

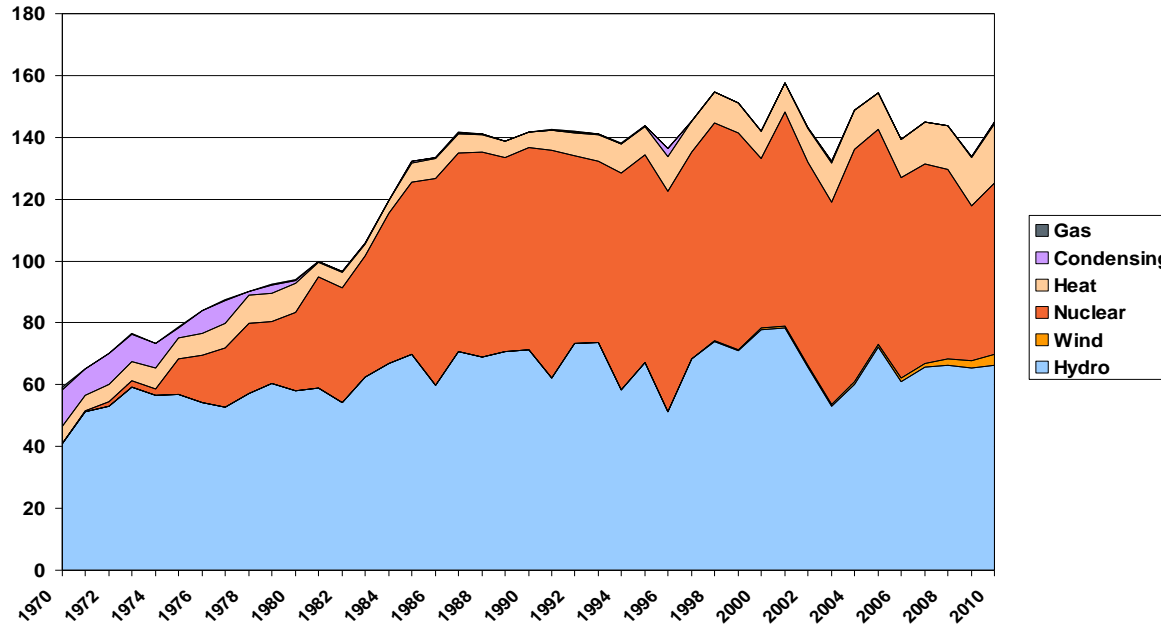
Deploying a Condition-Based Maintenance Strategy in the Hydro Power Business

Presented by **Tomas Stark** and **Magnus Holmbom**



Hydro Power – The backbone of Swedish electricity production

Electricity production in Sweden [TWh]



The Laxede hydro power plant (Lule river)



The Akkats hydro power plant (Lule river)

Vattenfall Hydro Power

The Third Largest Hydro Power Producer In Europe

Vattenfall Hydro Power - Nordic

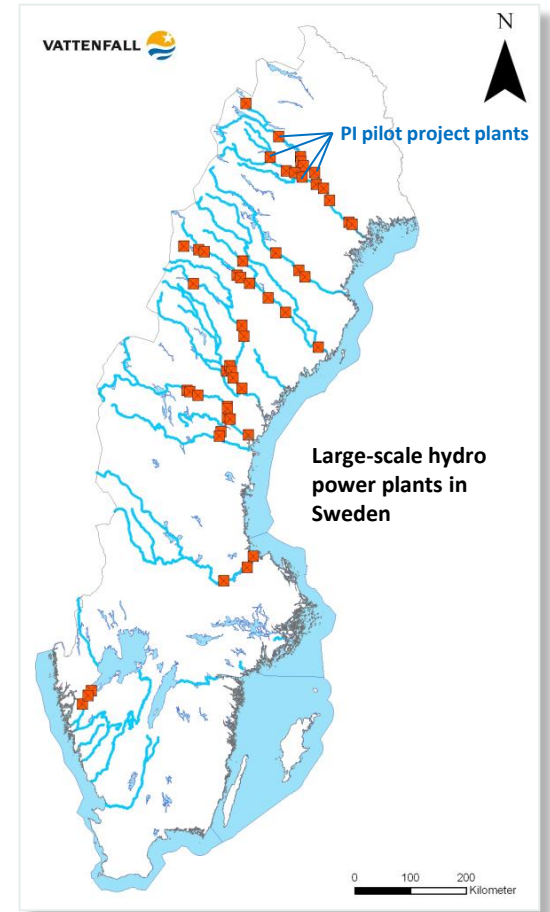
Number of employees	~ 520
Annual turnover	~ 950 M€

Assets, production och capacity

Large-scale power plants	55 (1 in Finland)
Small-scale power plants	50 (9 in Finland)
Annual production	30 - 35 TWh
Capacity	8.300 MW

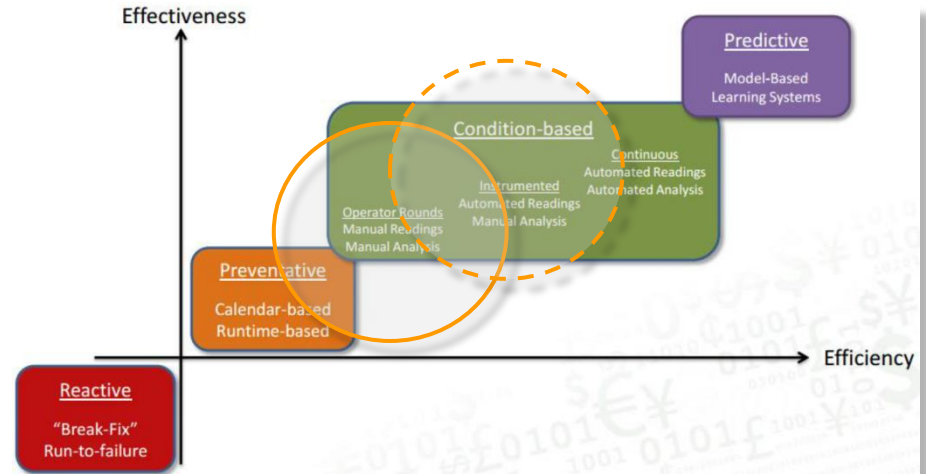
Investments in refurbishment

For the period 2013 to 2023	1.400 M€
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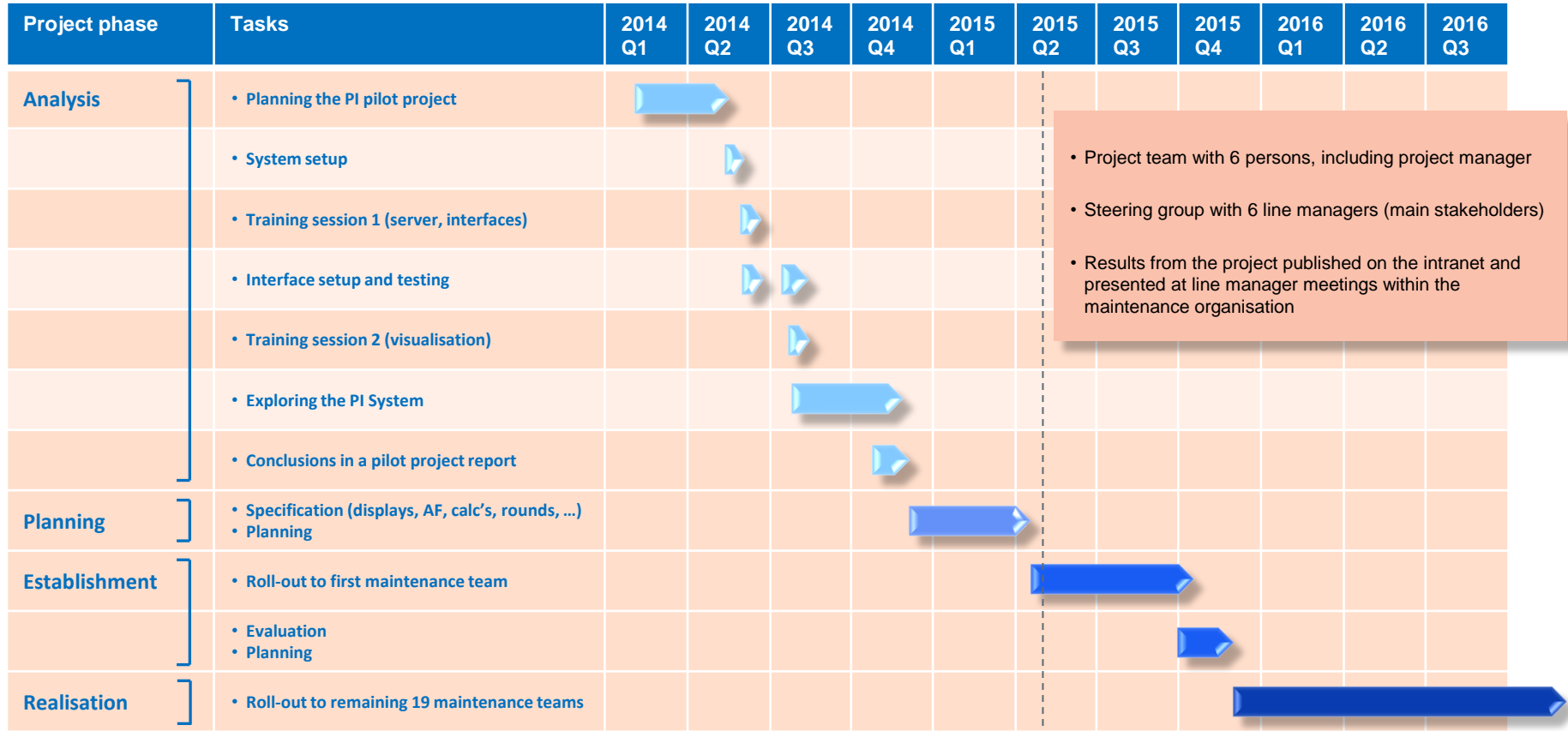
Background

- Need for a new strategy for Condition-Based Maintenance
- Old data historian system not sufficient to support new strategy
- PI system evaluated and used previously in Vattenfall, and decided leading solution
- Management team took decision to start an analysis phase to evaluate if
 - the PI System could replace the existing system
 - support the new strategy and vision
 - add value by being flexible, able to integrate with other systems, and support a planned "Hydro Information Portal"



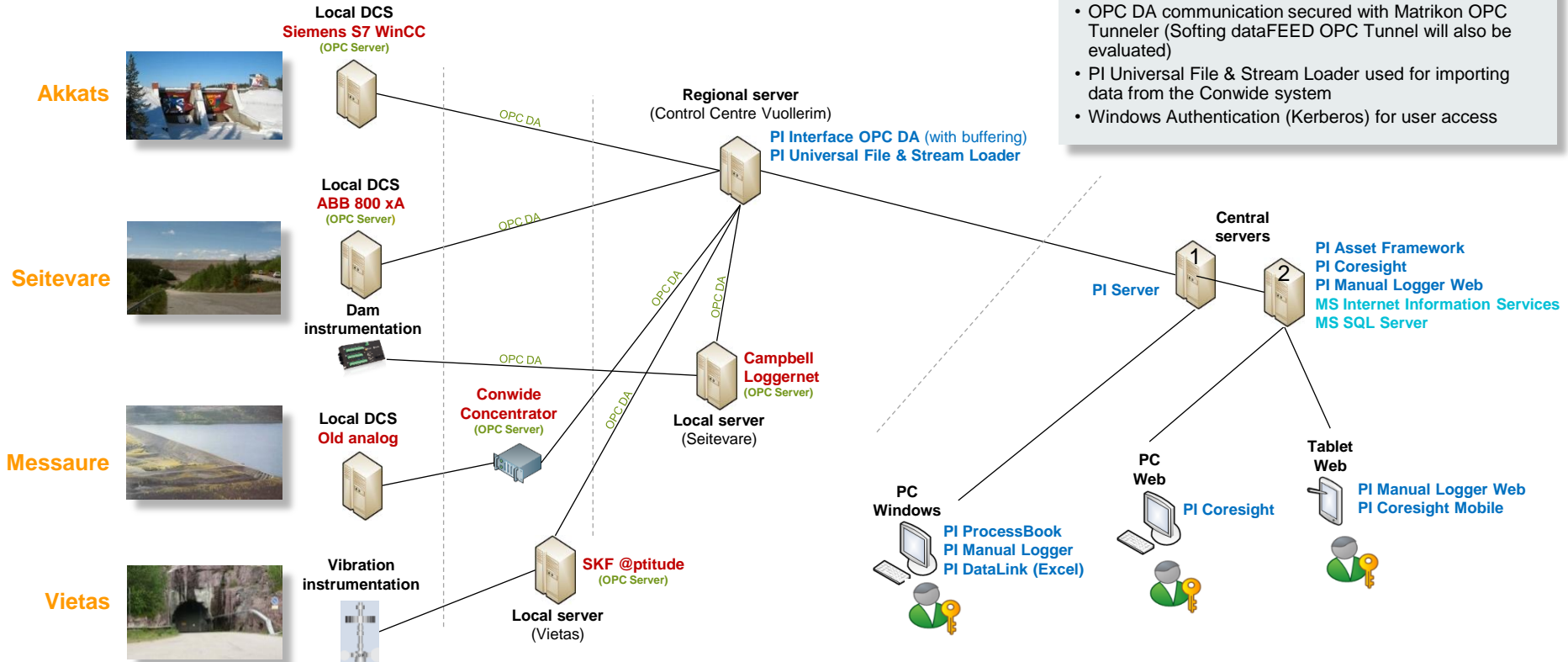
Source: OSIsoft's CBM Guidebook

Our one year journey with the PI System



System setup (pilot)

- Setup was chosen in order to test data capture from modern DCS's, old analog DCS's, dam instrumentation system, and vibration monitoring system
- OPC DA communication secured with Matrikon OPC Tunneler (Softing dataFEED OPC Tunnel will also be evaluated)
- PI Universal File & Stream Loader used for importing data from the Conwide system
- Windows Authentication (Kerberos) for user access



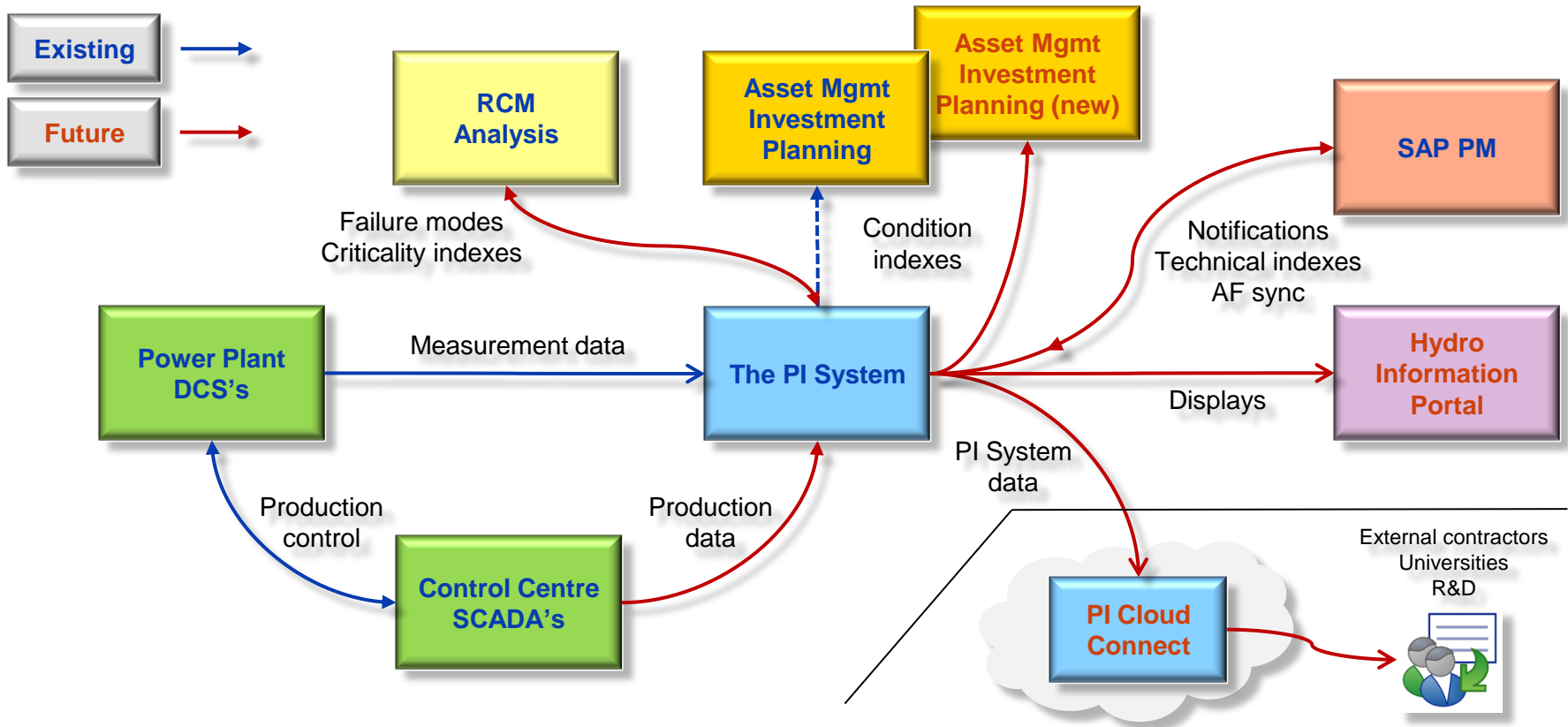
Conclusions from the pilot project

The pilot project verified that the PI System

1. is an **adequate replacement** for the current Conwide system, and fulfills the needs for both plant maintenance and dam safety;
2. provides **added value** with a more stable data capture, a richer analysis functionality, and flexible integration possibilities;
3. provides the prerequisites and **supports the vision and strategy** for our future maintenance development;
4. represents an **important building block** of a planned "Hydro Information Portal", publishing e.g. process data, analyses and KPI's in real-time.



The PI System as part of the IT landscape – Future plan



Trend Analytics

Element template setup

The screenshot displays the PI System Explorer interface. The left pane shows a tree view of the 'Magnus' library, with 'Temperatortrend Template' selected under 'Element Templates'. The right pane shows the configuration table for this template, with tabs for 'General', 'Attribute Templates', 'Ports', and 'Analysis Templates'. The 'Attribute Templates' tab is active, showing a table of attributes.

Name	Description	Default Value
Drifttid		0
Min drifttid för trend		0 min
Mätvärde		0 °C
Normvärde		0 °C
Trend index		0
Trend index 1		78
Trend index 2		74
Trend index 3		70
Trend index 4		65
Trend index 5		60
Trendat värde		0 °C
Trendvillkor uppfyllt		False

Create element from template

The screenshot displays the 'Magnus - PI System Explorer' interface. The left-hand pane shows a tree view of system elements. Three elements are circled in red: 'Trend NSTL' under 'G1 Generator', 'Trend OSTL' under 'G1 Magnetiseringsystem', and 'Trend TSTL' under 'G1 Turbin'. The right-hand pane shows the 'Trend OSTL' element selected, with its properties listed in a table. This table is also circled in red.

Name	Value	Category	Unit Of Measure
Drifttid	0		<None>
Min drifttid för trend	360 min		minute
Mätvärde	26,32639 °C		degree Celsius
Normvärde	66 °C		degree Celsius
Trend index	4	Trend index	<None>
Trend index 1	78	Trend index	<None>
Trend index 2	74	Trend index	<None>
Trend index 3	70	Trend index	<None>
Trend index 4	65	Trend index	<None>
Trend index 5	60	Trend index	<None>
Trendat värde	65,8078058714103 °C	Trend index	degree Celsius
Trendvillkor uppfyllt	False		<None>

Trend index calculation

Trend NSTL

General Child Elements Attributes Ports Analyses Version

Name: Trendvillkor

Description:

Categories:

Analysis Type: Expression Rollup Event Frame Generation

Name	Expression	Value	Output Attribute
Variab1e1	<code>If('Drifttid'>'Min drifttid för trend') then true else false</code>	False	Trendvillkor uppfyllt
Variab1e2	<code>if('Trendvillkor uppfyllt'= true) then TagAvg('Mätvärde', '-10m', '**') else NoOutput()</code>	-	Trendat värde
Variab1e3	<code>if('Trendat värde'>'Trend index 5' And 'Trendat värde'<'Trend index 4') Then 5 Else if('Trendat värde'>'Trend index 4' And 'Trendat värde'<'Trend index 3') then 4 Else if('Trendat värde'>'Trend index 3' And 'Trendat värde'<'Trend index 2') then 3 Else if('Trendat värde'>'Trend index 2' And 'Trendat värde'<'Trend index 1') Then 2 Else if('Trendat värde'>'Trend index 1') Then 1 Else NoOutput()</code>	4	Trend index

Trend NSTL

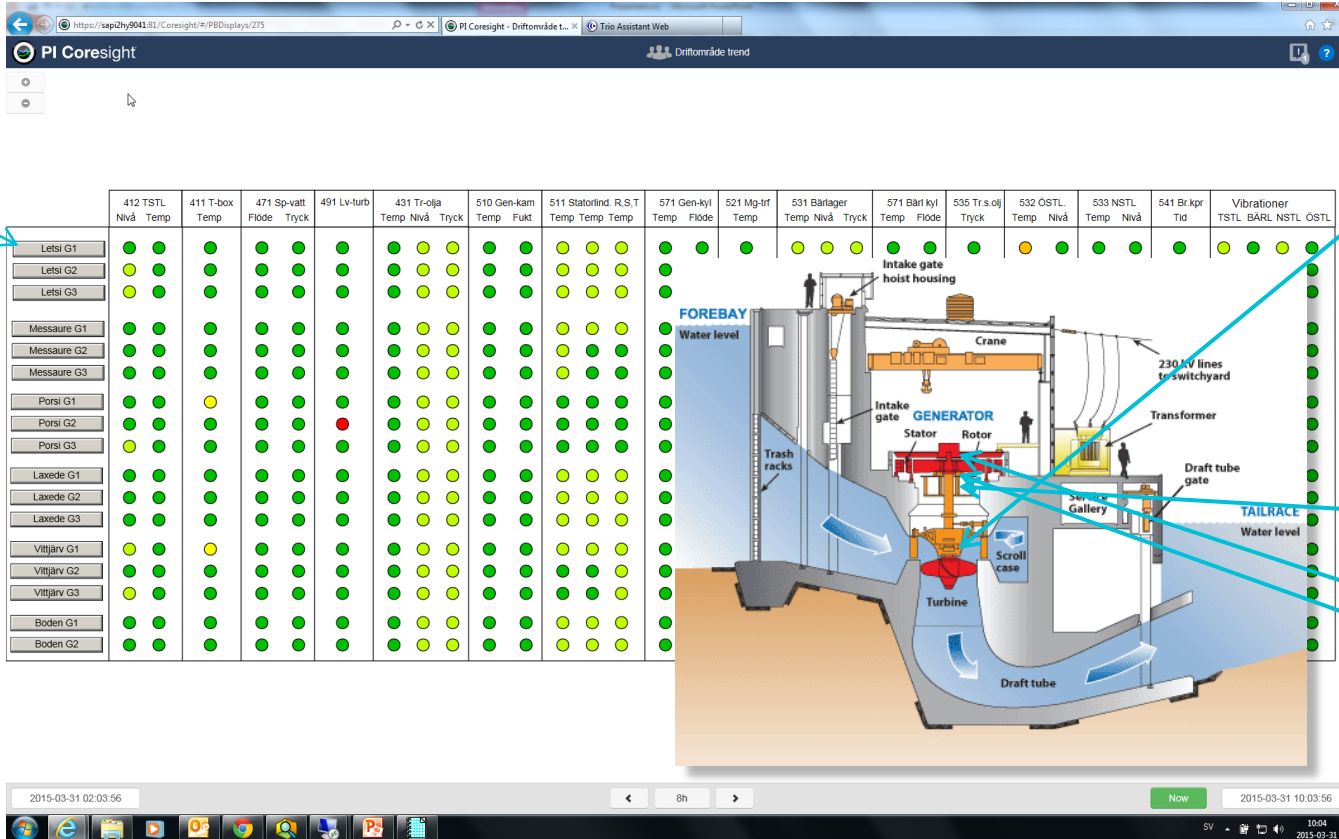
General Child Elements Attributes Ports Analyses Version

Filter

Name	Value	Category	Unit Of Measure
Drifttid	0		<None>
Min drifttid för trend	60 min		minute
Mätvärde	35,93802 °C		degree Celsius
Normvärde	0 °C		degree Celsius
Trend index	4	Trend index	<None>
Trend index 1	78	Trend index	<None>
Trend index 2	74	Trend index	<None>
Trend index 3	63	Trend index	<None>
Trend index 4	62	Trend index	<None>
Trend index 5	60	Trend index	<None>
Trendat värde	62,2420280033331 °C	Trend index	degree Celsius
Trendvillkor uppfyllt	False		<None>

Overview of trends

Plant unit



English translation

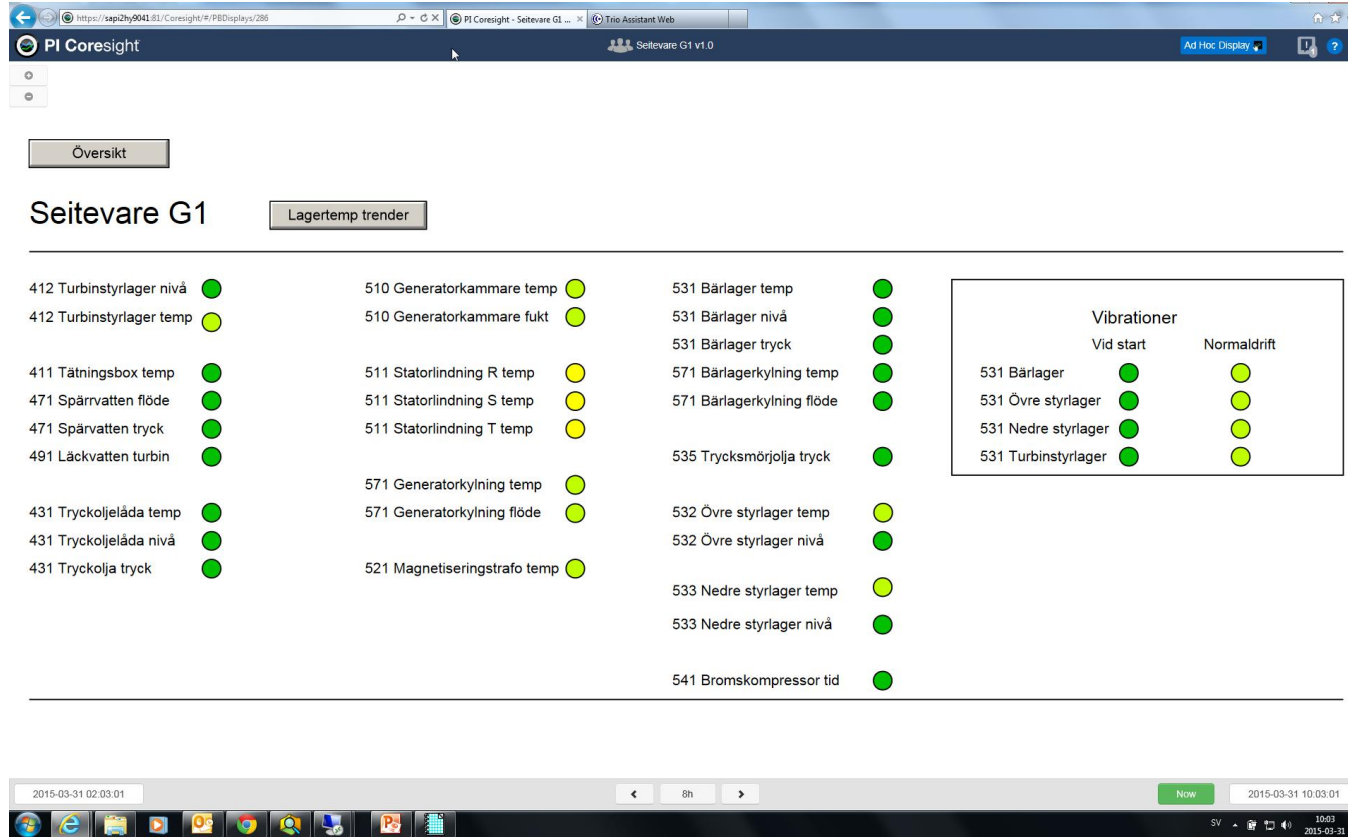
Turbine

- Turbine guide bearing
- Stuffing
- Barrier water
- Leakage water
- Pressure oil

Generator

- Generator chamber
- Stator winding
- Generator cooling
- Excitation transformer
- Thrust Bearing
- Bearing cooling
- Pressure lubricating oil
- Upper guide bearing
- Lower guide bearing
- Brake compressor
- Vibrations

Individual trends



English translation

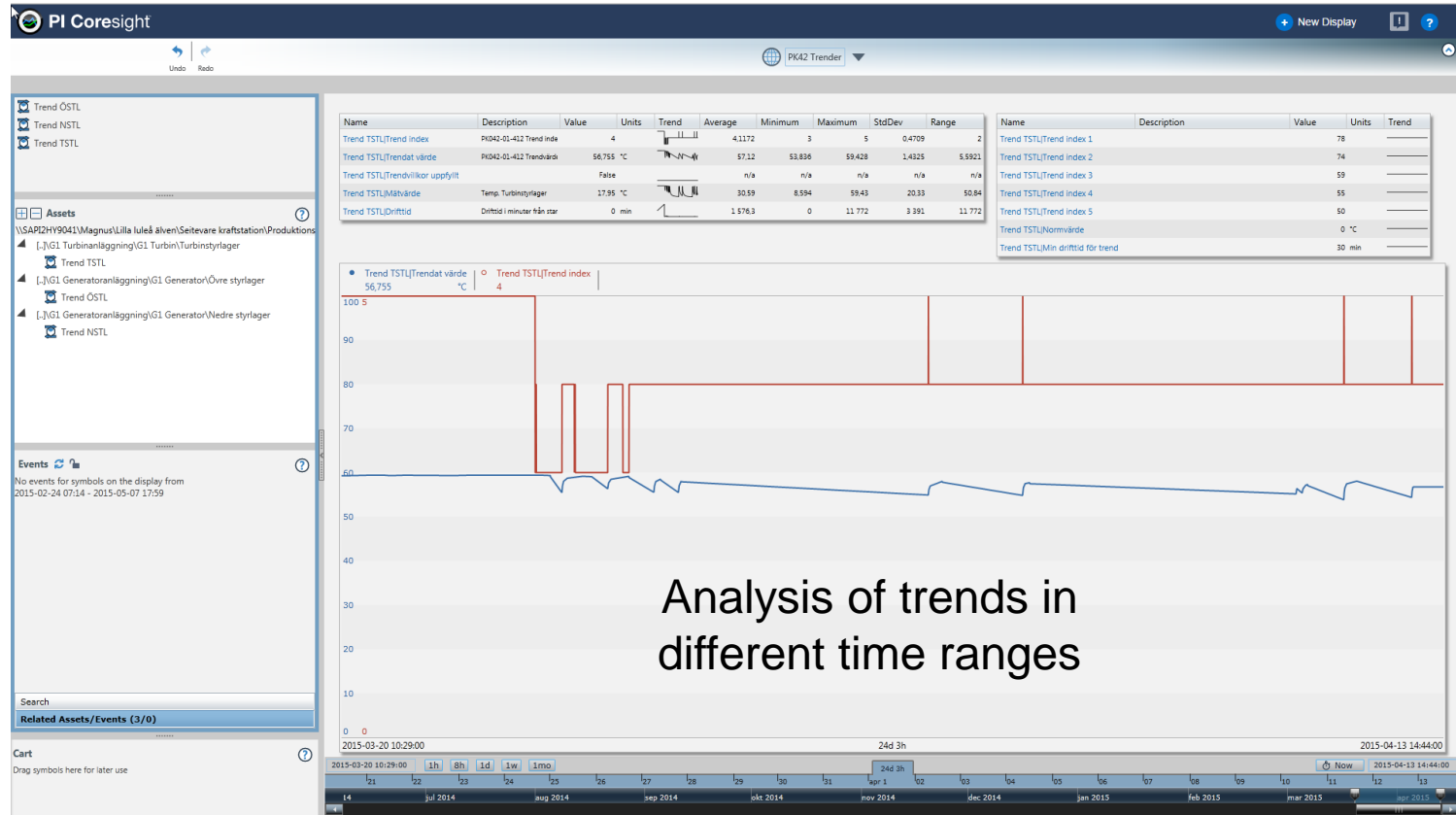
Turbine

- Turbine guide bearing
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- Barrier water
- Leakage water
- Pressure oil

Generator

- Generator chamber
- Stator winding
- Generator cooling
- Excitation transformer
- Bearing
- Bearing cooling
- Pressure lubricating oil
- Upper guide bearing
- Lower guide bearing
- Brake compressor
- Vibrations

Element relative display



Notification setup

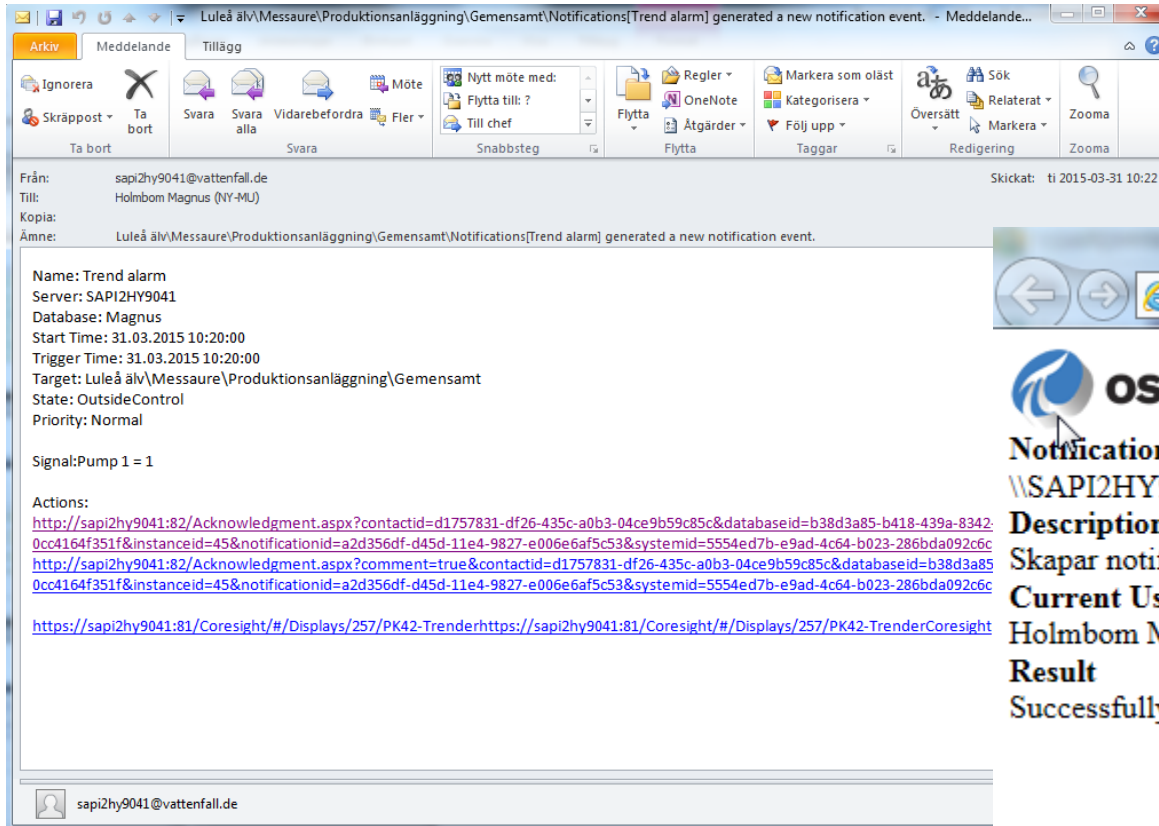
The image displays three overlapping screenshots of the PI System Explorer software interface, illustrating the configuration of a notification for a trend alarm.

Top-left screenshot: Shows the 'Library' tree on the left. The 'Trend alarm' notification is highlighted under the 'Notification Templates' folder. The main pane shows the 'Trend alarm' configuration with the 'Trigger' tab selected. The 'Creation and Startup Options' section has 'Automatically create a notification for ea' selected. The 'Trigger' section shows the target as 'Temperaturtrend Template' and three conditions: 'Trend index = Trend index 3', 'Trend index = Trend index 2', and 'Trend index = Trend index 1'. The 'Message' section shows '0 item(s) of custom content available to sub' and '0 customized delivery format(s) configured'. The 'Subscriptions' section shows '1 subscription(s) to this notification'.

Top-right screenshot: Shows the 'Notifications' tree on the left. The 'Trend alarm (Trend OSTL)' notification is highlighted. The main pane shows the 'Trend alarm' configuration with the 'Trigger' tab selected. The 'Creation and Startup Options' section has 'Automatically create a notification for ea' selected. The 'Trigger' section shows the target as 'Trend OSTL' and three conditions: 'Trend index = Trend index 3', 'Trend index = Trend index 2', and 'Trend index = Trend index 1'. The 'Message' section shows '0 item(s) of custom content available to subscribers' and '0 customized delivery format(s) configured for Email'. The 'Subscriptions' section shows '1 subscription(s) to this notification'.

Bottom-right screenshot: Shows the 'Trend alarm' configuration with the 'Trigger' tab selected. The 'Creation and Startup Options' section has 'Automatically create a notification for ea' selected. The 'Trigger' section shows the target as 'Trend OSTL' and three conditions: 'Trend index = Trend index 3', 'Trend index = Trend index 2', and 'Trend index = Trend index 1'. The 'Message' section shows '0 item(s) of custom content available to subscribers' and '0 customized delivery format(s) configured for Email'. The 'Subscriptions' section shows '1 subscription(s) to this notification'.

Delivery of notification



The screenshot shows a web browser window with the URL: <http://sapi2hy9041:82/Acknowledgment.aspx?contactid=d1757831-df26-435c-a0b3-04ce9b59c85c&databaseid=b38d3a85-b418-439a-8342-0cc4164f351f&instanceid=45¬ificationid=a2d356df-d45d-11e4-9827-e006e6af5c53&systemid=5554ed7b-e9ad-4c64-b023-286bda092c6c>

The page content includes:

- OSIsoft logo
- Notification**
- \\SAPI2HY9041\Magnus[Trend alarm]
- Description**
- Skapar notification då pumpen går
- Current User**
- Holmbom Magnus
- Result**
- Successfully acknowledged

Create notification in SAP PM

Skapa UH-meddel.: Felanmälan (AU)

Medd.status: ÖMED

Order:

Innehåll

Ärende: B-NORM N10 Normal driftäge "Vid start"

2015.03.31 15:08:56 Lars Gren (IASG) Tel. 0706111238
Hög temp styrlager, grundorsaksanalys görs tilli vacken

Position

Feluppstakt: BVM-GEN 050 Periodiskt eller rondarbete

Skadebild:

Text:

Orsakskod:

Text orsak:

Uppgift: 1 av 1

Basidpunkter

Önskad start: 2015.03.31 00:00:00 Prioritet: Planerbar

Önskat slut: 2015.05.31 00:00:00

Referensobjekt

Systemposition: FK042-01-532 Övre styrlager

Utrustning:

Ansvarsområden

Planeringsgrupp: M02 2100 Driftgrupp Jokkmok

Ansv. prod.grp: PV_IBI 21XX PV Internt arbete

Handläggare:

Meddelande från: IASG Meddelandedatum: 2015.03.31 00:00:00

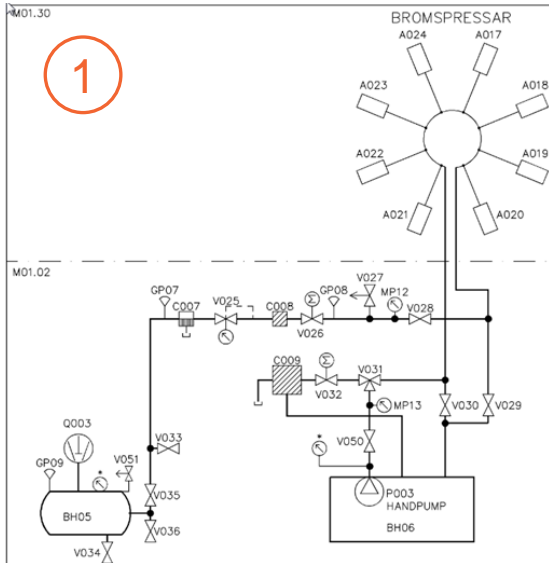
Failure Mode Analysis

Failure Mode Analysis

1. Choose subsystem and use system descriptions and functional descriptions
2. Analysis of current maintenance activities (CMMS)
3. Map all known failure modes to maintenance activities (FMEA)

RCM = Reliability Centered Maintenance
FMECA = Failure Modes, Effects and Criticality Analysis

Rad	FM	CA	Class	Template	Criticality	Status	Last Updated	Updated By	FMECA Name	De
1	6840	Nej			1	R	2009-04-16 15:31:25	OLOV	Fel tryckmätkedja bromssystem	
2	6841	Nej			3	R	2009-04-15 12:13:53	OLOV	Fel lägesmätkedja bromssystem	
3	6839	Nej			3	R	2009-04-15 14:38:33	OLOV	Fel tryckmätkedja bromsventil	
4	6128	Nej			2	R	2009-04-15 14:04:42	OLOV	Säkerhetsventil bromskompressor öppnar ej	
5	6838	Nej			3	R	2009-04-15 13:13:30	OLOV	Säkerhetsventil bromstavla öppnar ej	
6	6833	Nej			3	A	2008-01-25 10:57:44	OLOV	Oljebeläggning på bromsbana	
7	6830	Nej			3	A	2008-01-25 10:57:34	OLOV	Fel reduceringsventil	
8	6836	Nej			3	A	2008-01-25 10:57:52	OLOV	Utslitna bromsbelägg	
9	6842	Nej			3	A	2008-01-25 10:57:31	OLOV	Fel i bromskompressor	
10	6831	Nej			4	A	2008-01-25 10:57:38	OLOV	Kärvande bromspress	
11	6835	Nej			4	A	2008-01-25 10:57:48	OLOV	Läckage rörsystem/bromspressar	



BETECKNINGAR

Operationslistor för

Rad	FM	CA	Class	Template	Criticality	Status	Last Updated	Updated By	FMECA Name	De
K001-01-541										
K001-01-541										
K001-01-541-C001										
K001-01-541-C001										
K001-01-541-C001										
K001-01-541-Q001										
K001-01-541-Q001										
K001-01-541-Q001-BH01										
K001-01-541-8001										
K001-01-541-V001										
K001-01-541-V002										
K001-02-541										
K001-02-541										
K001-02-541										
K001-02-541										
K001-02-541-C001										
K001-02-541-C001										
K001-02-541-C001										
K001-02-541-Q001										
K001-02-541-Q001										
K001-02-541-Q002										
K001-02-541-8001										

Failure Mode Analysis, cont.

- Go through all notifications in CMMS. Are there any new failure modes previously unidentified? Fault frequency analysis.
- Which failure modes may be identified with condition monitoring?

Ändra meddelanden: Lista över meddelanden

Mon...	V	Medd.	Typ	Systemposition	Prioritet	Beskrivning	Order	PG
		31153016	VM	PK003-03-540	Planerbar	PK003 hamiltonventiler inventering		MN2
		31235760	VM	IK010-02-540	Akut	IK10 G2 Översyn åtg. kärvande bromspr.	6034022	MM6
		31230556	VM	TK002-01-541	Akut	TK2 G1 bromstryck lågt		MS2
		31236006	VM	IK031-03-541	Akut	IK31 G3 fel		MM3
		31236009	VM	IK035-02-541-Q001	Akut	G2 Bromsluft ej ok	6034153	MM2
		31236007	VM	PK046-02-540	Akut	Pk46 AD2 Lång tid stoppsekvens stoppsteg		MN3
				PK046-02-540	Akut	AD2 Lång tid stoppsekvens stoppsteg 6	6034350	MN3
				PK044-01-540	Akut	PK44 G1 Bromstryck	6035530	MN2
				IK031-03-541	Akut	G3 Bromsar ej till stopp.	6034676	MM3
				PK002-02-541	Akut	PK2 G2 krypning		MN1
				PK002-01-541	Akut	PK002 G1 Startblock		MN1
				PK002-02-540	Planerbar	PK2 G2 krypning	6034794	MN1
				NK002-02-540	Planerbar	NK2 G2 Kärvande bromspress	6035187	MV4
				ÅK002-00-541-Q002	Planerbar	Bromskompressor S-ventil ÅK2	6035206	MS1
				PK002-02-541	Planerbar	PK2 Krypning		MN1
				PK002-01-541-GP01	Akut	PK2 G1 Lågt bromstryck ur funktion		MN1
				PK002-02-541	Akut	G2 krypning		MN1
				IK031-04-541	Planerbar	G4 kärvande ventil bromsning	6036964	MM3
				PK046-03-540	Planerbar	PK46 G3 BROMSBANAN	6036566	MN3
				PK002-02-541	Planerbar	PK2 G2 krypning		MN1
				PK052-01-541-Q001	Planerbar	PK52 G1 bromskompressor	6040664	MN1
				IK032-01-541	Akut	G1 oljedimsmörjare		MM3
				IK035-02-540	Planerbar	Bromskompressor mycket gångtid	6037213	MM2
				NK009-01-541	Planerbar	NK9 Magnetventil bromsutrustning	6039160	MV2

FMECA Name	Symptom 1	Symptom 2	Condition monitoring
Fel tryckmätkedja bromsventil	Lång stopptid	Utebliven manöver	Stoptid, Gränslägen bromsar
Fel lägesmätkedja bromssystem	Ej frigivning		Gränslägen bromsar
Fel tryckmätkedja bromsventil	Felaktig manöver		Gränslägen bromsar, signal:Bromsar till
Säkerhetsventil bromskompressor öppnar ej	Högt tryck	5	Tryck kompressor
Säkerhetsventil bromstavla öppnar ej	Högt tryck		Tryck efter kompressor
Oljebeläggning på bromsbana	Lång stopptid		Stoptid: signal bromsar från
Fel reduceringsventil	Avvikande tryck		Bromstryck
Utslitna bromsbelägg	Lång stopptid		Stoptid: signal bromsar från
Fel i bromskompressor	Lågt tryck	Lång gångtid	Tryck kompressor, gångtid kompressor
Kärvande bromspress	Lång stopptid	Ej frigivning bromsar	Gränslägen bromsar, signal:Bromsar till
Läckage rörsystem/bromspressar	Gångtid kompressor		Gångtid kompressor, Bromstryck

Symptoms

Failure modes for break system

Sensor needs

Condition monitoring

Failure Mode Analysis, cont.

6. Which measurements are required? (Process to install new sensors)
7. Define a general analysis model
8. Adapt to local conditions by using parameters (requires deeper local knowledge of each power plant)
9. Classify normal and deviating conditions in 5 levels (technical index)

Asset structure

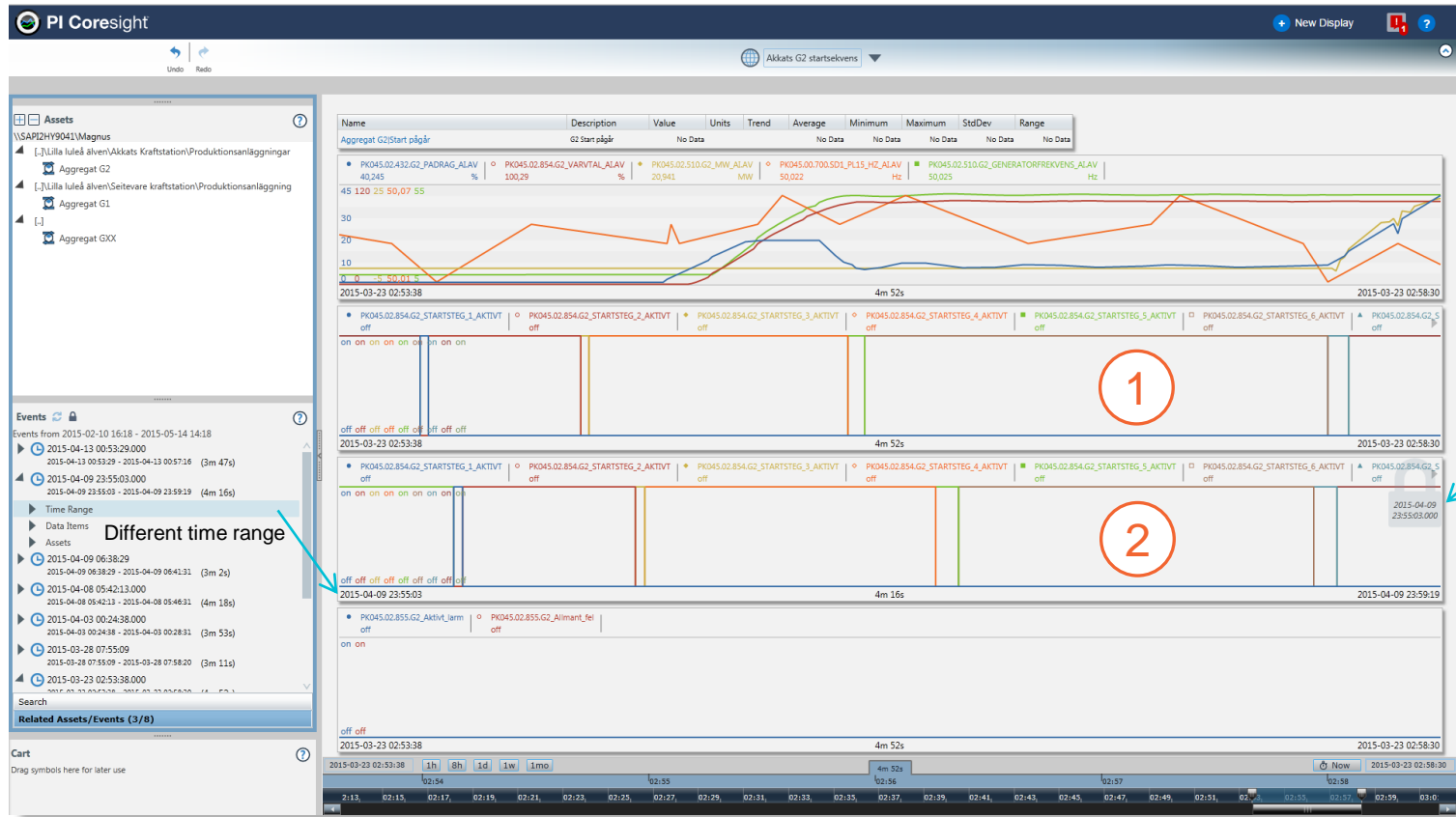
Fault modes from RCM

Calculation of technical index ("Analyses" tab)

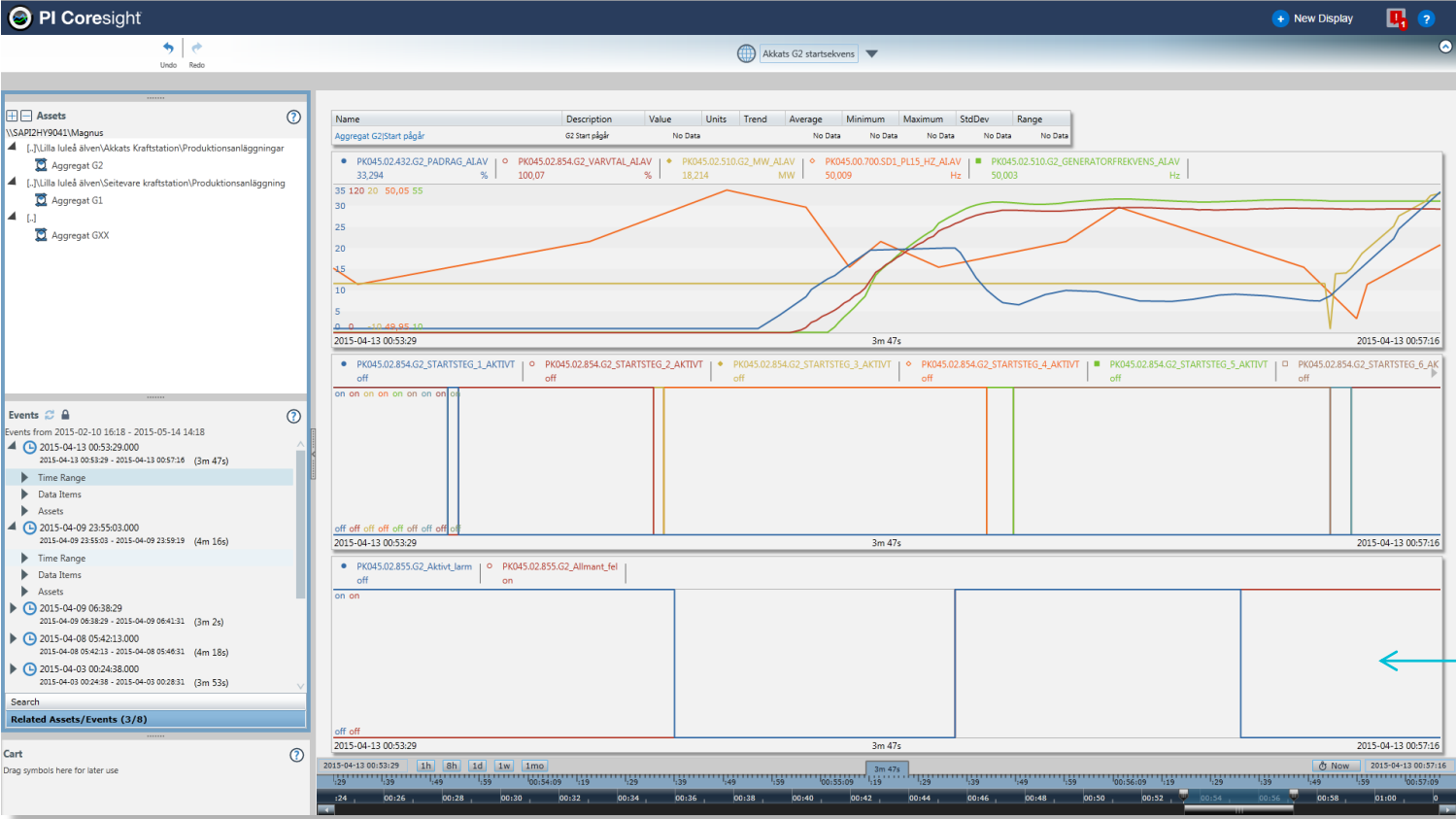
Name	Value	Category	Unit Of Measure
Bromspress 1 till	on		<None>
Bromspress 1 från	off		<None>
Anliggande bromsar	off		<None>
Tryckvakt tryck efter ventil	off		<None>
Tryckvakt Lågt tryck före ventil	off		<None>
Normtid Bromspress Från - Till	5 s		second
Normtid Bromspress Till-från	15 s		second
Norm bromstryck	4 bar		bar
Kärvande bromspress Tekniskt index	4		<None>

Calculated index, to be presented in a display and/or used to generate a notification

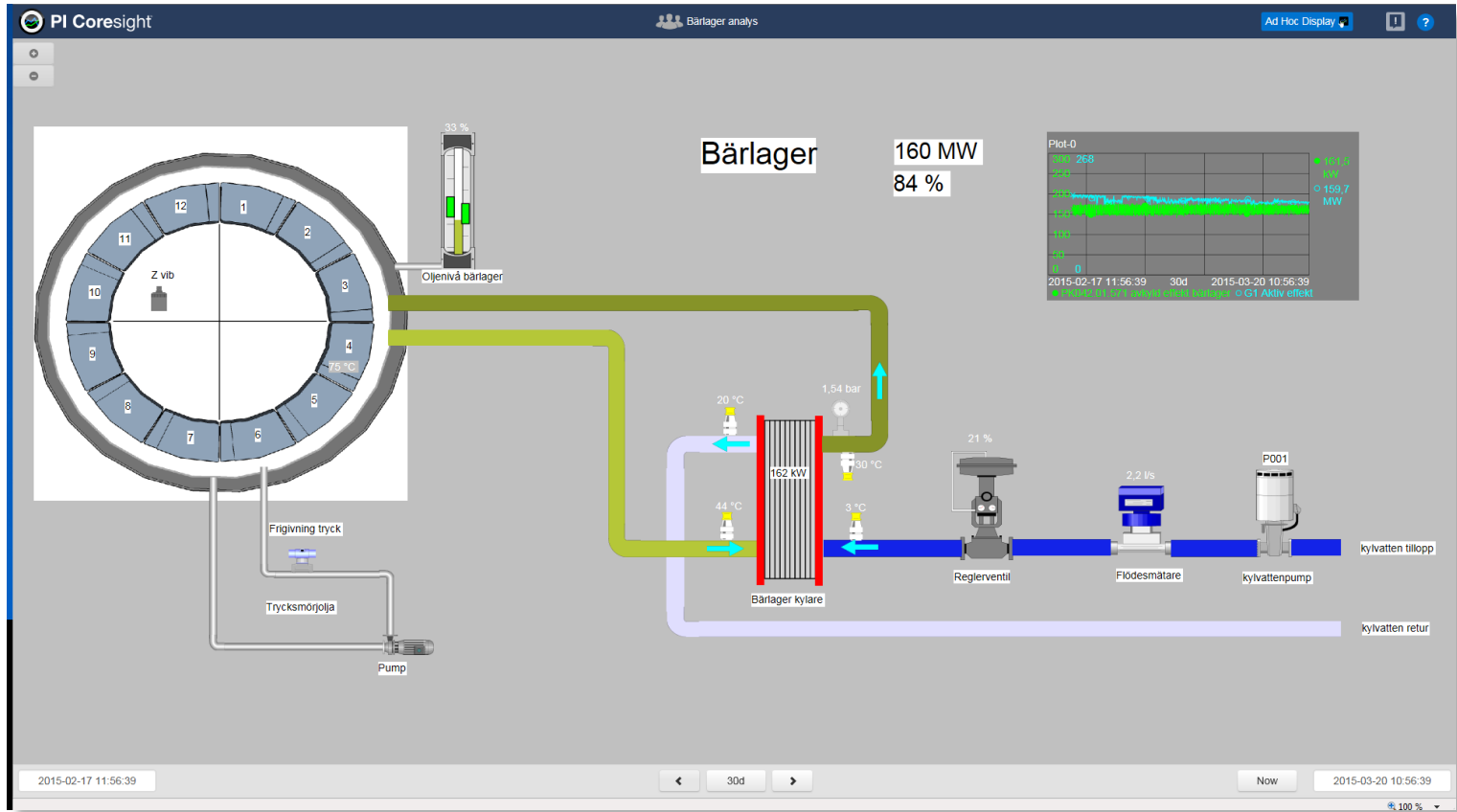
Comparing startup event sequences



Alarm during startup



System overview – Thrust Bearing cooling

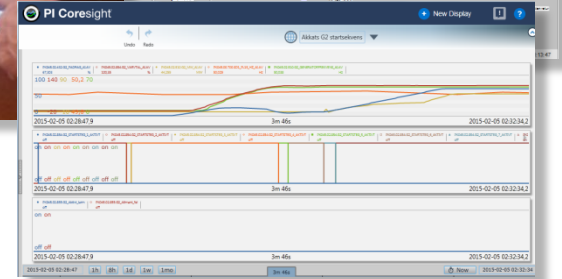
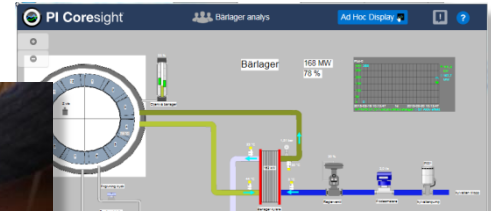
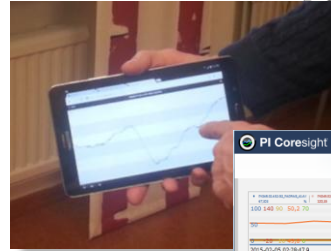


Deploying a Condition-Based Maintenance Strategy in the Hydro Power Business

“We needed to implement a new strategy and the existing IT solution did not provide the necessary functionality for this. After a thorough evaluation project in 2014, we are now deploying the PI System and use many of the possibilities in the implementation of the new strategy.”

Stina Pettersson

Head Of Maintenance Development
Vattenfall Vattenkraft AB



VATTENFALL 

Business Challenge

- Need for a new strategy and standardised methodology for Condition-Based Maintenance
- Old data historian system not sufficient

Solution

- Implementing the PI system as data infrastructure, analytical modeling and presentation tool
- Use of Android tablets for on-site manual rounding with PI Manual Logger and visualization of PI System data through PI Coresight displays

Results and Benefits

- Improved common continuous monitoring of the hydro power plants
- Reduced costs for unplanned maintenance (~1.5% of total maintenance costs)
- Increased accuracy in asset condition assessment

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