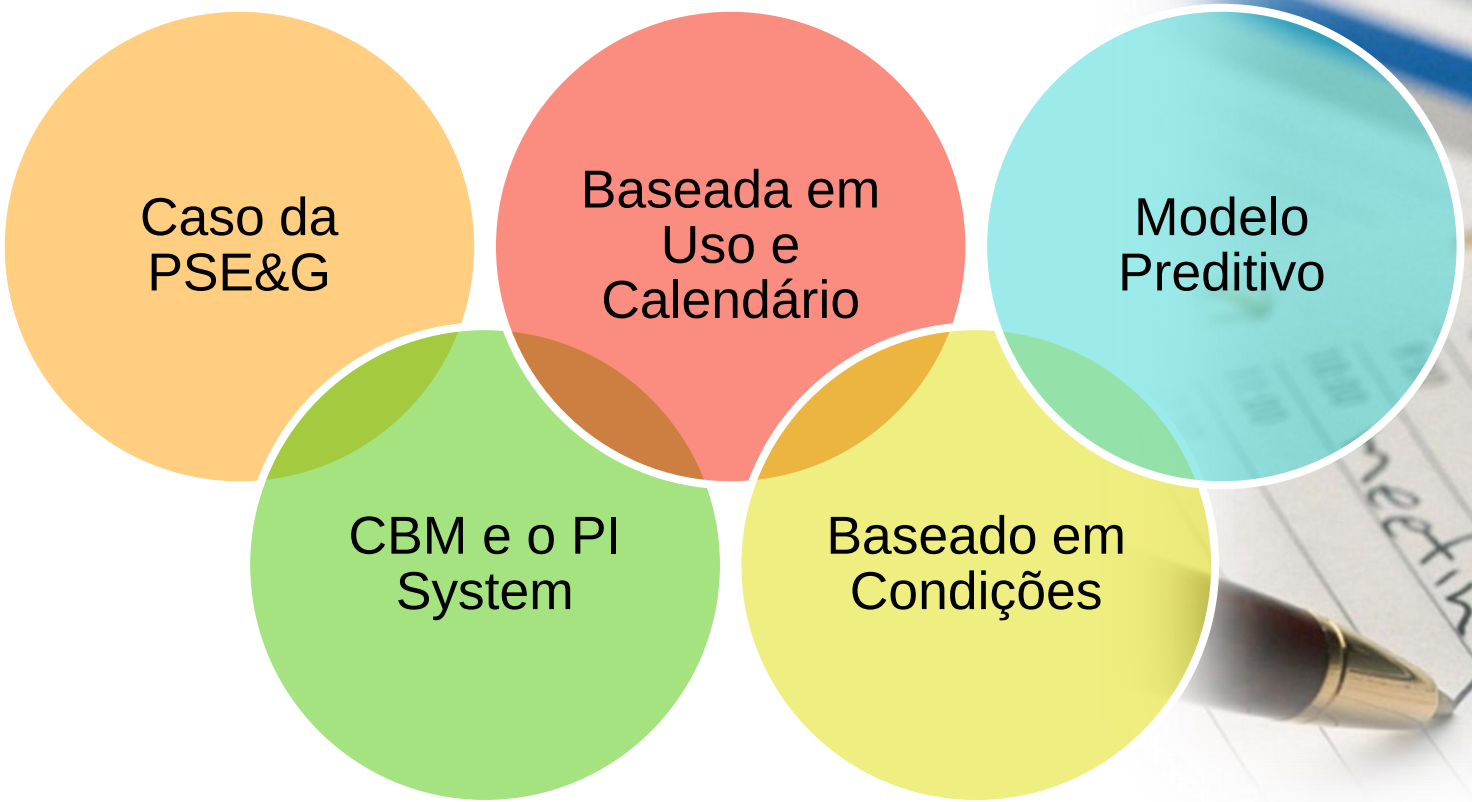
Obrigado pela participação!

O webinar começará em instantes

Para conectar o audio, selecione "Communicate" -> Audio Connection e escolha a saída de áudio que deseja utilizar para escutar ao Webinar

CBM - Estratégias para evitar falhas e reduzir custos

Agenda



Conditioned Based Maintenance (CBM)

Presented by:

Richard Wernsing

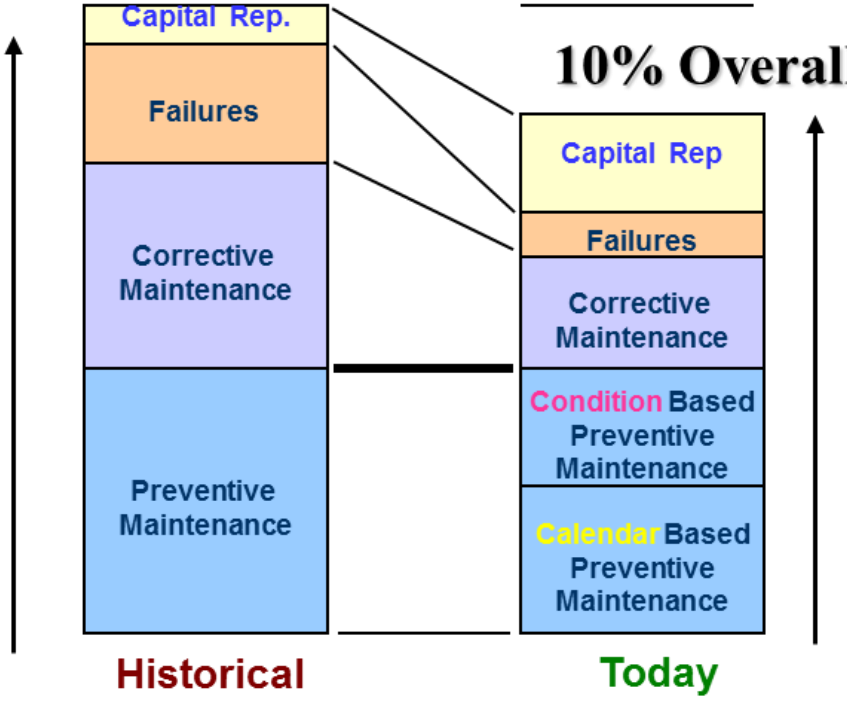
Asset Information and System Policy Leader

Presented for:
San Paulo, Brazil
OSI Soft User Group
Richard Wernsing
June 8 2016

PSE&G
We make things work for you.

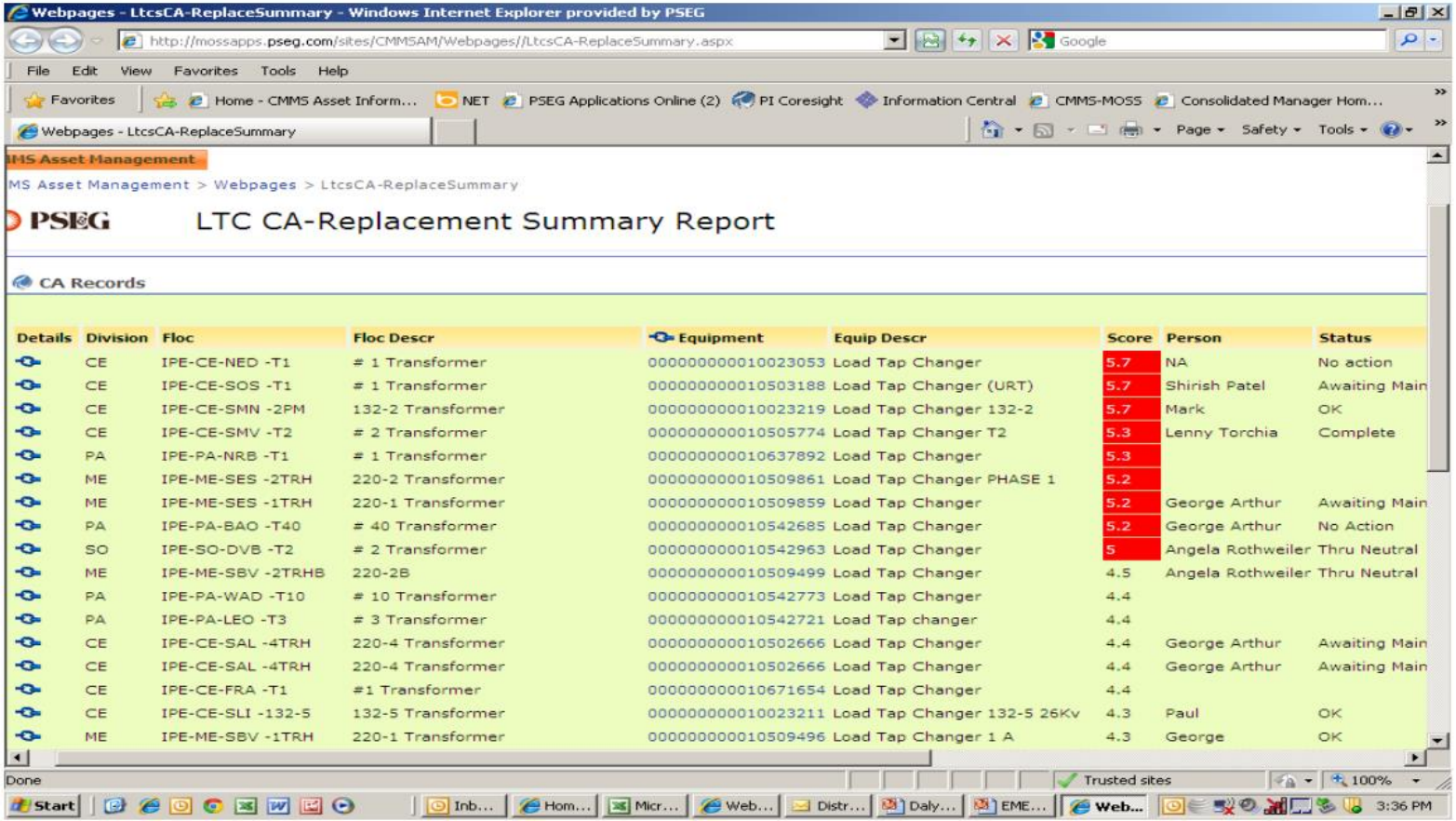
Benefits Breakdown

These annual expenditures protect $1.7 B of inside plant assets and full benefits after approximately five years.



Note:
Illustration depicts overall changes in maintenance investment strategy.

Asset Health Score

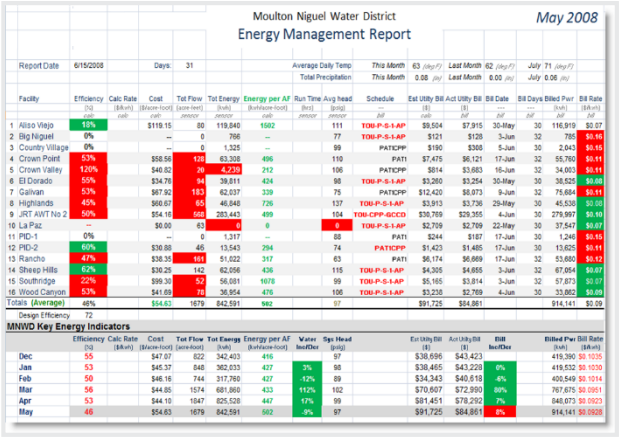


Details	Division	Floc	Floc Descr	Equipment	Equip Descr	Score	Person	Status
	CE	IPE-CE-NED -T1	# 1 Transformer	000000000010023053	Load Tap Changer	5.7	NA	No action
	CE	IPE-CE-SOS -T1	# 1 Transformer	000000000010503188	Load Tap Changer (URT)	5.7	Shirish Patel	Awaiting Main
	CE	IPE-CE-SMN -2PM	132-2 Transformer	000000000010023219	Load Tap Changer 132-2	5.7	Mark	OK
	CE	IPE-CE-SMV -T2	# 2 Transformer	000000000010505774	Load Tap Changer T2	5.3	Lenny Torchia	Complete
	PA	IPE-PA-NRB -T1	# 1 Transformer	000000000010637892	Load Tap Changer	5.3		
	ME	IPE-ME-SES -2TRH	220-2 Transformer	000000000010509861	Load Tap Changer PHASE 1	5.2		
	ME	IPE-ME-SES -1TRH	220-1 Transformer	000000000010509859	Load Tap Changer	5.2	George Arthur	Awaiting Main
	PA	IPE-PA-BAO -T40	# 40 Transformer	000000000010542685	Load Tap Changer	5.2	George Arthur	No Action
	SO	IPE-SO-DVB -T2	# 2 Transformer	000000000010542963	Load Tap Changer	5	Angela Rothweiler	Thru Neutral
	ME	IPE-ME-SBV -2TRHB	220-2B	000000000010509499	Load Tap Changer	4.5	Angela Rothweiler	Thru Neutral
	PA	IPE-PA-WAD -T10	# 10 Transformer	000000000010542773	Load Tap Changer	4.4		
	PA	IPE-PA-LEO -T3	# 3 Transformer	000000000010542721	Load Tap changer	4.4		
	CE	IPE-CE-SAL -4TRH	220-4 Transformer	000000000010502666	Load Tap Changer	4.4	George Arthur	Awaiting Main
	CE	IPE-CE-SAL -4TRH	220-4 Transformer	000000000010502666	Load Tap Changer	4.4	George Arthur	Awaiting Main
	CE	IPE-CE-FRA -T1	#1 Transformer	000000000010671654	Load Tap Changer	4.4		
	CE	IPE-CE-SLI -132-5	132-5 Transformer	000000000010023211	Load Tap Changer 132-5 26Kv	4.3	Paul	OK
	ME	IPE-ME-SBV -1TRH	220-1 Transformer	000000000010509496	Load Tap Changer 1 A	4.3	George	OK

Reducing Energy Costs

Moulton Niguel Water
Leading the Way in Service

Energy management is a business process in Moulton Niguel Water where **Reduce energy costs** for pumping water in the distribution network relieves a strain to operation budget



Moulton Niguel Water District — May 2008
Energy Management Report

Report Date	6/15/2008	Days:	31	Average Daily Temp:	This Month	63 (deg-F)	Last Month	62 (deg-F)	July 71 (deg-F)
				Total Precipitation	This Month	0.08 (in)	Last Month	0.00 (in)	July 0.06 (in)

	Facility	Efficiency (%)	Calc Rate ($/kWh)	Cost ($/acre-foot)	Tot Flow (acre-feet)	Tot Energy (kWh)	Energy per AF (kWh/acre-foot)	Run Time (hrs)	Avg head (psig)	Schedule	Est Utility Bill ($)	Act Utility Bill ($)	Bill Date	Bill Days	Billed Pwr (kW)	Bill Rate ($/kWh)
1	Aliso Viejo	58%		$119.15	80	119,040	1502		111	TOU-P-S-1-AP	$9,504	$7,915	30-May	30	116,919	$0.07
2	Big Niguel	0%		--	0	766	--		77	TOU-P-S-1-AP	$121	$128	3-Jun	32	785	$0.16
3	Country Village	0%		--	0	1,325	--		99	PATICPP	$190	$308	5-Jun	30	2,043	$0.15
4	Crown Point	53%		$58.56	128	63,308	496		110	PAT1	$7,475	$6,121	17-Jun	32	55,760	$0.11
5	Crown Valley	120%		$40.82	20	4,230	212		106	PATICPP	$814	$3,683	16-Jun	32	34,003	$0.11
6	El Dorado	55%		$34.79	94	39,011	414		98	TOU-P-S-1-AP	$3,260	$3,254	30-May	30	38,526	$0.09
7	Galivan	53%		$67.92	183	62,037	339		75	PATICPP	$12,420	$8,073	9-Jun	32	76,684	$0.11
8	Highlands	45%		$60.67	65	46,848	726		137	TOU-P-S-1-AP	$3,913	$3,736	29-May	30	45,538	$0.08
9	JRT AWT No 2	50%		$54.16	568	283,443	499		104	TOU-CPP-SCCD	$30,769	$29,355	4-Jun	30	279,997	$0.10
10	La Paz	--		$0.00	63	0	0		0	TOU-P-S-1-AP	$2,709	$2,709	22-May	30	37,547	$0.07
11	PID-1	0%		--	0	1,317	--		88	PAT1	$244	$187	17-Jun	30	1,240	$0.15
12	PID-2	60%		$30.88	46	13,543	294		74	PATICPP	$1,423	$1,485	17-Jun	30	13,625	$0.11
13	Rancho	47%		$38.35	161	51,022	317		63	PAT1	$6,174	$6,669	17-Jun	32	53,660	$0.12
14	Sheep Hills	62%		$30.25	142	62,056	436		115	TOU-P-S-1-AP	$4,305	$4,655	3-Jun	32	67,054	$0.07
15	Southridge	22%		$99.30	52	56,081	1078		99	TOU-P-S-1-AP	$5,165	$3,814	3-Jun	32	57,873	$0.07
16	Wood Canyon	53%		$41.69	78	36,954	476		106	TOU-P-S-1-AP	$3,218	$2,769	4-Jun	30	33,862	$0.09
Totals (Average)		46%		$54.63	1679	842,591	502		97		$91,725	$84,861			914,141	$0.09
	Design Efficiency	72														

MNWD Key Energy Indicators

	Efficiency (%)	Calc Rate ($/kWh)	Cost ($/acre-foot)	Tot Flow (acre-feet)	Tot Energy (kWh)	Energy per AF (kWh/acre-foot)	Water Inst/Dec	Sys Head (psig)	Est Utility Bill ($)	Act Utility Bill ($)	Bill Inst/Dec	Billed Pwr (kW)	Bill Rate ($/kWh)
Dec	55		$47.07	822	342,403	416		97	$38,696	$43,423		419,390	$0.1035
Jan	53		$45.37	848	362,033	427	3%	98	$38,465	$43,228	0%	419,532	$0.1030
Feb	50		$46.16	744	317,760	427	-12%	89	$34,343	$40,618	-6%	400,549	$0.1014
Mar	56		$44.85	1574	681,869	433	112%	102	$70,607	$72,990	80%	767,675	$0.0951
Apr	53		$44.10	1847	825,528	447	17%	99	$81,451	$78,292	7%	848,073	$0.0923
May	46		$54.63	1679	842,591	502	-9%	97	$91,725	$84,861	8%	914,141	$0.0928

CHALLENGES

Lack of operational visibility and real-time analytics for energy consumption

- The need to deliver safe drinking water cost effectively

SOLUTION

Energy management becoming a business process with PI as the core solution

- Reduce electrical demand charges

RESULTS

Monitoring pump efficiency and optimizing electrical consumption of pumping in real time to leverage demand response and time of use, thereby reducing electricity costs by 15%

- Reduce energy costs within the water distribution network by $200,000+ per year

Real-time Energy Management

Moulton Niguel Water
Leading the Way in Service

15% or $200,000+ Annual energy savings, Save $1.50/person served each year

								Total Precipitation		This Month	0.08 (in)	Last Month	0.00 (in)	July	0.06 (in)	
	Facility	Efficiency	Calc Rate	Cost	Tot Flow	Tot Energy	Energy per AF	Run Time	Avg head	Schedule	Est Utility Bill	Act Utility Bill	Bill Date	Bill Days	Billed Pwr	Bill Rate
		(%)	($/kwh)	($/acre-foot)	(acre-feet)	(kwh)	(kwh/acre-foot)	(hrs)	(psig)	---	($)	($)	---	---	(kwh)	($/kwh)
		calc	calc	calc	sensor	sensor	calc	sensor	sensor	bill	calc	bill	bill	bill	bill	bill
1	Aliso Viejo	18%		$119.15	80	119,840	1502		111	TOU-P-S-1-AP	$9,504	$7,915	30-May	30	116,919	$0.07
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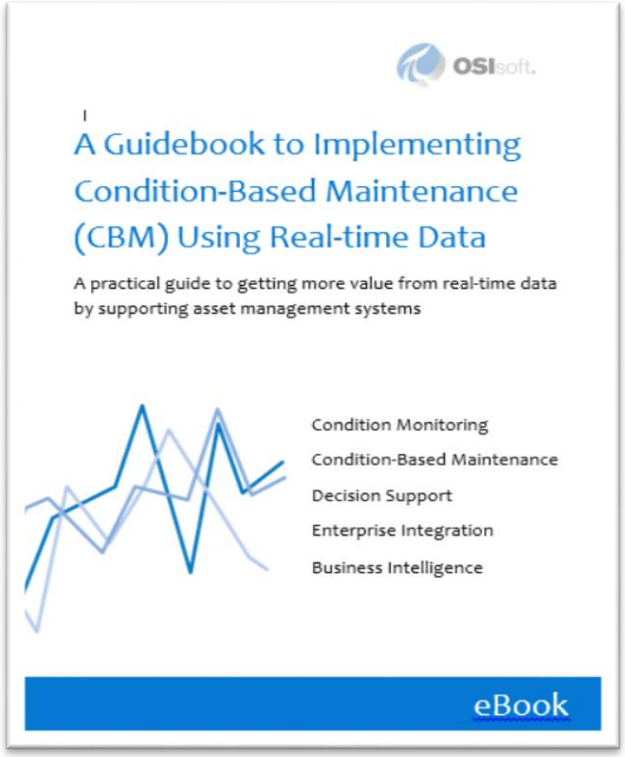
	(%)	($/kwh)	($/acre-foot)	(acre-foot)	(kwh)	(kwh/acre-foot)		(psig)		($)	($)			(kwh)	($/kwh)
Dec	55		$47.07	822	342,403	416		97		$38,696	$43,423			419,390	$0.1035
Jan	53		$45.37	848	362,033	427	3%	98		$38,465	$43,228	0%		419,532	$0.1030

Guia de implementação de CBM com o PI System



Terms & Definitions

Implementation Guidance

PI System Overview for CBM

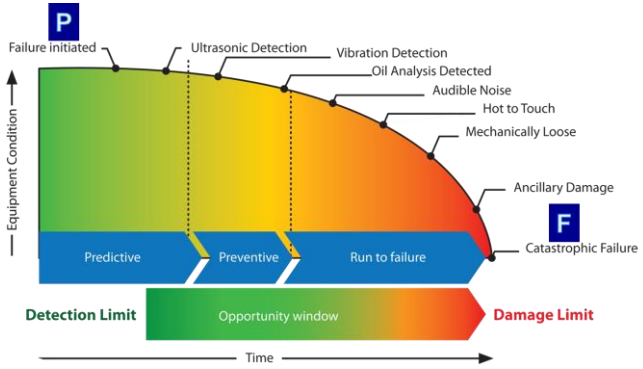
PI System Integration w/ CMMS

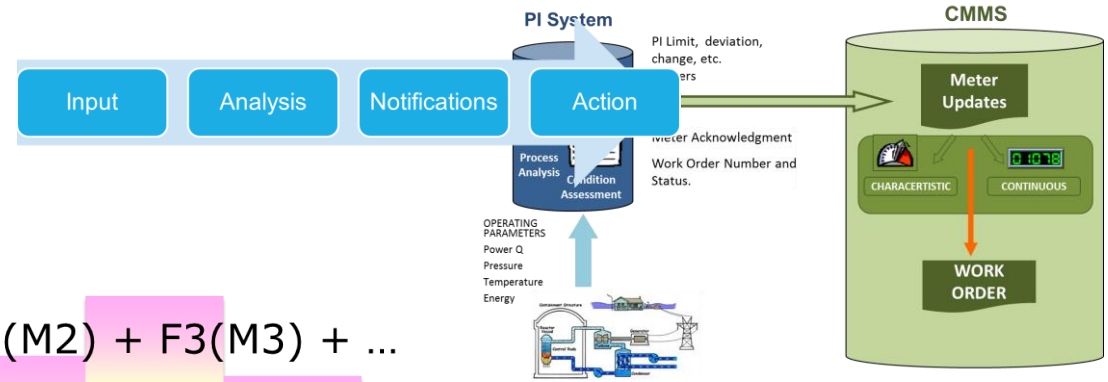
Enabling Opportunities

Solution Examples

Industry References

Quatro Metodologias todas possíveis com PI System





$$CA = F1(M1) + F2(M2) + F3(M3) + \ldots$$

Condition Assessment & Criticality Determination

Motor =
Análise do Óleo Lubrificante = 4 (0.3) = 1.2
+ Vida útil remanescente = 3 (0.2) = 0.6
+ Idade do Equipamento= 4 (0.1) = 0.4
+ Carga Máxima Suportada = 4 (0.2) = 0.8
+ Histórico de Falhas = 2 (0.2) = 0.6
= **3.6 (of 5)**

Os 6 passos de CBM *com o* PI System

PI Integrators &
PI System Access

Microsoft SQL Server · infor · sas · SAP · ORACLE · IBM · JDEdwards

1. Conectar às fontes relevantes
2. Coletar e armazenar os datos
3. Criar contexto (Baseado em ativos)
4. Aplicar lógica de Monitoramento de Condições
5. Visualizar condições em tempo real
6. Alertar e notificar

PI Interfaces & PI Connectors

Notifications

Event Frames

Analysis

PI Asset Framework

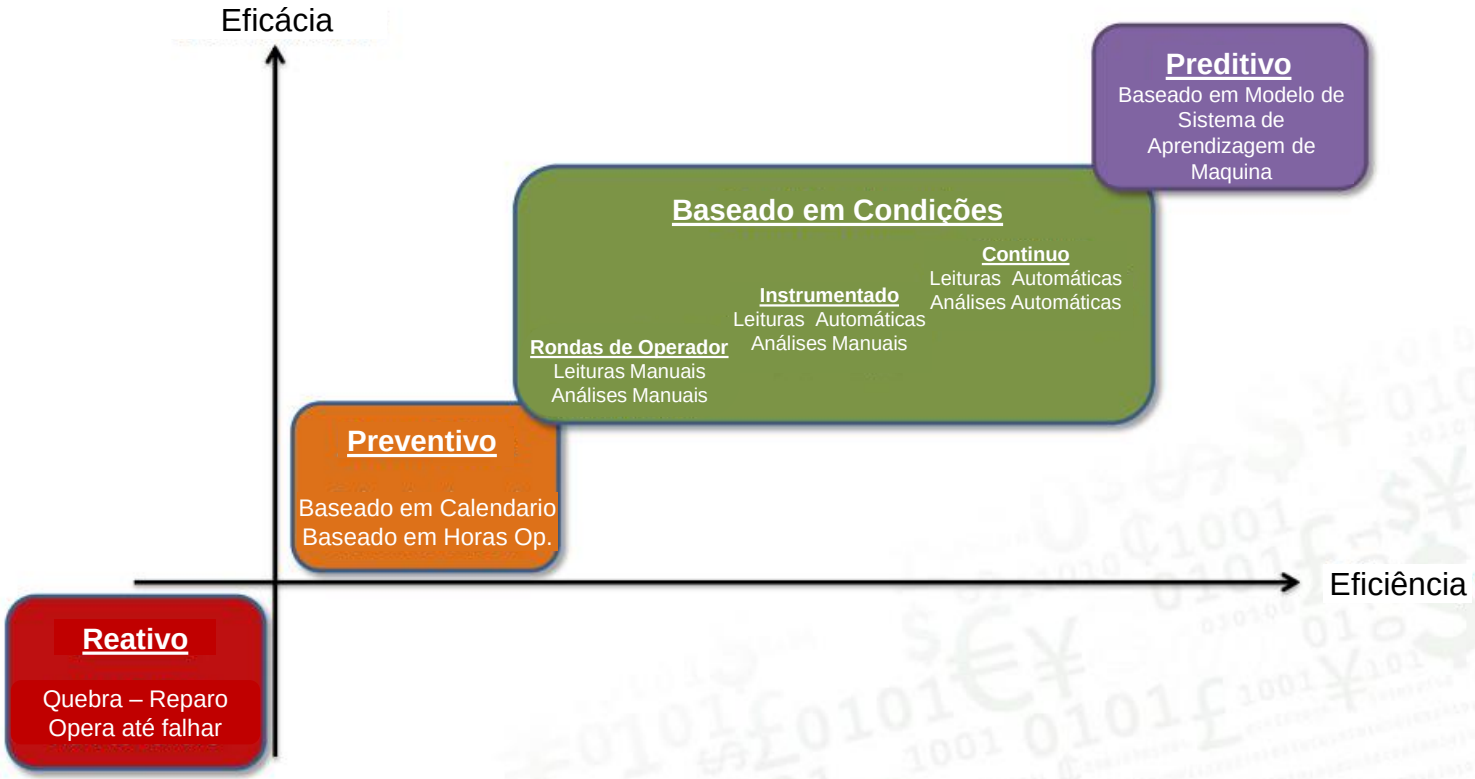
PI Data Archive

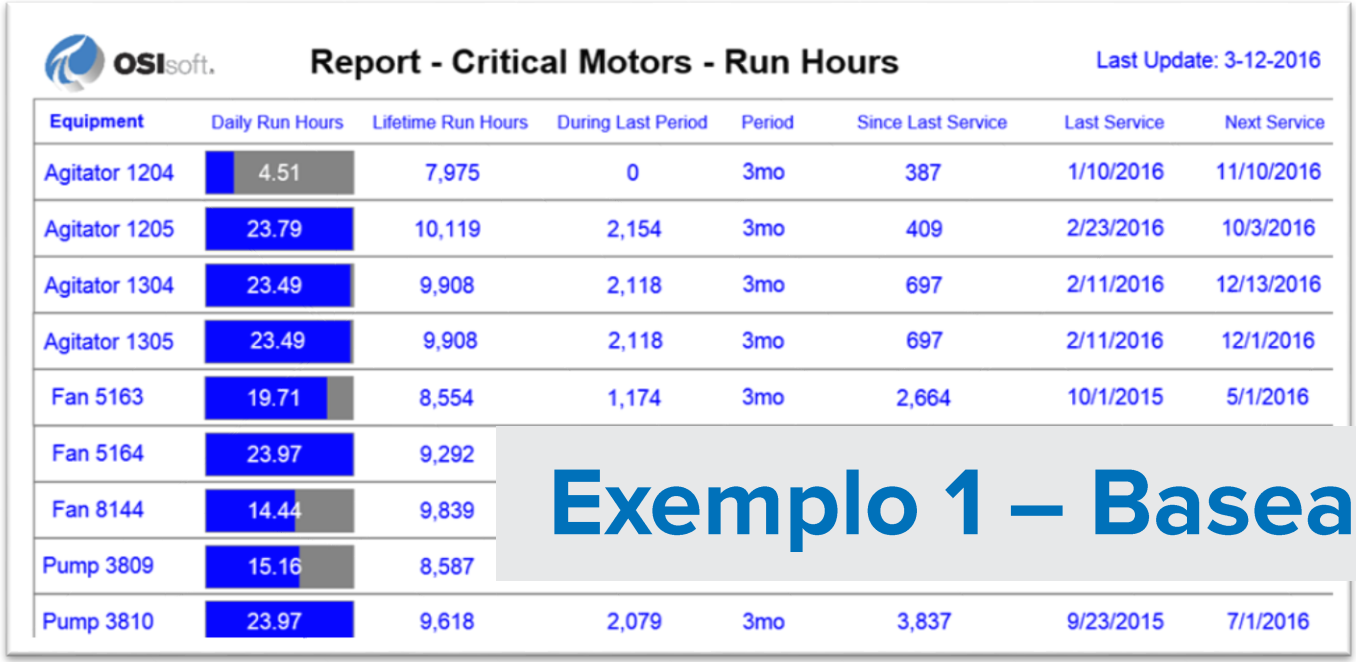
PI Server

PI Visualization Suite

- PI Coresight
- PI ProcessBook
- PI DataLink
- PI WebParts

Além da Manutenção Baseada em Calendario





OSIsoft.

Report - Critical Motors - Run Hours

Last Update: 3-12-2016

Equipment	Daily Run Hours	Lifetime Run Hours	During Last Period	Period	Since Last Service	Last Service	Next Service
Agitator 1204	4.51	7,975	0	3mo	387	1/10/2016	11/10/2016
Agitator 1205	23.79	10,119	2,154	3mo	409	2/23/2016	10/3/2016
Agitator 1304	23.49	9,908	2,118	3mo	697	2/11/2016	12/13/2016
Agitator 1305	23.49	9,908	2,118	3mo	697	2/11/2016	12/1/2016
Fan 5163	19.71	8,554	1,174	3mo	2,664	10/1/2015	5/1/2016
Fan 5164	23.97	9,292					
Fan 8144	14.44	9,839					
Pump 3809	15.16	8,587					
Pump 3810	23.97	9,618	2,079	3mo	3,837	9/23/2015	7/1/2016

Exemplo 1 – Baseado em Uso

Report - Critical Motors - Run Hours

Last Update: 7-11-2016

Equipment	Daily Run Hours	Lifetime Run Hours	During Last Period	Period	Since Last Service	Last Service	Next Service
Agitator 1204	0.00	8,373	398	3mo	395	1/10/2016	11/10/2016
Agitator 1205	24.00	13,037	2,907	3mo	3,327	2/23/2016	10/3/2016
Agitator 1304	24.00	12,828	2,908	3mo	3,616	2/11/2016	12/13/2016
Agitator 1305	24.00	12,828	2,908	3mo	3,616	2/11/2016	12/1/2016
Fan 5163	24.00	12,331	3,778	3mo	6,441	10/1/2015	5/1/2016
Fan 5164	24.00	12,155	2,862	3mo	6,428	10/2/2015	5/2/2016
Fan 8144	24.00	12,751	2,902	3mo	6,547	10/5/2015	5/5/2016
Pump 3809	0.00	8,983	387	3mo	3,614	10/10/2015	5/10/2016
Pump 3810	24.00	12,487	2,858	3mo	6,706	9/23/2015	7/1/2016
Pump 5301	24.00	11,999	2,841	3mo	5,342	11/20/2015	8/1/2016
Pump 5302	0.00	7,828	279	3mo	2,787	11/11/2015	8/23/2016
Pump 8209	0.00	10,310	470	3mo	2,818	12/2/2015	9/1/2016
Pump 8210	24.00	11,499	2,886	3mo	5,354	10/2/2015	5/2/2016

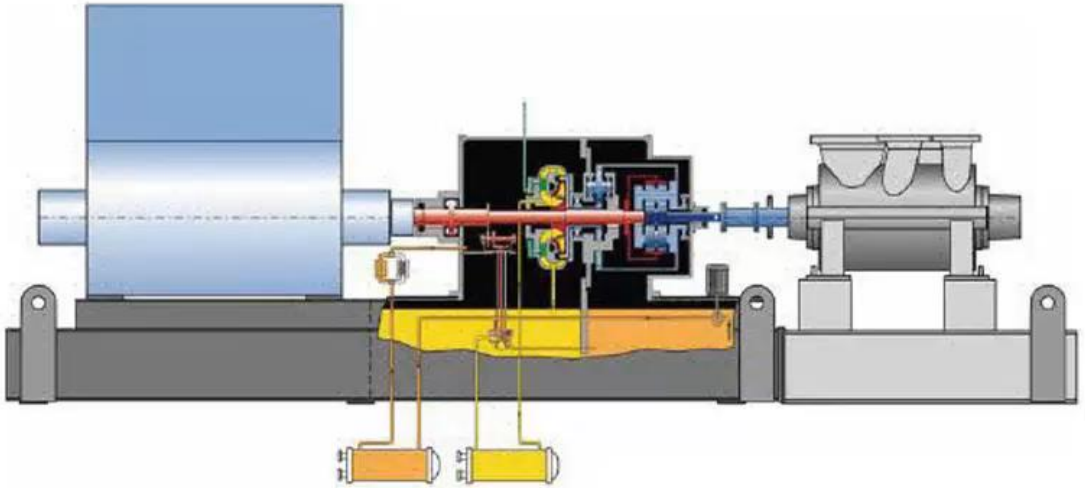
6/11/2016 11:59:33 AM | 30d | Now | 7/11/2016 11:59:33 AM

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW PI DATALINK PI BUILDER

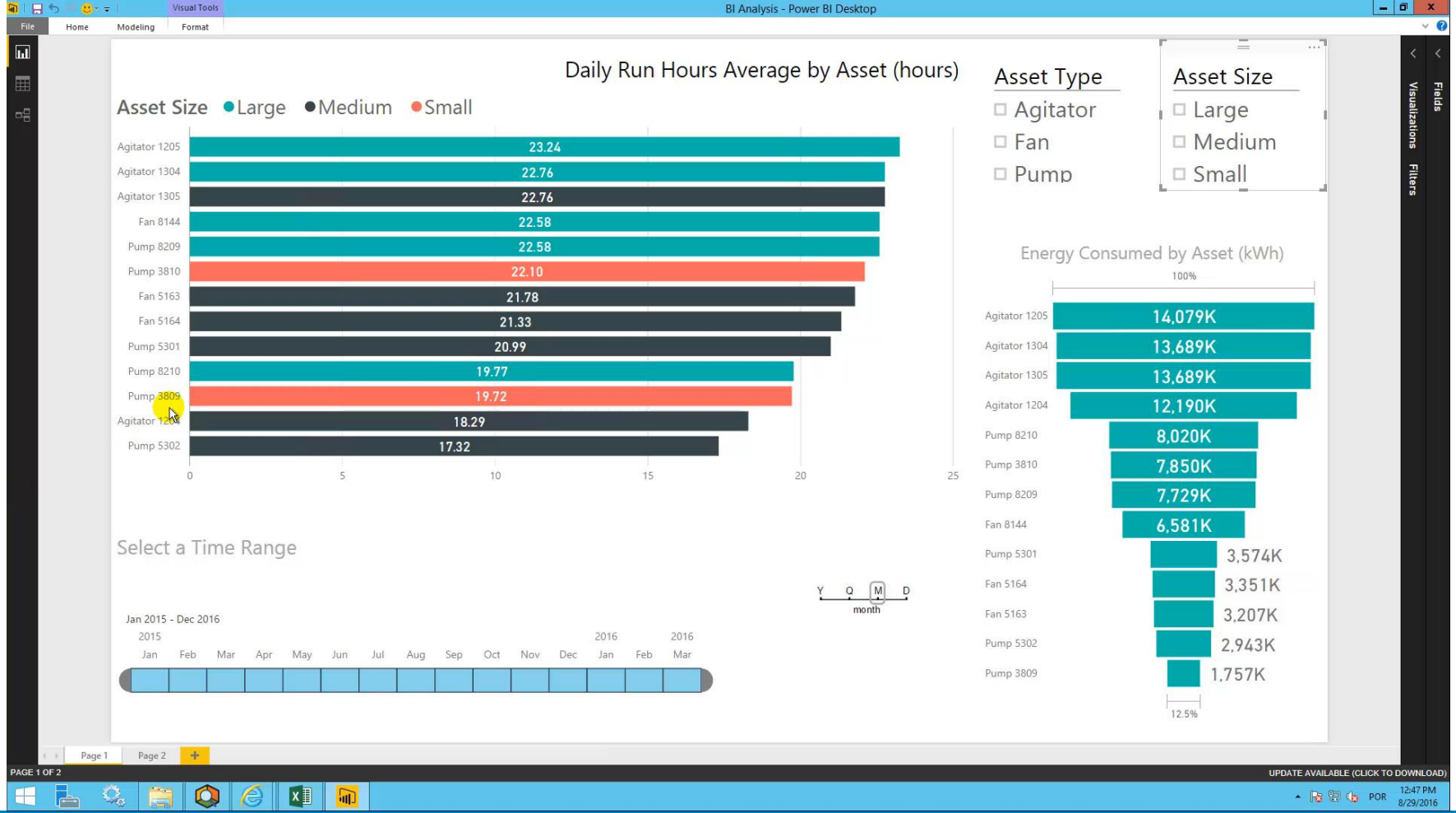
Fan 5164

Fan	Medium
Lifetime RunHours	13,354.58
Daily RunHours	24
RunHours Since Last Maintenance	7,627.95
zLast Maintenance	02-Oct-15
zNext Maintenance	02-May-16
Energy per Ton (Actual)	106.87
Energy per Ton (Expected)	108.52
Saved Energy (%)	2%

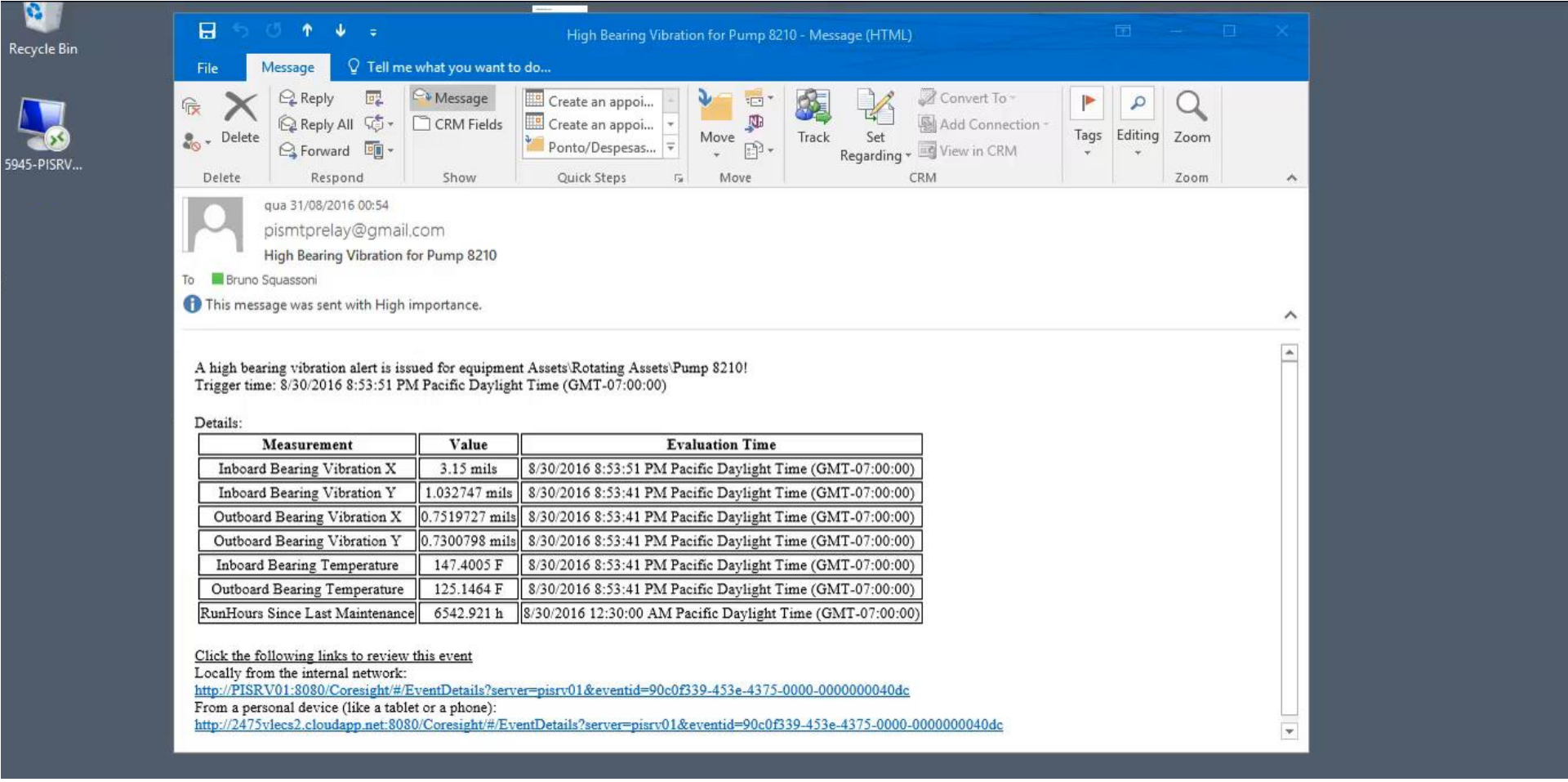
Production Rate (last 3 months)

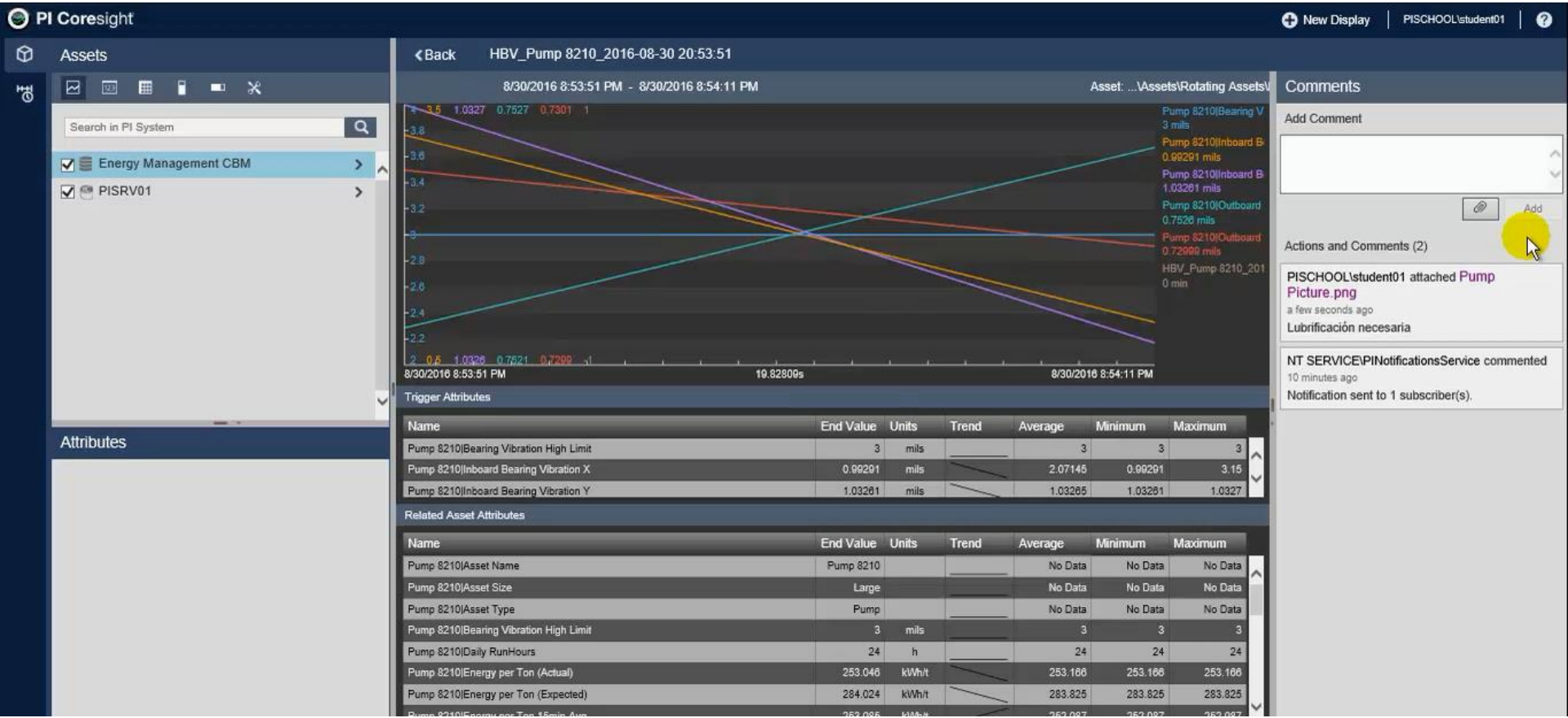


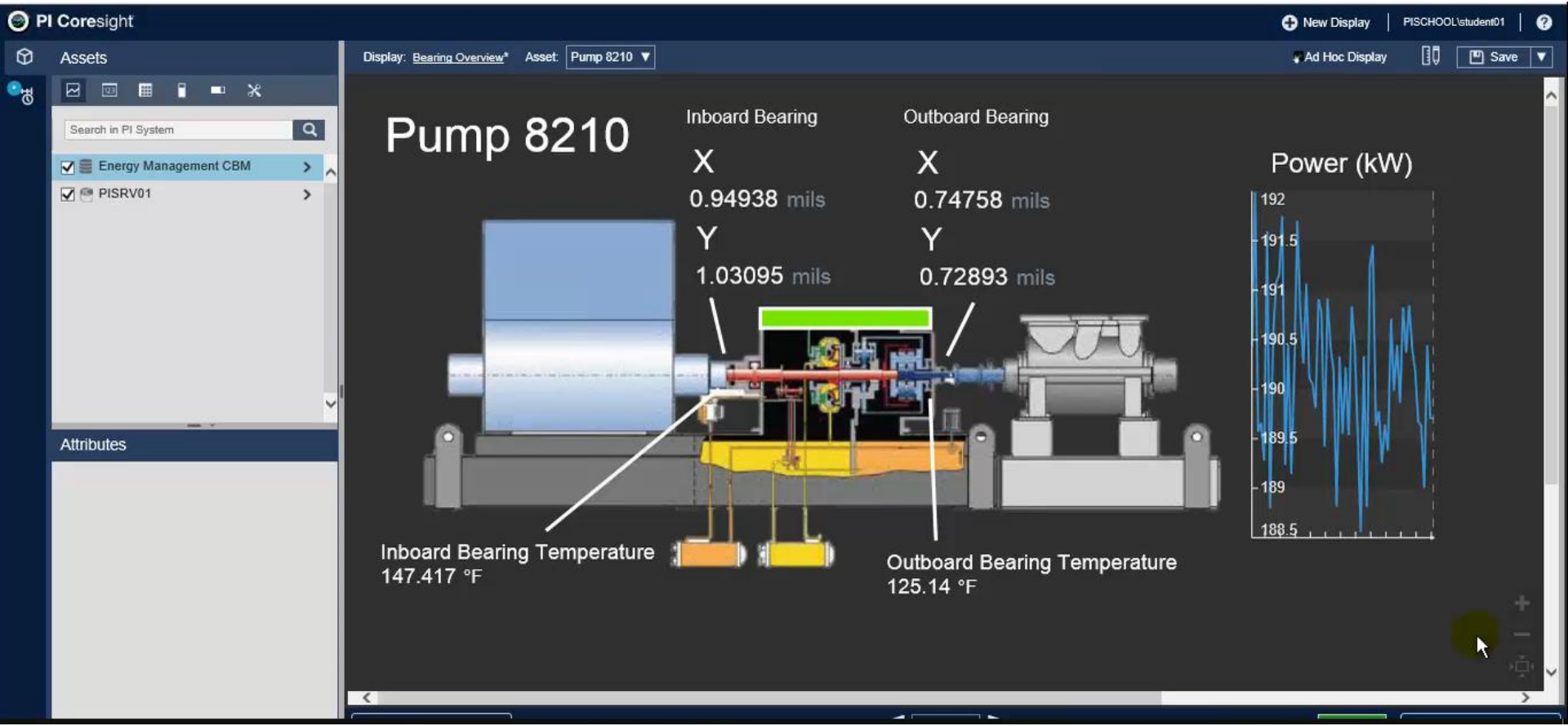
All Motors Run Hours | Individual Analysis

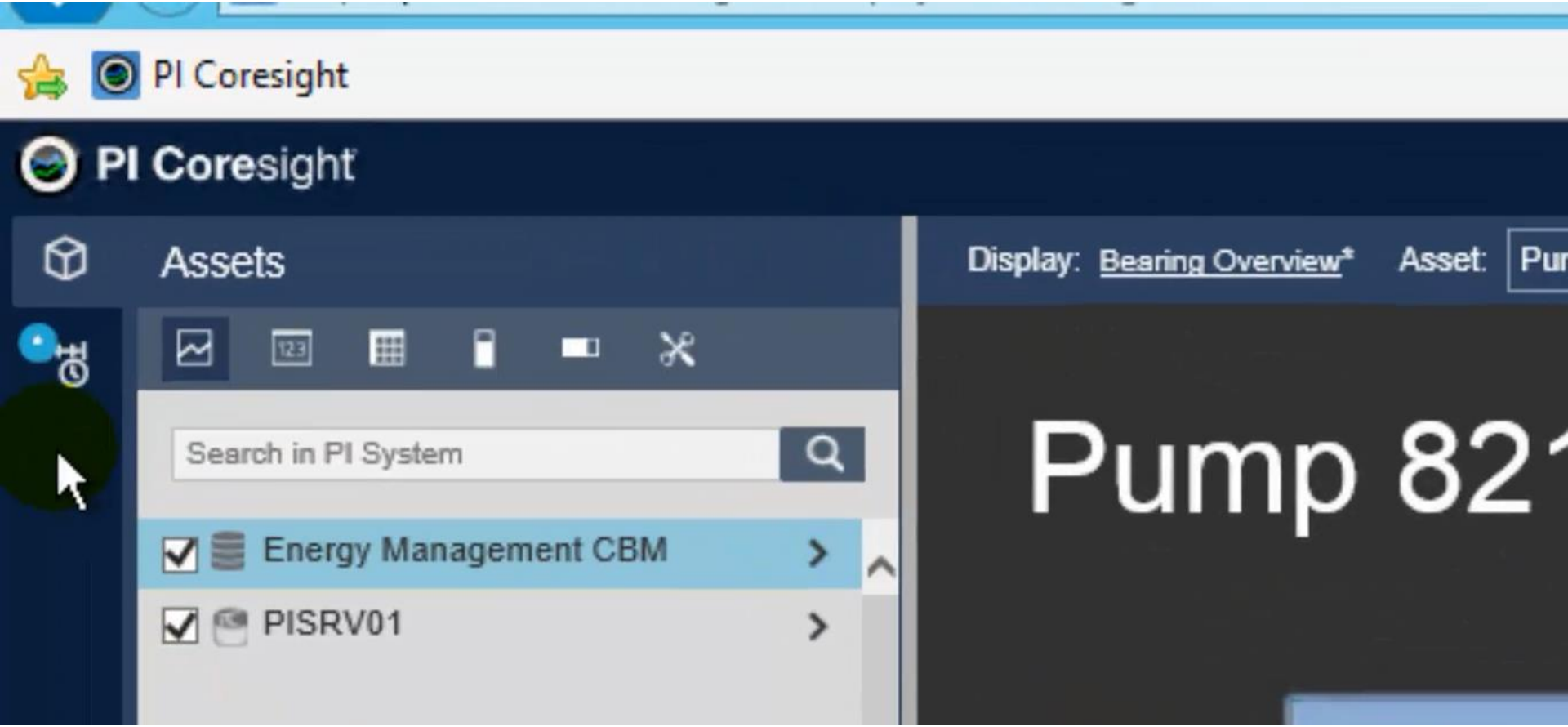


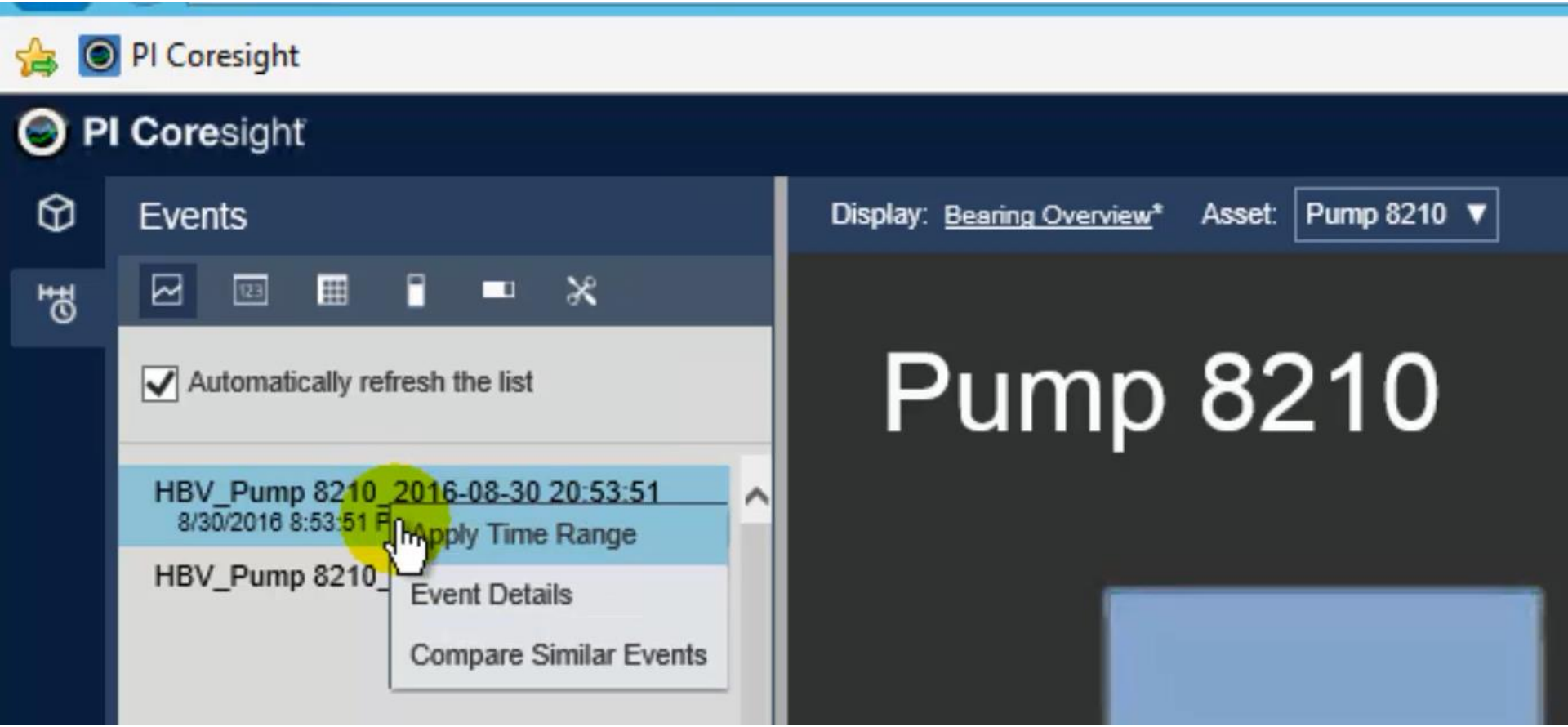
Exemplo 2 – Baseado em Condições

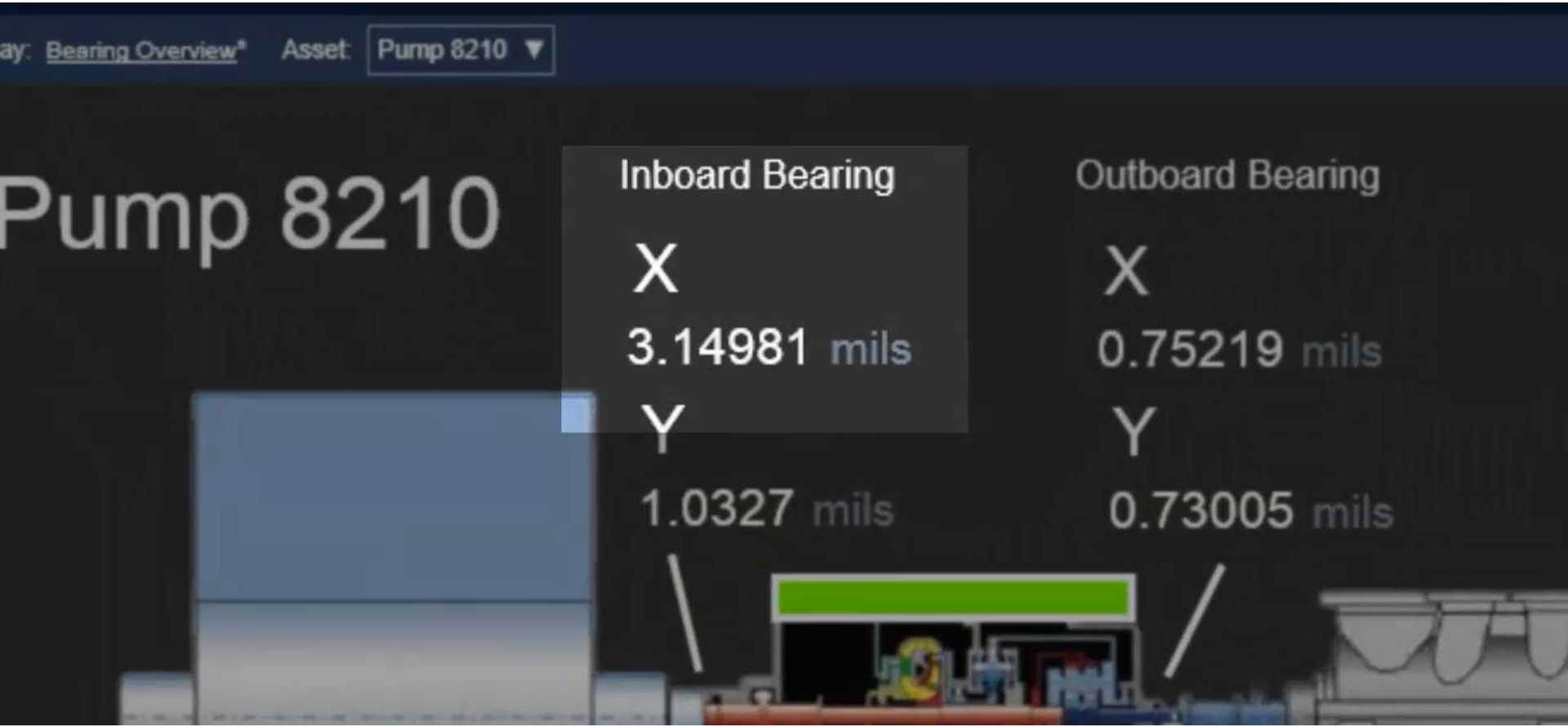


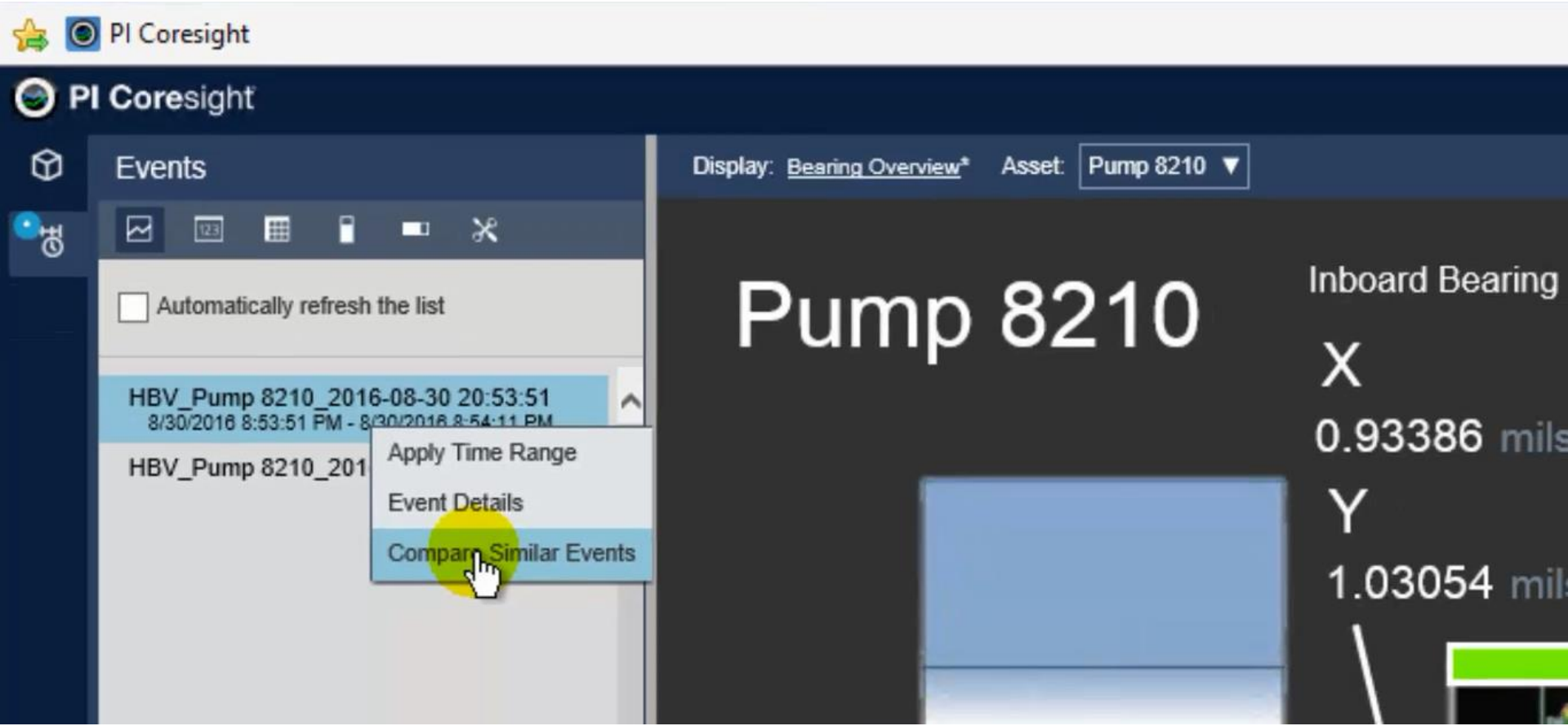


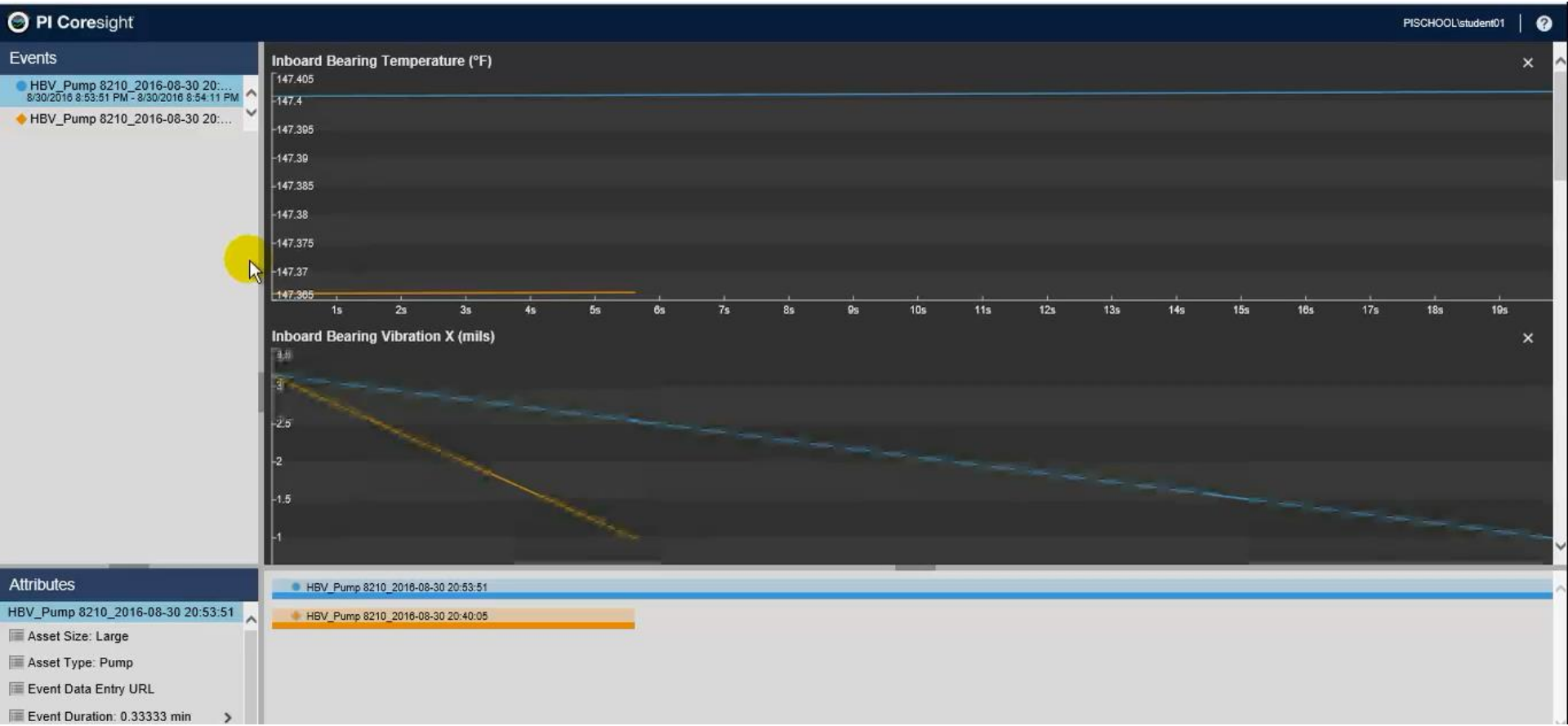


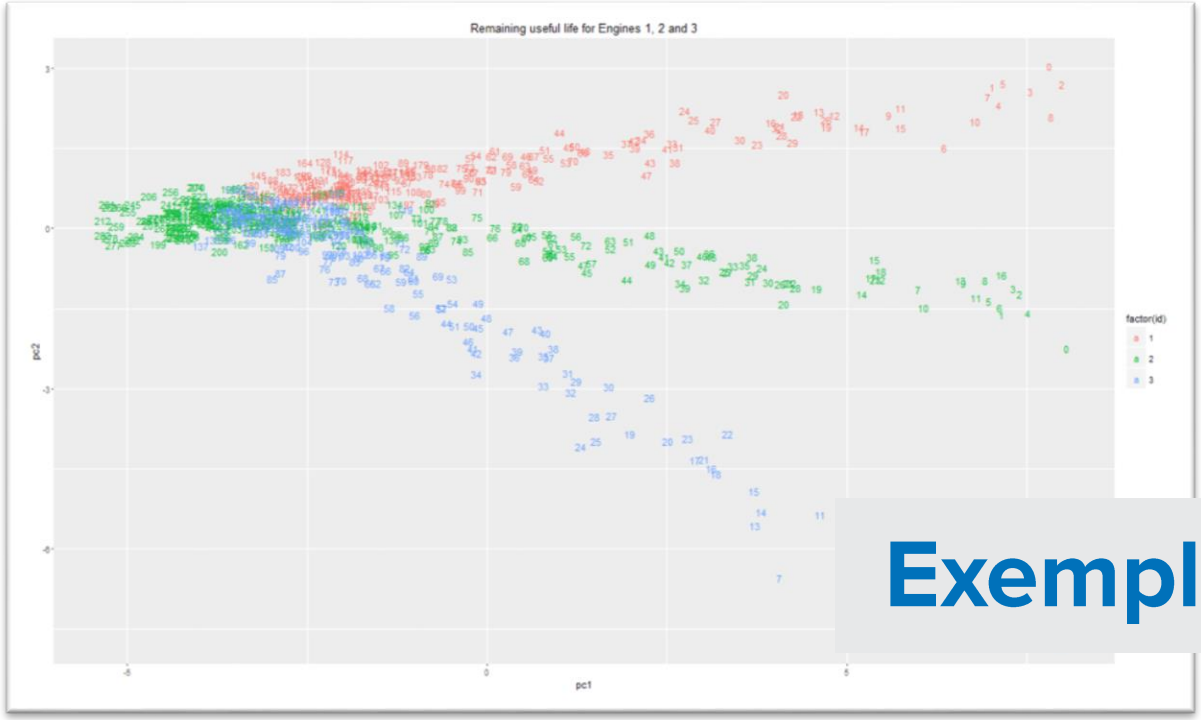








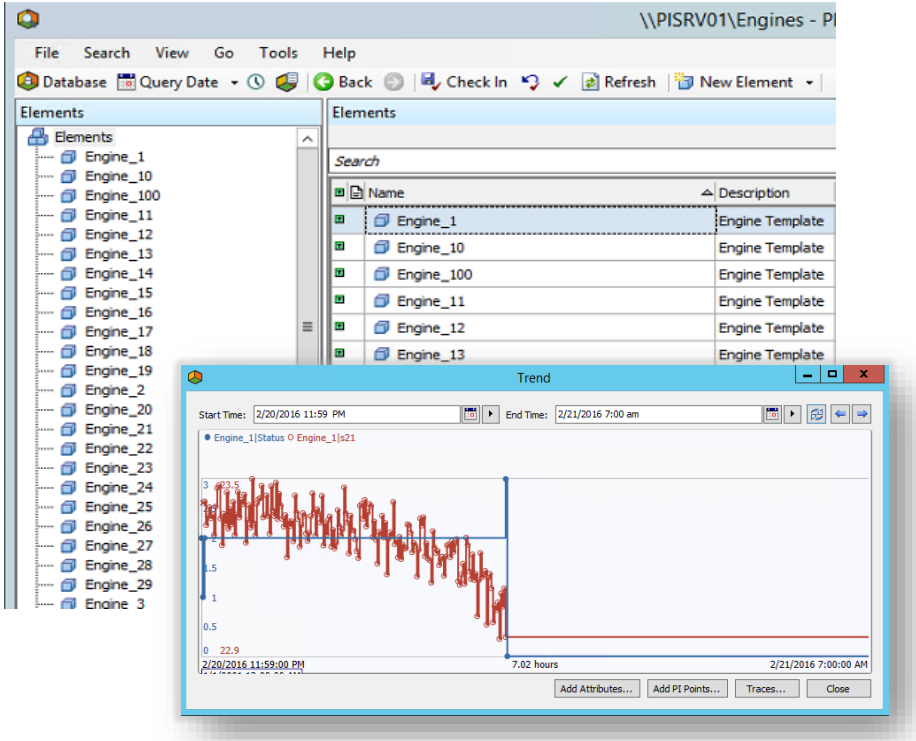




Exemplo 3 – Preditivo

Dados de Laboratorio do PI System e Modelo AF de “Maquinas”

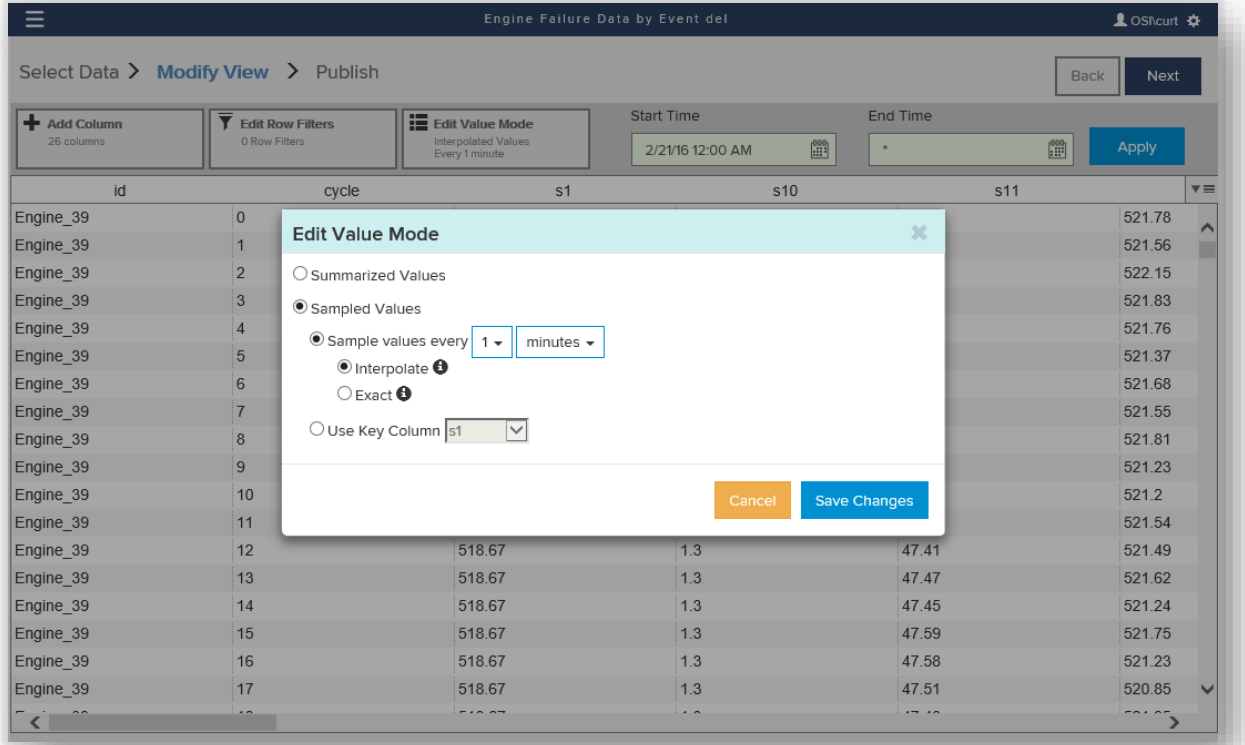
- Dados para 100 maquinas
  - 21 sensores
  - 3 ajustes
- O tempo de operação entre falhas varia
  - Hora inicial é sempre 21/2/16 12am
  - A hora de falha não excede 21/2/16 7:00 am
- Estados de Operação
  - “Running”, “Failed”, “Stopped”



*A. Saxena, K. Goebel, D. Simon, and N. Eklund, “Damage Propagation Modeling for Aircraft Engine Run-to-Failure Simulation”, in the Proceedings of the Ist International Conference on Prognostics and Health Management (PHM08), Denver CO, Oct 2008.

PI Integrator for Business Analytics – *Modificando a Vista*

- Criar uma view dos Eventos (PI Event View) e publicar como arquivo texto
- Datos Selecionados
  - Event Frames
  - Asset Element
  - Attributes
- “Modify View”
  - Amostras de um minuto
- Publicar “Publish”
  - Criar Arquivos texto (Create text file)



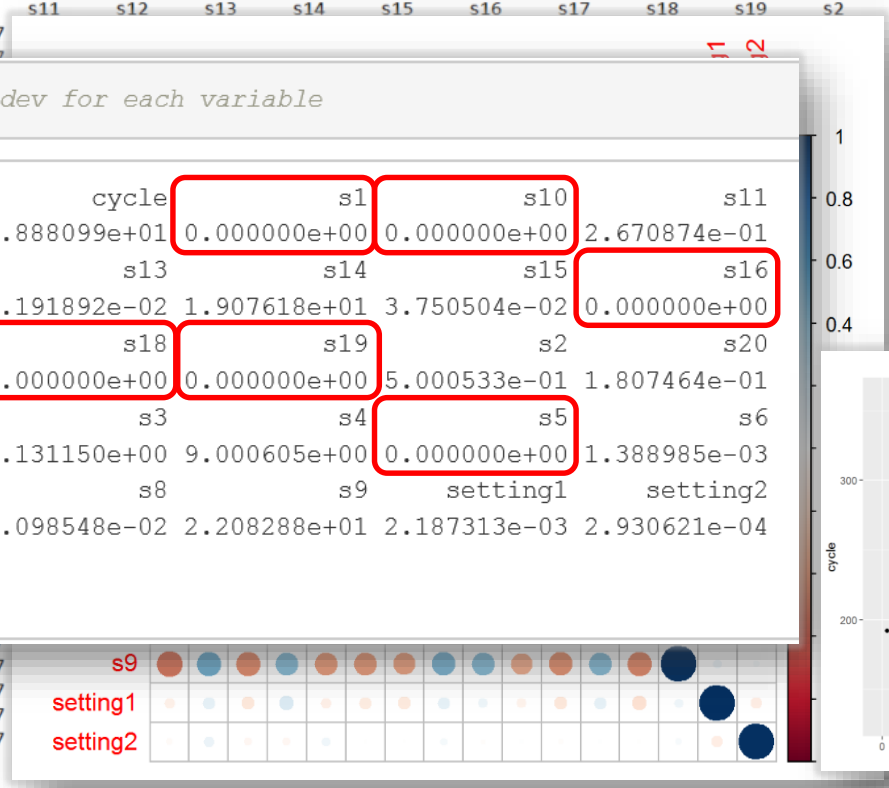
Resumo do R Script – *Revisão dos dados de Maquinas*

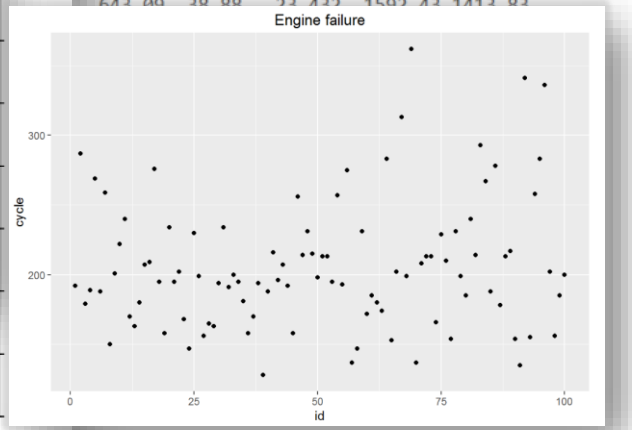
```
id          cycle   s1      s10     s11     s12     s13     s14     s15     s16     s17     s18     s19     s2
Engine_39       0       518.67
Engine_39       1       518.67
Engine_39       2       518.67
Engine_39       3       518.67
Engine_39       4       518.67
Engine_39       5       518.67
Engine_39       6       518.67
Engine_39       7       518.67
Engine_39       8       518.67
Engine_39       9       518.67
Engine_39       10      518.67
Engine_39       11      518.67
Engine_39       12      518.67
Engine_39       13      518.67
Engine_39       14      518.67
Engine_39       15      518.67
Engine_39       16      518.67
Engine_39       17      518.67
Engine_39       18      518.67
Engine_39       19      518.67
Engine_39       20      518.67
Engine_39       21      518.67
Engine_39       22      518.67
Engine_39       23      518.67
Engine_39       24      518.67
Engine_39       25      518.67
Engine_39       26      518.67
Engine_39       27      518.67
Engine_39       28      518.67
Engine_39       29      518.67
```

```
s20     s21     s3      s4      s5
642.72  38.9    23.2947 1592.37 1410
642.61  38.82   23.4604 1586.25 1407.99
642.26  38.73   23.2669 1586.25 1407.48
642.46  38.82   23.3789 1587.9  1405.23
642.31  38.73   23.3338 1587.08 1408.78
642.6   38.98   23.3029 1592.86 1405.05
642.65  38.91   23.2378 1596.39 1406.06
643.4   38.8    23.3534 1592.81 1403.31
642.13  38.84   23.2386 1592.98 1406.26
642.43  38.97   23.2466 1590.41 1402.45
642.76  38.87   23.3439 1588.85 1409.87
642.53  38.73   23.29   1585.95 1415.5
642.98  38.89   23.1604 1585.78 1402.06
```

```
sapply(e, sd)   #sdev for each variable
```

```
##           id        cycle           s1          s10          s11
## 2.922763e+01 6.888099e+01 0.000000e+00 0.000000e+00 2.670874e-01
##          s12          s13          s14          s15          s16
## 7.375534e-01 7.191892e-02 1.907618e+01 3.750504e-02 0.000000e+00
##          s17          s18          s19           s2          s20
## 1.548763e+00 0.000000e+00 0.000000e+00 5.000533e-01 1.807464e-01
##          s21           s3           s4           s5           s6
## 1.082509e-01 6.131150e+00 9.000605e+00 0.000000e+00 1.388985e-03
##           s7           s8           s9     setting1     setting2
## 8.850923e-01 7.098548e-02 2.208288e+01 2.187313e-03 2.930621e-04
##     setting3
## 0.000000e+00
```





Resumo do R Script – *Vida Útil Remanescente (Remaining Useful Life)*

Remaining Useful Life (RUL) = (Event Frame Duration – Cycle) + 1

(Example, for engine (id) 1: 191 - 1 – 1)

id	cycle	s11	s12	s13	s14	s15	s17	s2	s20	s21	s3	s4	s6	s7	s8	s9	setting1	setting2	rul
1	1	47.47	521.7	2388	8139	8.419	392	641.8	39.06	23.42	1590	1401	21.61	554.4	2388	9046	-0.0007	-0.0004	191
1	2	47.49	522.3	2388	8131	8.432	392	642.1	39.00	23.42	1592	1403	21.61	553.8	2388	9044	0.0019	-0.0003	190
1	3	47.27	522.4	2388	8133	8.418	390	642.4	38.95	23.34	1588	1404	21.61	554.3	2388	9053	-0.0043	0.0003	189
1	4	47.13	522.9	2388	8134	8.368	392	642.4	38.88	23.37	1583	1402	21.61	554.5	2388	9049	0.0007	0.0000	188
1	5	47.28	522.2	2388	8134	8.429	393	642.4	38.90	23.40	1583	1406	21.61	554.0	2388	9055	-0.0019	-0.0002	187
1	6	47.16	521.7	2388	8133	8.411	391	642.1	38.98	23.37	1584	1398	21.61	554.7	2388	9050	-0.0043	-0.0001	186
1	7	47.36	522.3	2388	8132	8.397	392	642.5	39.10	23.38	1592	1398	21.61	554.3	2388	9059	0.0010	0.0001	185
1	8	47.24	522.5	2388	8131	8.408	391	642.6	38.97	23.31	1583	1401	21.61	553.9	2388	9041	-0.0034	0.0003	184
1	9	47.29	521.8	2388	8126	8.373	392	642.1	39.05	23.41	1591	1395	21.61	553.7	2388	9046	0.0008	0.0001	183
1	10	47.03	521.8	2388	8129	8.429	393	641.7	38.95	23.47	1591	1400	21.61	553.6	2388	9052	-0.0033	0.0001	182
1	11	47.15	521.4	2388	8141	8.434	392	642.3	38.94	23.48	1582	1401	21.61	554.5	2388	9050	0.0018	-0.0003	181
1	12	47.18	521.8	2388	8134	8.394	391	642.1	39.06	23.37	1583	1400	21.61	554.5	2388	9049	0.0016	0.0002	180

Resumo do R Script– *Componentes Principais*

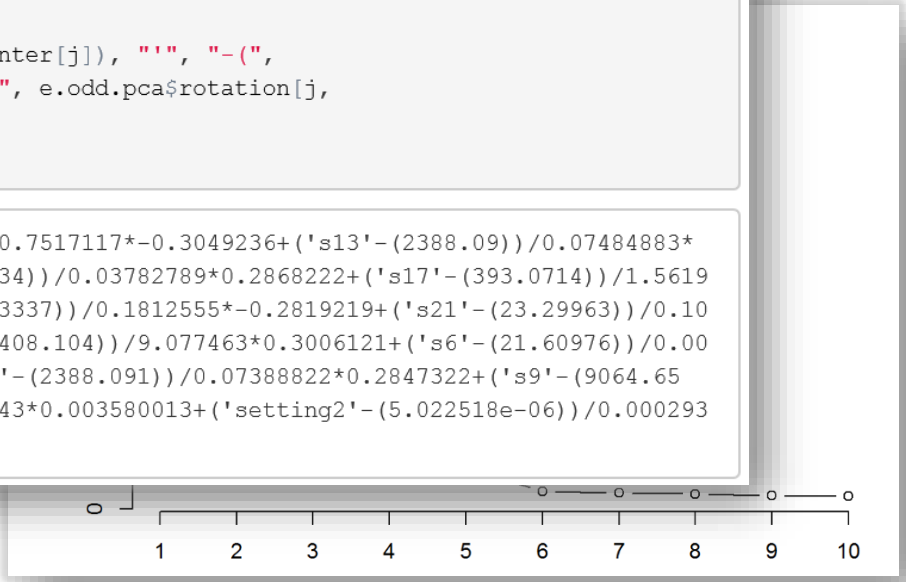
Extract principal components

```
e.odd.pca = prcomp(e.odd.obs, scale = T, center = T)  #fit principal components (PC), use only odd engine data

su
```

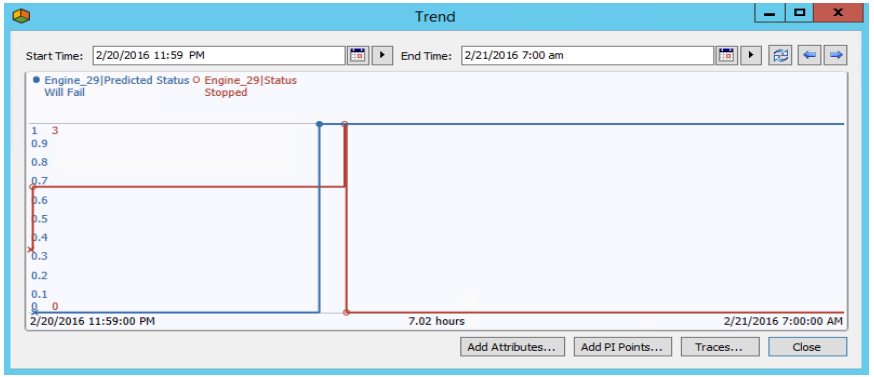
```
# get pc1 equation
pc1eq = ""
for (j in 1:17) {
    pc1eq = cat(sep = "", pc1eq, "+(", "'", names(e.odd.pca$center[j]), "'", "-(",
        e.odd.pca$center[j], ")", ")/", e.odd.pca$scale[j], "*", e.odd.pca$rotation[j,
            1])
}
```

```
## +('s11'-(47.51488))/0.2701003*0.3090913+('s12'-(521.4901))/0.7517117*-0.3049236+('s13'-(2388.09))/0.07484883*
0.2845465+('s14'-(8143.502))/19.7965*0.04163657+('s15'-(8.438634))/0.03782789*0.2868222+('s17'-(393.0714))/1.5619
64*0.2685557+('s2'-(642.638))/0.5043607*0.2734667+('s20'-(38.83337))/0.1812555*-0.2819219+('s21'-(23.29963))/0.10
83872*-0.2834525+('s3'-(1590.048))/6.186916*0.2604444+('s4'-(1408.104))/9.077463*0.3006121+('s6'-(21.60976))/0.00
1539259*0.06360376+('s7'-(553.4522))/0.8983562*-0.2995252+('s8'-(2388.091))/0.07388822*0.2847322+('s9'-(9064.65
1))/22.72082*0.08204075+('setting1'-(-3.554925e-05))/0.002184843*0.003580013+('setting2'-(5.022518e-06))/0.000293
1999*0.003136759
```

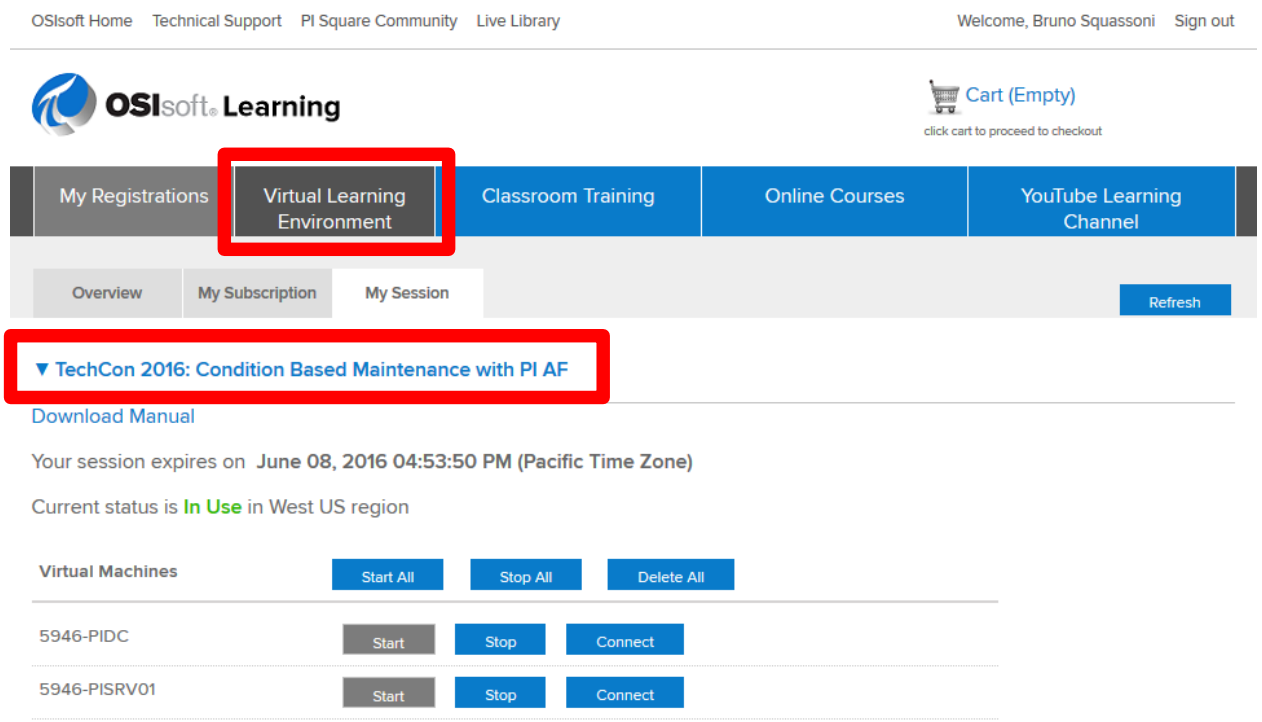


Implemententação no AF Analytics

- Copiar o modelo de R no campo de calculo do motor (Engine analysis template).
- Usar AF Analytics para replicar o calculo em todas as 100 maquinas.
- Recalcular os dados históricos, criar tendência de atributos de Status e Status Previsto (Predicted Status) para verificar se o tempo de alerta é suficiente.

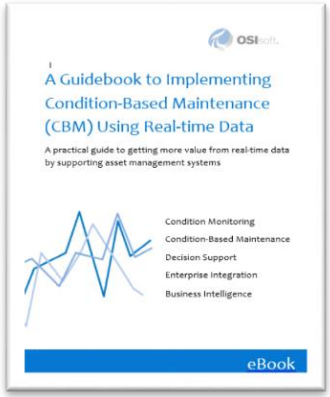


Virtual Learning Environment



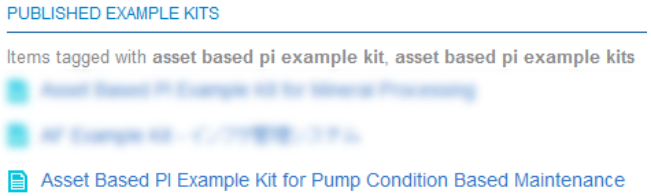
Conteúdos

- E-Book de CBM

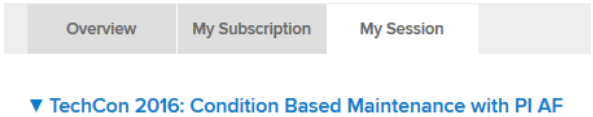


- PI Square
  The OSIsoft Community

Asset Based PI Example Kits



- Virtual Learning Environment



Obrigado

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