interface, resulted in a complete recovery of mudgun nozzle to tap hole fit, saving the company \$1 million per year, for every year the furnace operates past an 8 year campaign. The poor fit between the mudgun nozzle to tap hole, would not have been evident or remedied by the operators, based on existing control room data.

# Dofasco's Change in Maintenance Culture

## From 78% to 91% Equipment Availability



# Dofasco-Canada, Reliability Manager

“In Blast Furnace #4, we have extended the furnace campaign from 8 years to 15 years, resulting in a savings of \$1MM per year, or **\$7 MM** for 7 years. For Blast Furnace #3 we have extended the campaign from 8 years to 20 years, resulting in a savings of \$1MM per year, which results in a savings of **\$12MM** for 12 years. The projected savings are **\$19 MM** just for this case...”



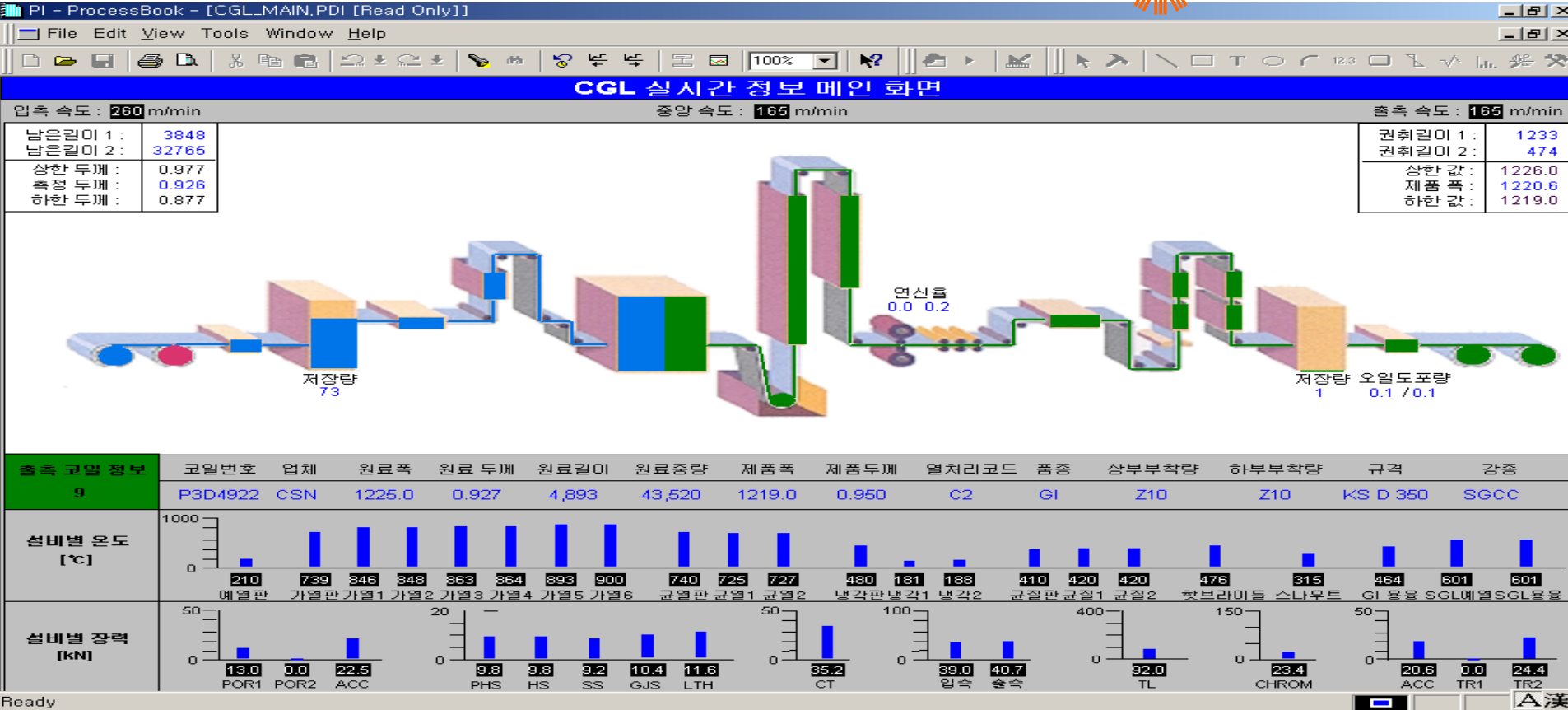
**Vlad Djuric,**  
**Reliability Manager**  
**Dofasco, Canada**

# Reduce Costs and Improve Quality

## 降低成本和提高性质



DONGBU STEEL



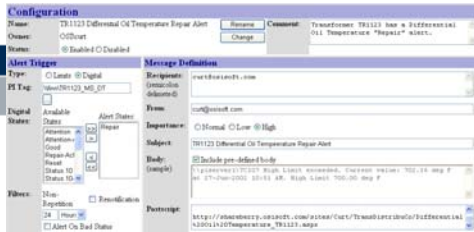
### Major Measuring Devices

- \* Thickness Gauge
- \* Zinc Coating Weight
- \* Furnace Thermometers
- \* Tension Meters
- \* Pin Hole Detector

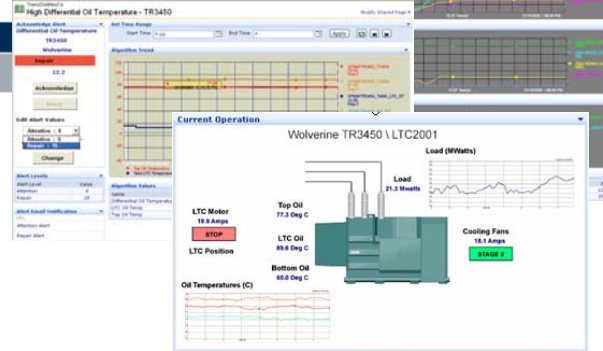
# OSIsoft Enabling Technology

OSIsoft 科技支持

# PI RtCBM 过程



**Alert Notification  
(PI Notification  
RtAlerts) 报警通知**



**Integrated Asset  
Information  
资产信息集成  
(RtWebParts)**



Disolved Gas Analysis

Sample Date	H2	CH4	C2H6	C2H4	C2H2	CO2	CO
09/26/90	193	115	137	38	<1	3004	223
08/01/94	279	185	164	51	<1	4213	341
03/06/95	489	399	320	109	<1	1652	315
03/28/96	1258	1980	590	369	<1	6524	530
03/21/98	1390	2568	790	561	<1	5952	554

**Asset Information 资产信息  
Structure  
(MDB and AF)**

TransDistribCo - Asset Maintenance Report

Reporting Period: 12/05/05 04:04 PM through 02/03/06 04:04 PM

Asset ID: TR3450 Substation: Wolverine

Serial No. Manufacturer Year Model MVA Rating kV Rating Fluid Capacity  
X9945 SEIMENS 1959 G-4567 50 120 3440

Time In Hours	Maintenance Algorithm Status Summary			
	Good	Attention	Repair	Repair (ACK)
Asset Status	311	73	953	103
Differential Oil Temperature	2	23	999	414

Station Reliability

Asset	Good	Attention	ack	Repair	ack
TR6676	0.0%	0.0%	100.0%	0.0%	
TR5493	100.0%	0.0%		0.0%	
TR4085	100.0%	0.0%		0.0%	
TR3450	0.0%	1.2%		98.8%	
TR1123	100.0%	0.0%		0.0%	

Showing 1 to 5 of 6

**Asset Reliability  
资产可靠性  
(PI OLEDB and  
RtReports)**

**Real-time Rule  
Assessment  
(PI ACE)**



**Improve Reliability  
提高可靠性**





# 结语

- 凭借你的现有的投资和资源, 更加利用 **PI**系统, 以为你们的单位组织, 提供更多的价值
- 进一步扩大效益, 由操作运行, 到工程, 计划, 保护, 维修和资产管理

谢谢 !!