



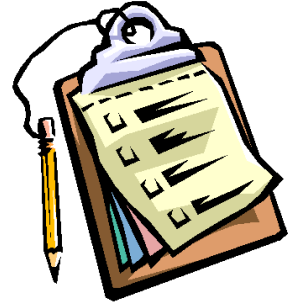
Implementation of the PI System to support Predictive Maintenance Diagnostics Across Oil & Gas Assets in Italy



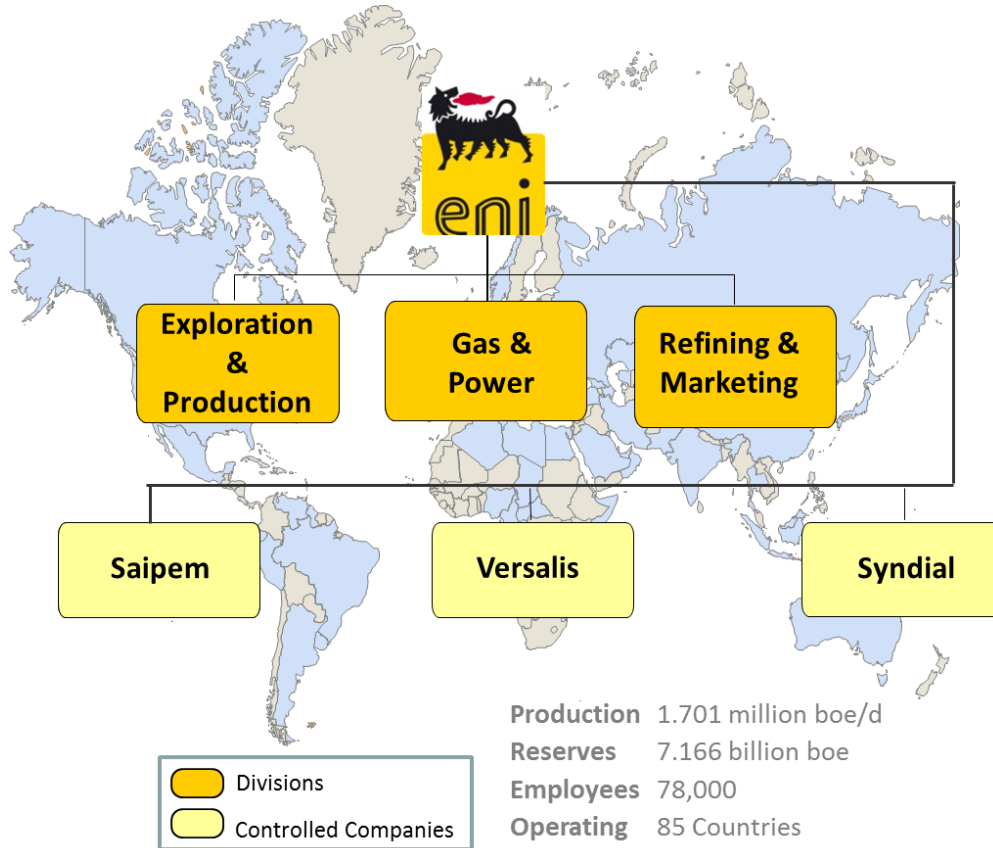
Presented by **Cristina Bottani**
Marco Piantanida

Agenda

- Introduction
- Business Challenge
- The Predictive Monitoring Process
- Role of the PI System
- Applications, Results & Benefits
- Next Steps
- Conclusions



Introduction: Eni – Global and Diversified



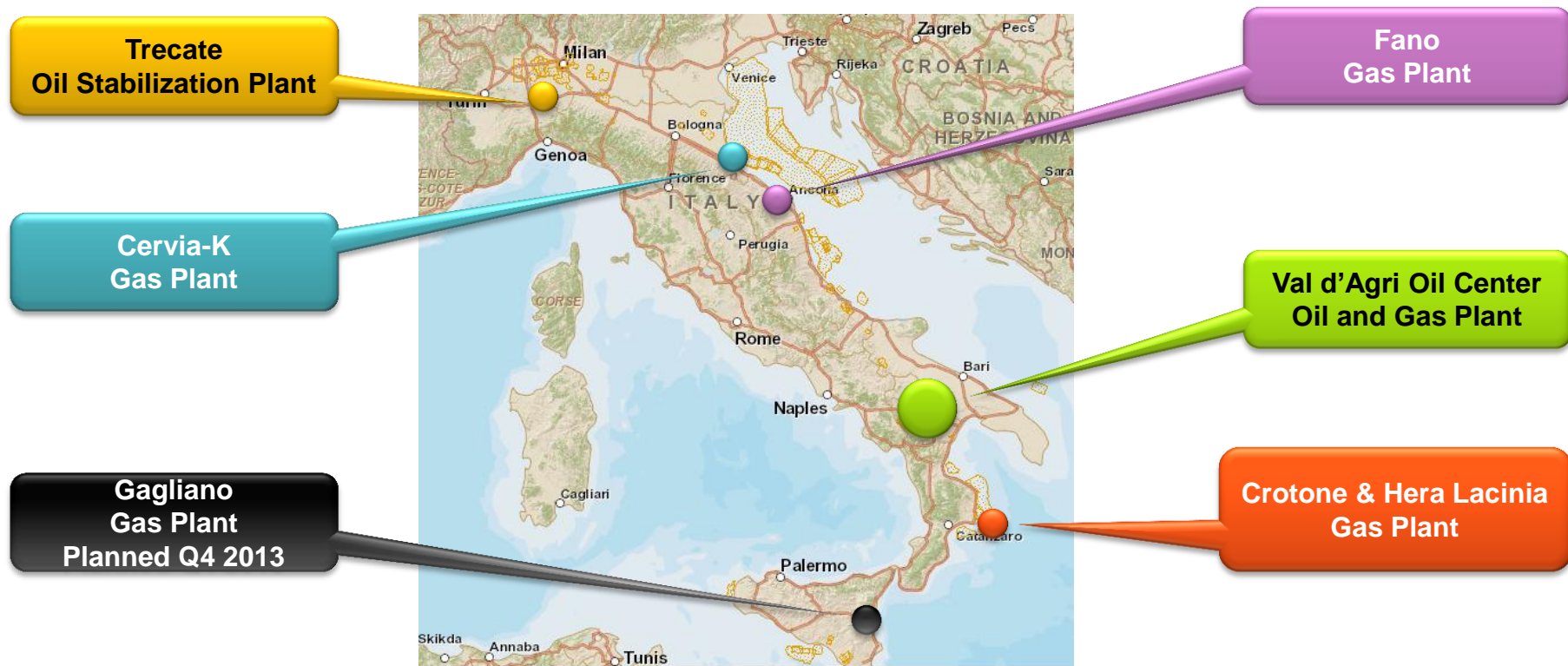
our mission

We are a major integrated energy company, committed to growth in the activities of finding, producing, transporting, transforming and marketing oil and gas.

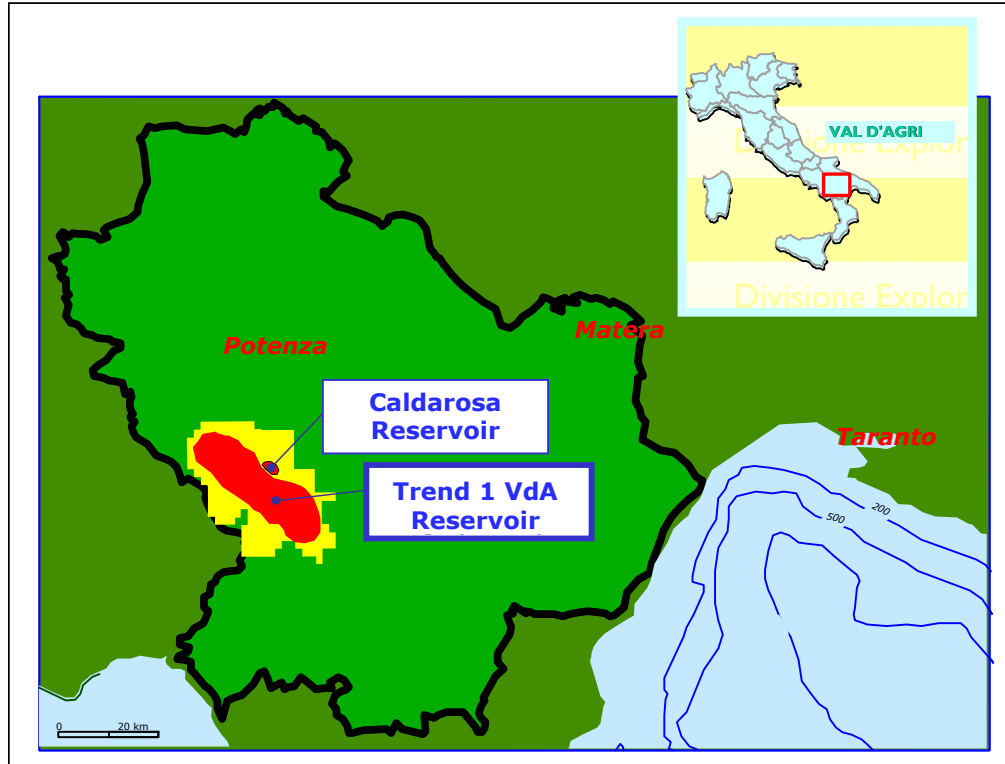
Eni men and women have a passion for challenges, continuous improvement, excellence and particularly value people, the environment and integrity.



The PI System in Italy – 5 Plants and Associated Fields

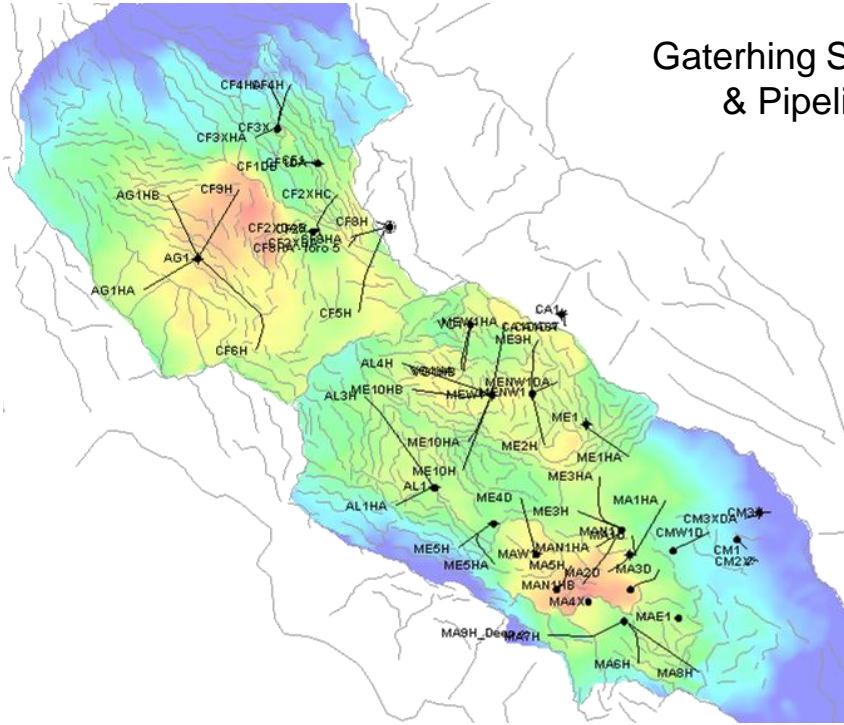


Business Challenge - The Val d'Agri Field

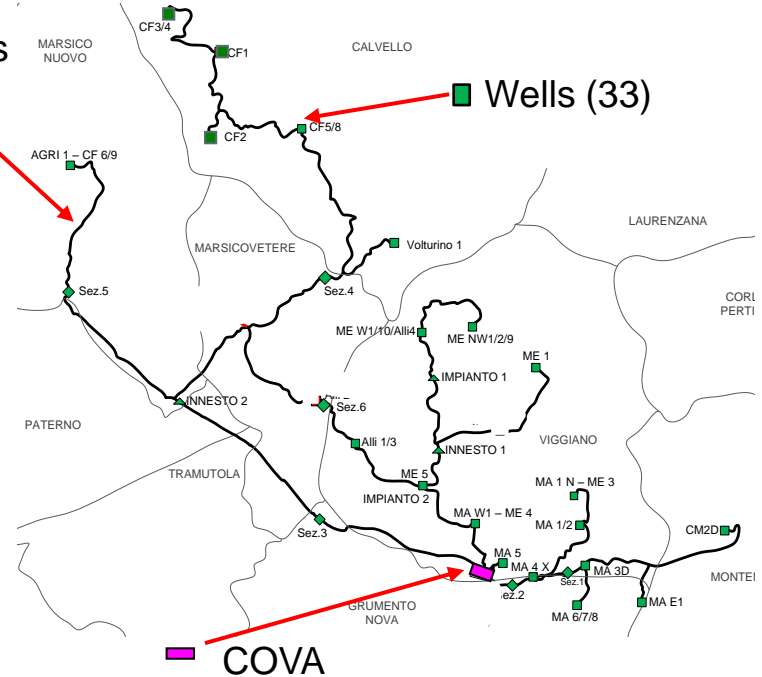


- Field is operated by Eni Spa
- Discovery well: MA1 in 1988 (Monte Alpi 1)
- Early production phase started in 1993 with MA2
- A total of 33 producer wells were drilled to date
 - 30 of them are currently tied in

Business Challenge - Wells and Pipelines



Gathering Systems
& Pipelines



COVA = Oil Center (“**C**entro **O**lio **V**al d’**A**gri”)

Business Challenge - Val d'Agri – Facility



- The Oil Center in Viggiano (Val d'Agri) has a target nominal capacity of 104 K barrels/day
- In 2012, the overall oil production was 95 K barrel/day from 26 wells, representing 30% of overall Eni's in Italy

Business Challenge - Equipment

- **Main Characteristics of the Plant**

- 4 Oil Trains (water, oil & gas separation, oil stabilization)
- Gas Treatment (compression, dehydration, sweetening, advanced treatment of sulfur)
- Power Generation and Utilities

- **Main rotating equipment**

- Power Generation: **3 Gas Turbines** (fully instrumented)
 - One spare Turbine is kept offline, on rotation
- Compression Unit: **7 low pressure + 6 high pressure reciprocating compressors** (not comprehensively instrumented)
 - One spare low P Compressor and one spare high P Compressor are kept offline, on rotation

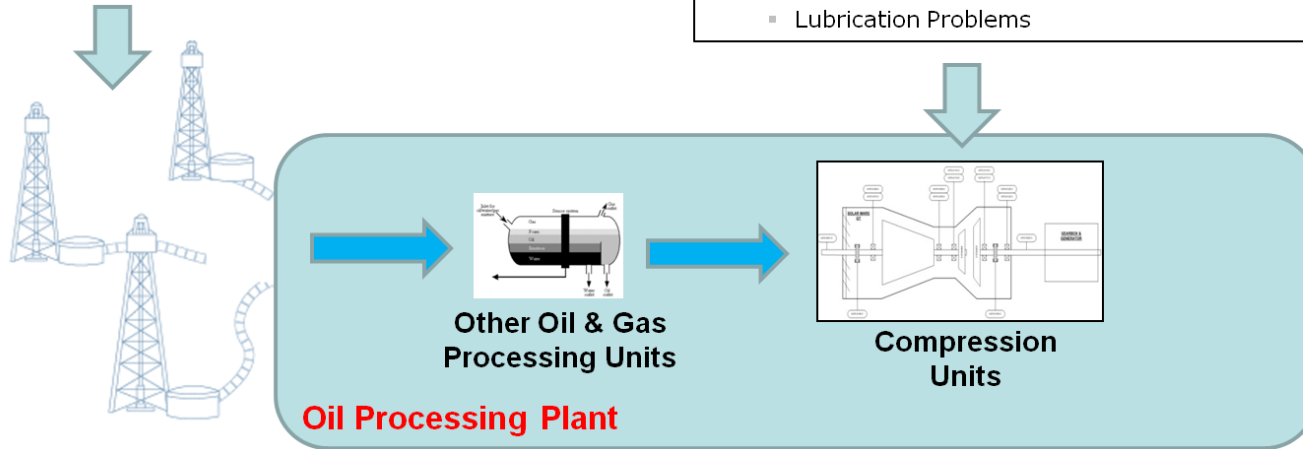
Main Challenges & Current Maintenance Process

- Variable operating conditions

- Slugs
- Progressive water cut increase
- Modifications in the GOR
- Additional production due to tie in of new wells

- Variety of issues

- Liquid carryover
- Sealing problems
- Filter fouling
- Lubrication Problems

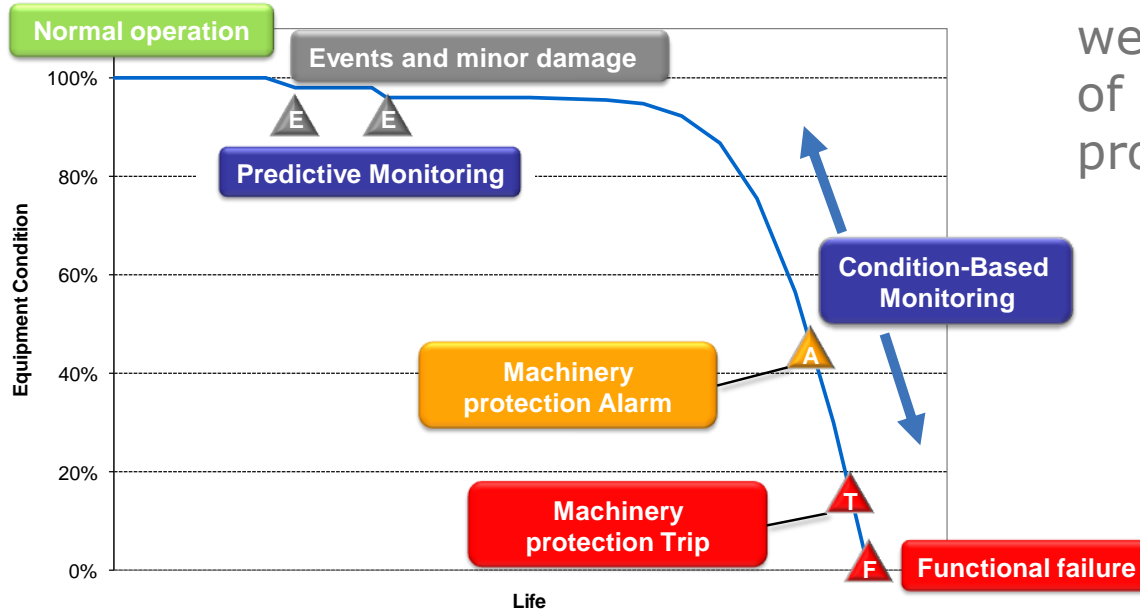


- Current Maintenance Process

- Planned (Preventive) Maintenance at 2,000 4,000 8,000 16,000 running hours
- Resident Maintenance Technicians allocated full time for the most important equipment



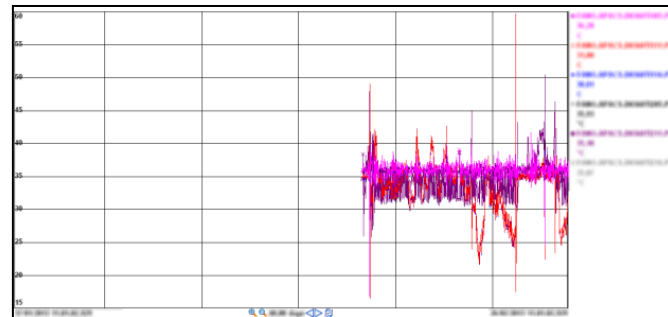
The Predictive Monitoring Concept



- Early detection (from several weeks to several months ahead of failure) of equipment problems
 - More time to plan and react

Predictive Monitoring Challenges

- Level of instrumentation of the equipment is often non-optimal
 - Mathematical methods based on **First Principle** models could be unable to perform due to the lack of key sensors
- Availability of **high fidelity** historical data was an issue
 - Often limited to few weeks
 - Complemented with offline measurements sampled sporadically (vibrations, boroscope inspections, infrared thermography, lube oil analysis, etc)
 - **Data driven** methods requiring a **comprehensive** set of high fidelity historical data would not work
 - **The implementation of the PI System allowed to overcome this problem**



The PI System in Italy – 5 Plants Instrumentation

Treccate

4 Reciprocating Compressors

Moore ICI DCS
InTouch Wonderware

60 tags

Cervia-K

2 Turbo Compressors

ABB Advant 500 DCS
IMS Stations

210 tags

Crotone & Hera Lacinia

2 Turbo Compressors 5 Reciprocating Compressors

RTAP Unix DCS
SDI eXPert SCADA

630 tags

Fano

2 Turbo Compressors

Moore APACS DCS

450 tags

Val d'Agri

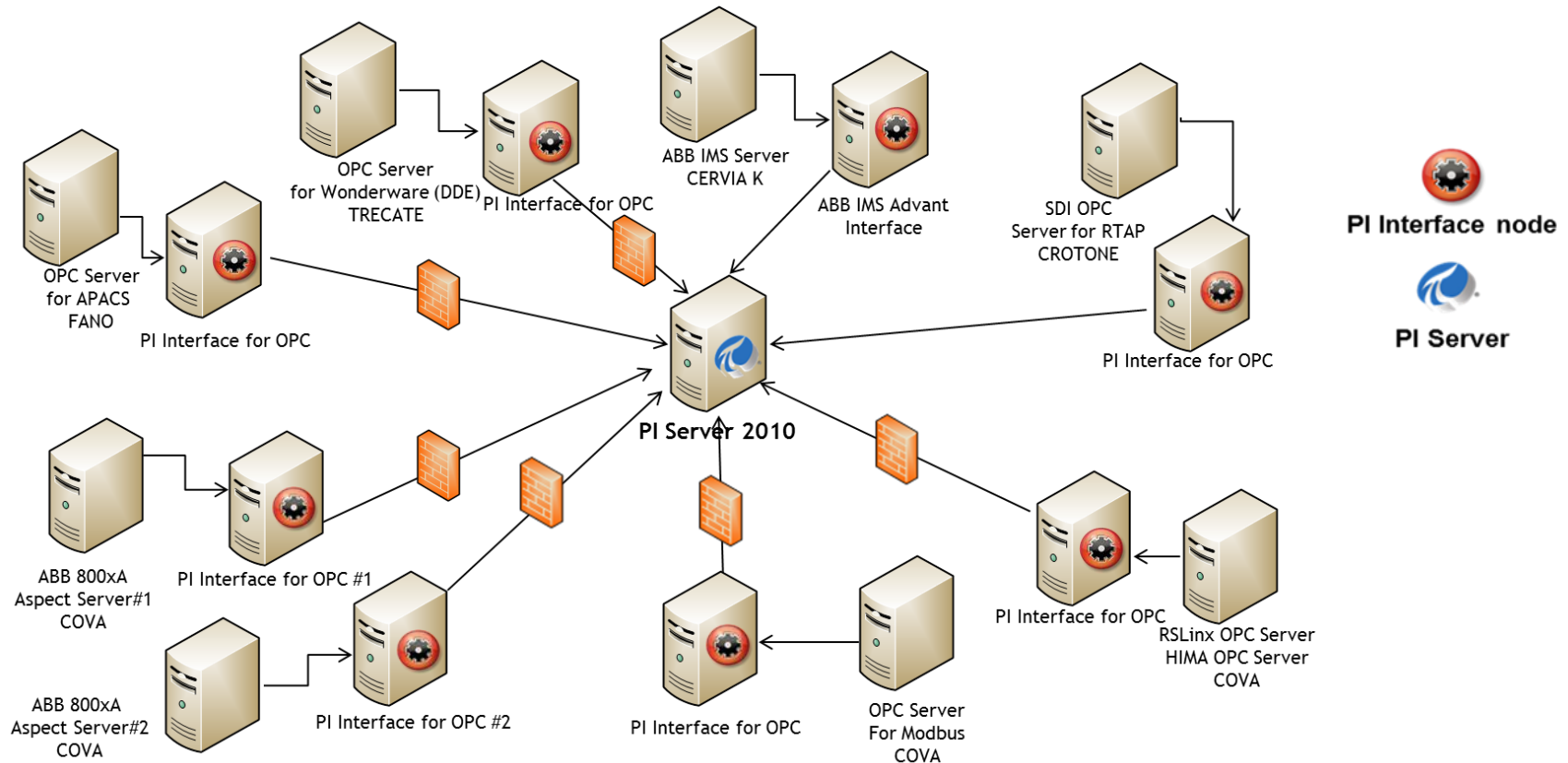
13 Reciprocating Compressors 3 Gas Turbines

ABB Advant OCS Master 300 DCS
ABB 800xA Aspect/Connectivity Server

1650 tags



Overall Architecture – An Integration Infrastructure

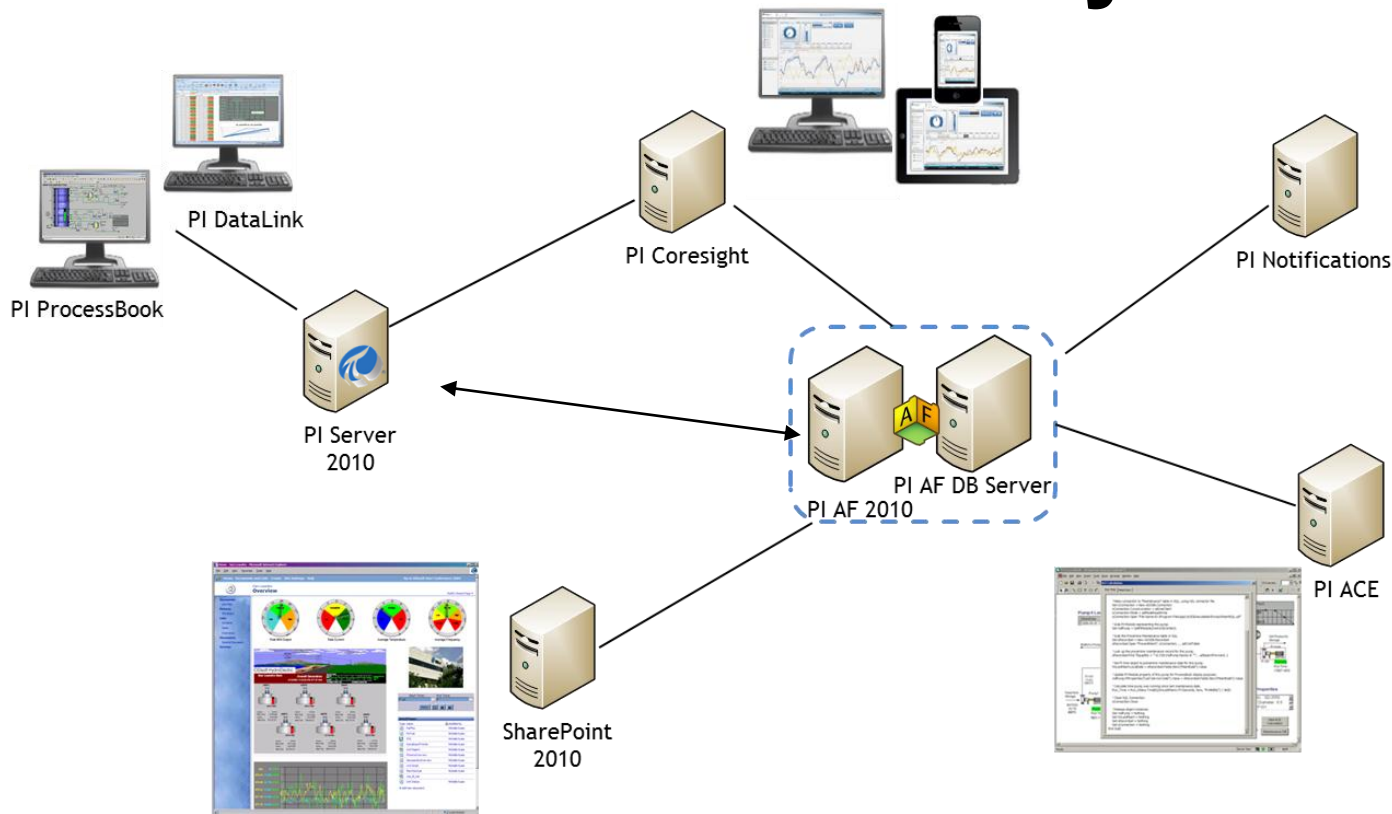


Perspective on the PI System....

- Power of PI System infrastructure
- Flexibility and richness of connectors of the PI System
 - Even very old DCS systems (dating back to 1991) have been interfaced



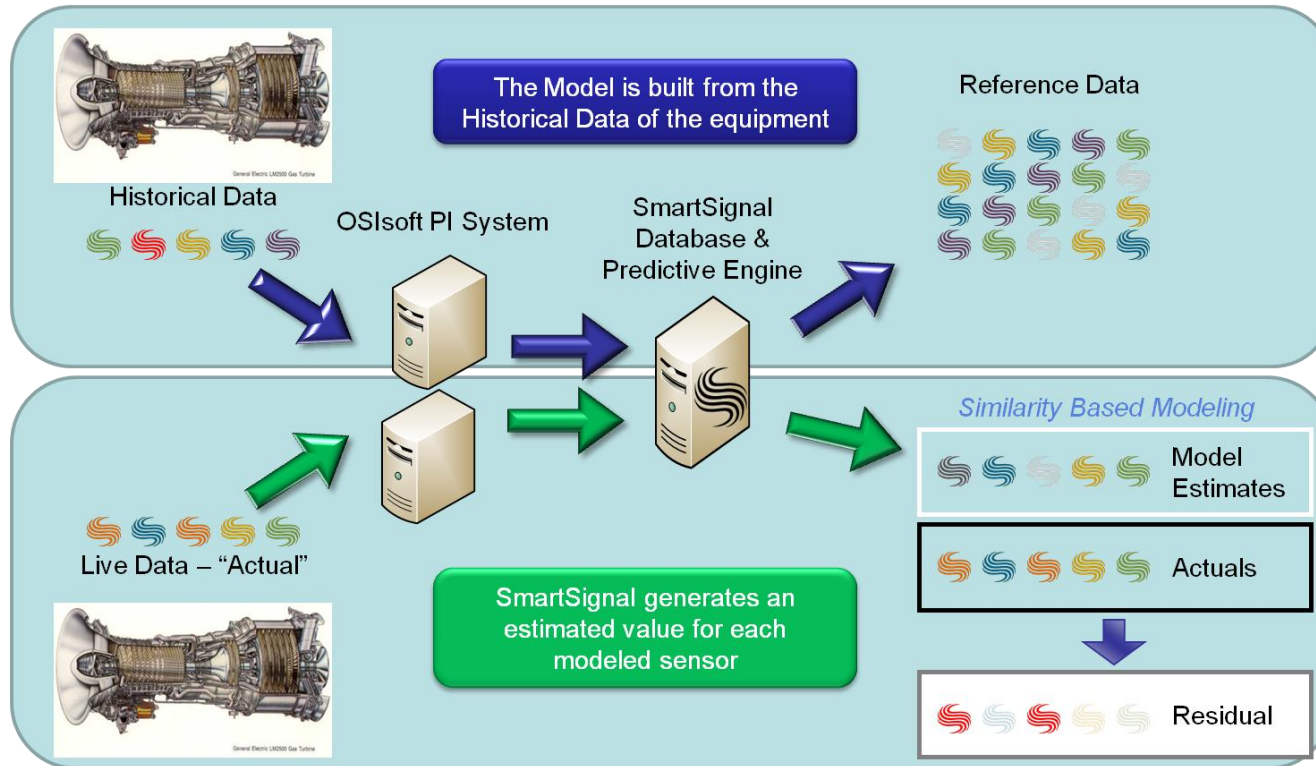
HQ Architecture - “More Eyes on PI”



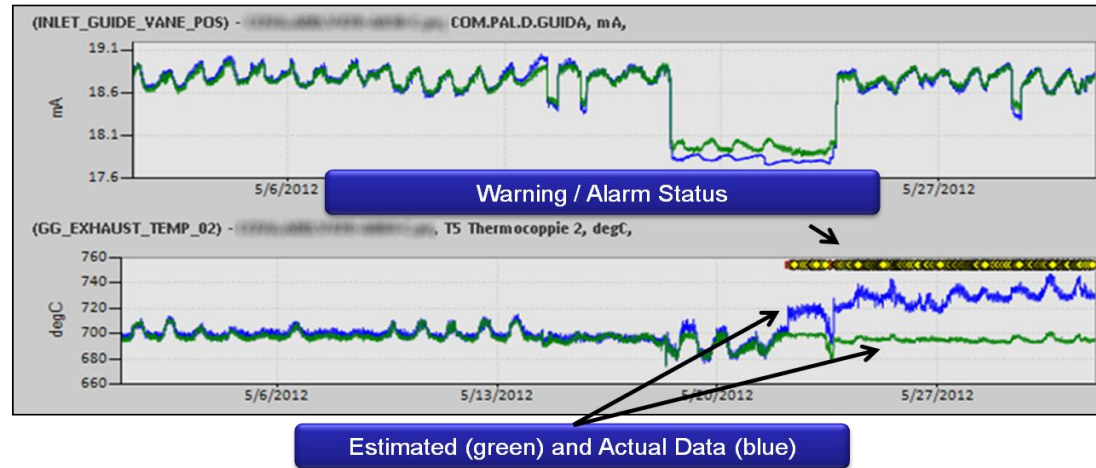
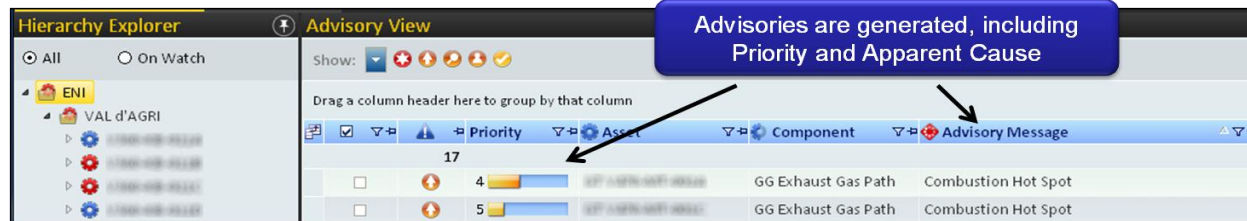
Two Roles of the PI System

- Feed a specialized Predictive Analytics Package (Smart Signal)
- Direct diagnosis tools when dealing with failures that are rapidly developing on the equipment
 - Cannot be detected by the predictive analytics package
 - Can be investigated with PI Process Book and PI Coresight

Feeding a specialized Predictive Analytics Package – Operation Concept



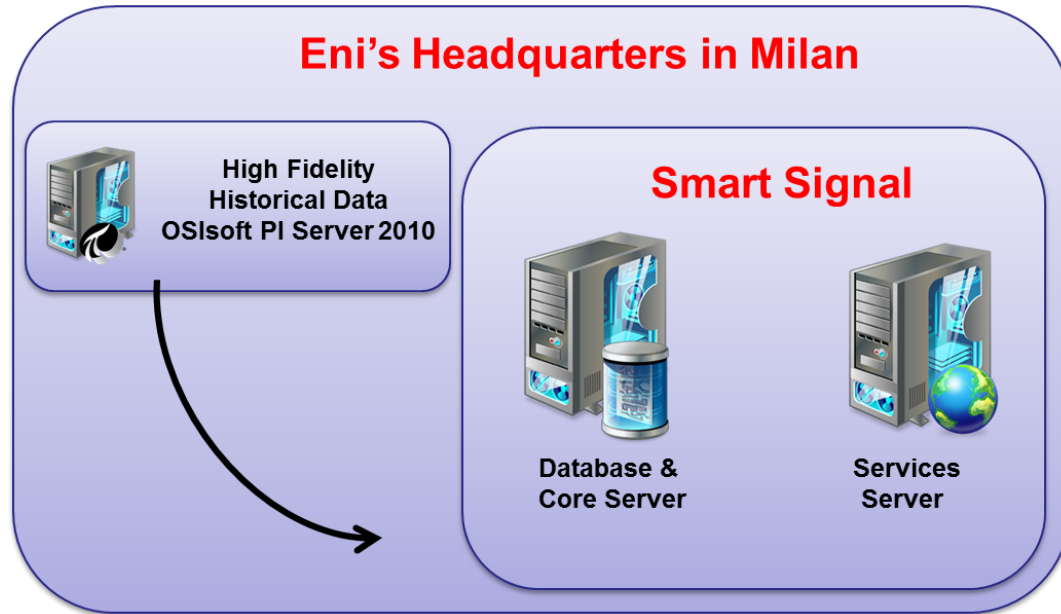
Feeding a specialized Predictive Analytics Package – Operation Concept



Predictive Monitoring Software: IT Architecture

On premise installation of the software.

Access of Smart Signal
analysts through
Internet / VPN

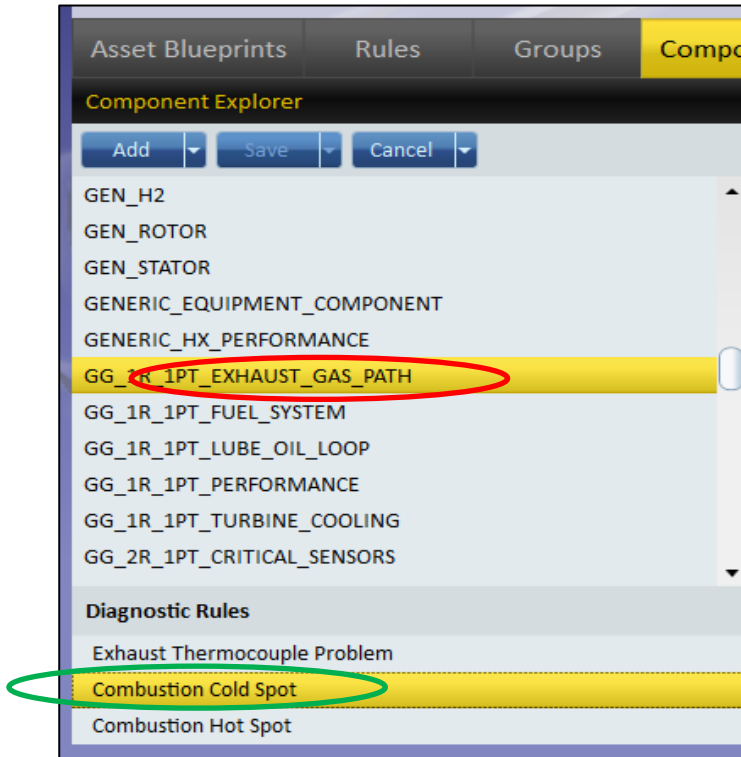


Direct Investigation for Rapidly Developing Events



- Development of a PI AF hierarchy consistent with the Predictive Monitoring package
- Development of PI Process Book files linked to PI AF
- PI Coresight linked to PI AF

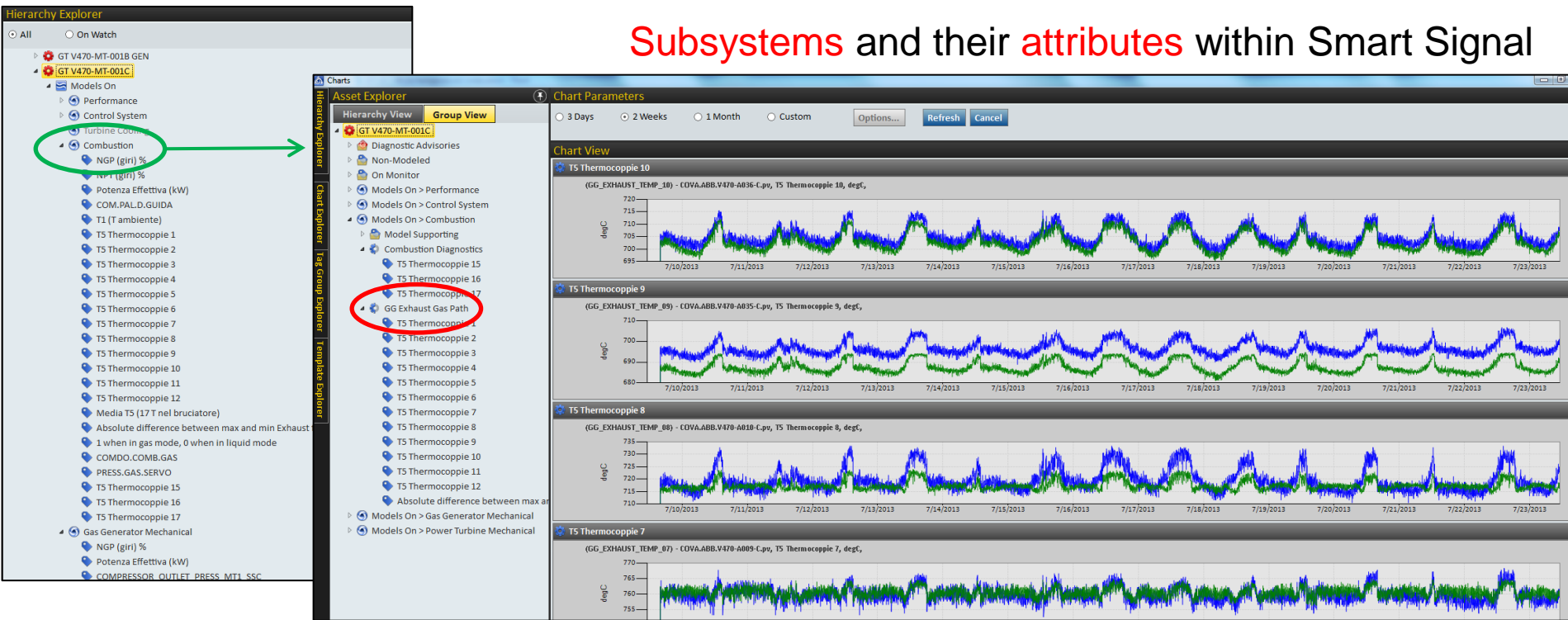
Development of a PI AF hierarchy Consistent with the Predictive Monitoring package



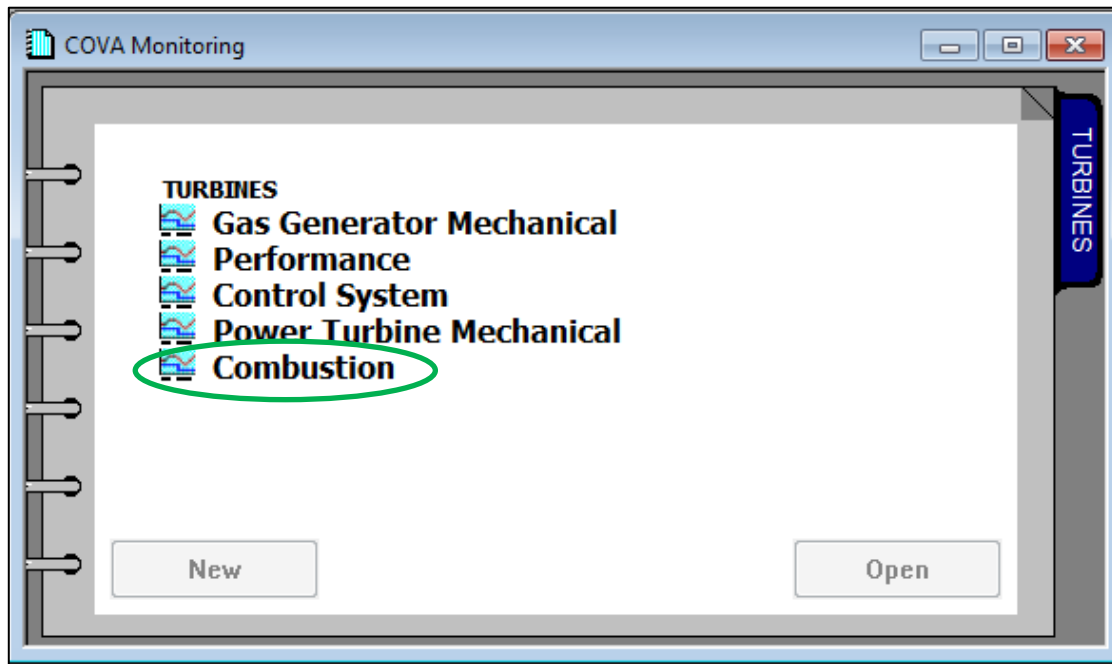
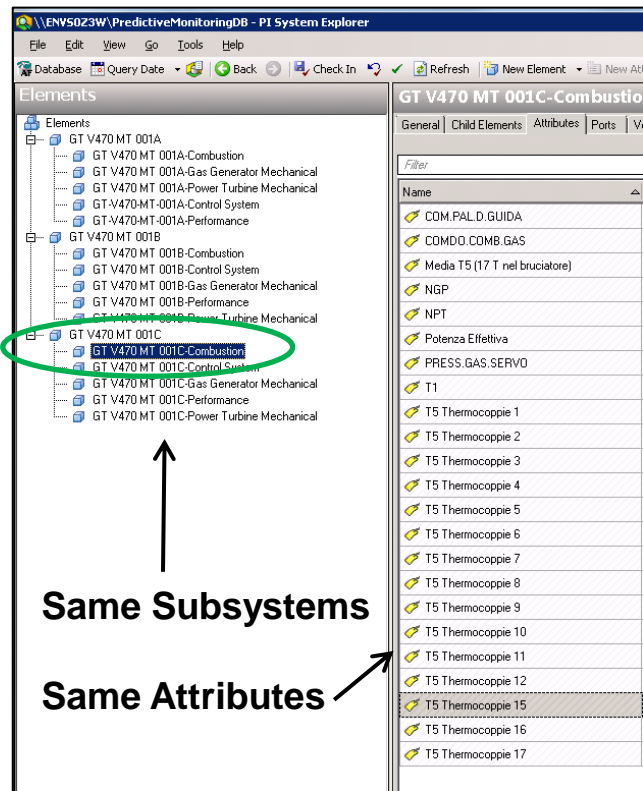
- Diagnostics Rules within Smart Signal are targeting different **subsystems** of the rotating equipment
 - e.g. the firing of the “Combustion Cold Spot” Rule will open the graphs of the “Combustion” → “GG Exhaust Gas Path” section of the Smart Signal GUI

Development of a PI AF hierarchy consistent with the Predictive Monitoring package

Subsystems and their attributes within Smart Signal



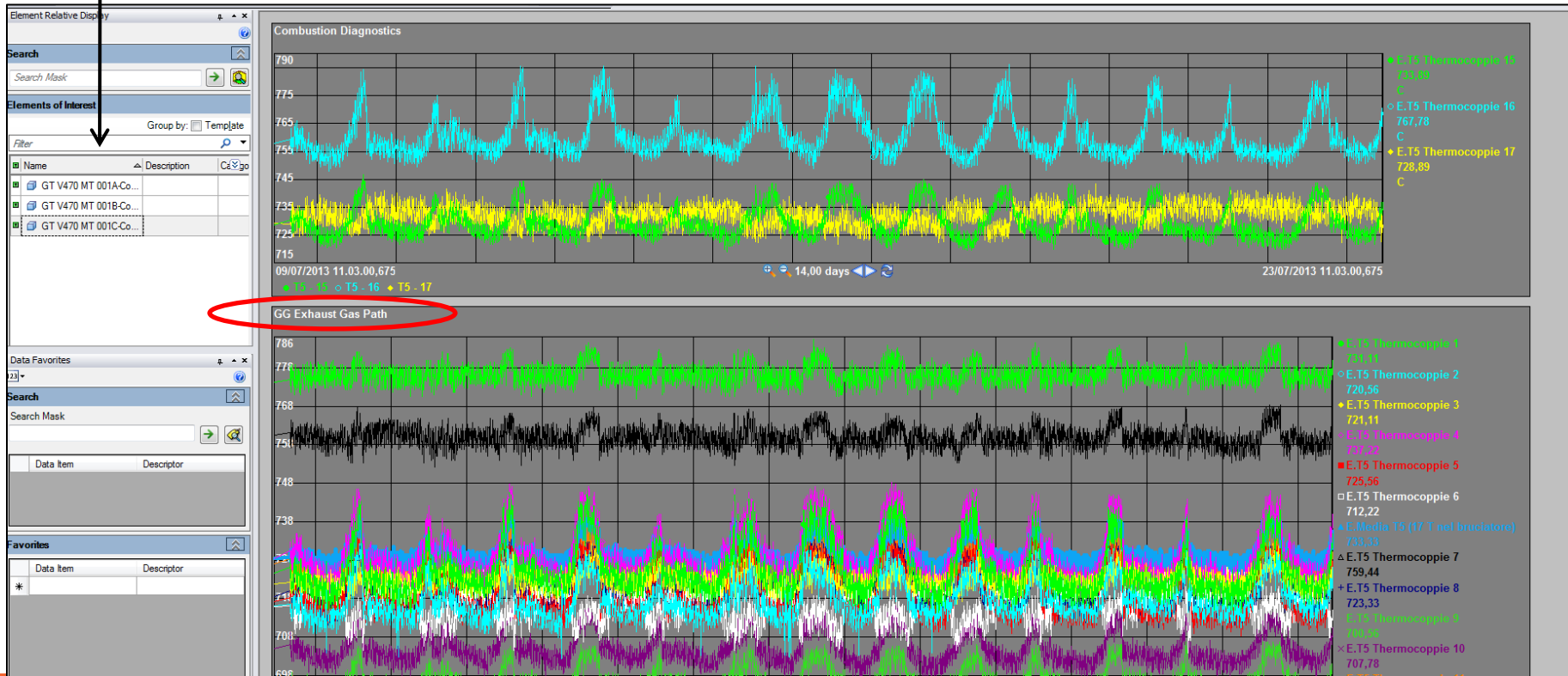
Development of a PI AF hierarchy consistent with the Predictive Monitoring package



PI AF & PI ProcessBook Hierarchy Representation

Analysis in PI ProcessBook

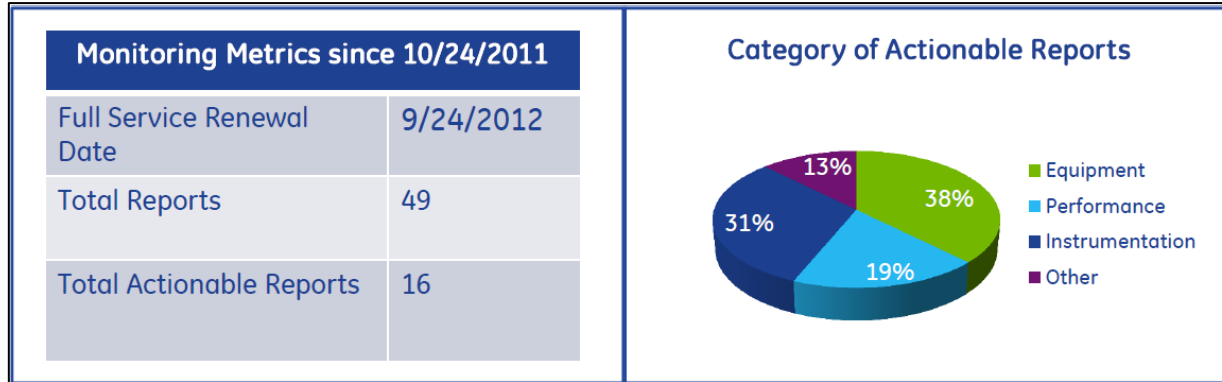
Linked to PI AF through Element Relative displays



Analysis in PI Coresight



Predictive Monitoring Results



- Approximately 1 new notification every week (on average)
- One out of 3 notifications has been actionable: the site has taken action to fix or mitigate the root cause of the problem
- A variety of equipment problems has been detected

Successful Catch: Broken Compressor Discharge Valve

Date of Notification: Oct 7, 2011

Equipment: [... omissis ...]

Type: Equipment/Mechanical

Description: We have seen an increase in the discharge temperature from 142 to 153 C.

Resolution: Action was taken during shutdown and a broken valve was replaced.

Insight: Discharge Temperature helps detect valve issues. Individual temperatures at each cylinder can help further localize the bad valve.



Successful Catch: Lubrication Problem and prevention of potential wear

Date of Notification: Jul 12, 2012

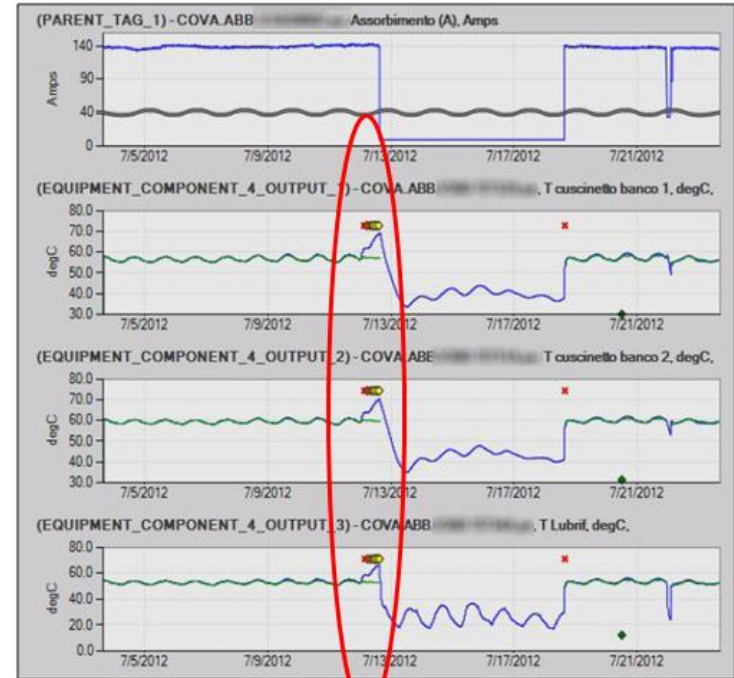
Equipment: [... omissis ...]

Type: Equipment/Electrical

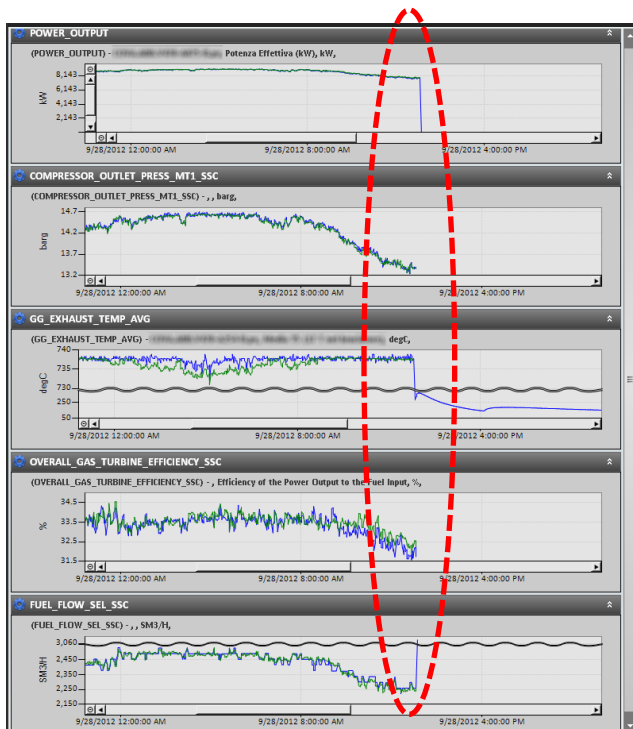
Description: The temperature of bearings 1 and 2 has been increasing up to ~69 C with model prediction at ~58 C.

Resolution: An electrical problem had shut down a cooling fan at the lube oil cooler. Connection was repaired.

Insight: Early detection of problem prevents unnecessary wear on the equipment.



Understand of the dynamics of the failure and help prevent the occurrence of similar cases in the future

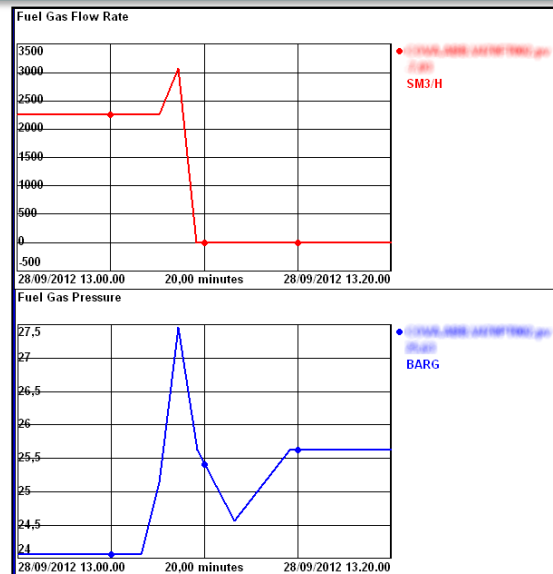


Failure Occurring without early warnings

Trip of Gas Turbines causing a partial controlled shutdown of the plant.



Deeper
Analysis
of
Data



Sudden increase in fuel gas due to sudden increase in the P and incorrect behavior of the regulation valve

Benefits



- **The following benefits were achieved:**
 - **Prevented damage** on electrical motor windings on 3 compressors - 150 K euro
- **The following benefits are expected:**
 - Increased production due to **reduction of unexpected equipment downtime** with consequent unplanned production losses
 - The future prevention of a case like the shutdown of the Gas Turbines would avoid a 15,000 barrel of lost production
 - **Reduced operating expenditure** due to unscheduled downtime and minimized equipment damage
 - 1.1% – 2.4% increase the availability of the equipment
 - **Optimization of maintenance operation**
 - Expected saving in the range 250 – 400 K euro per year

Future Plans and Next Steps



- Other assets are being integrated (Nigeria, Alaska, Congo, Pakistan)
 - PI Web Parts, PI AF
- Centre of Excellence on ESP Pumps Worldwide
 - PI Web Parts, PI AF, PI Coresight, mobile devices

Summary

The implementation of the PI System allowed to support Predictive Diagnostics of rotating equipment across a number of assets in Italy



Business Challenge

- Diverse instrumentation and control environment
- Lack of high fidelity historical data
- Rotating Equipment is subject to a variety of issues due to the variable operating conditions of an Oil & Gas plant
- Need for proactive analytics

Solution

- PI System – integration infrastructure
- Retention of high fidelity historical data
- Integration and alignment of asset hierarchy with predictive monitoring package
- Use of PI System analytics, notification & visualization capabilities

Results and Benefits

- Better visibility on the activities of OEM technicians in the plant
- 16+ actionable diagnostics with avoided equipment damage
- Increased overall equipment availability
- Reduced maintenance costs
- Culture of continuous improvement

Conclusions

- The PI System allowed to effectively introduce the Predictive Monitoring concept across several Oil & Gas plants within Eni
 - Flexibility to cope with very old DCS and SCADA systems
 - Capability to feed data to specialized Predictive Analytics packages
 - Richness of graphical tools to perform direct analysis of data (PI Process Book, PI Coresight)

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