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## Empowering Business in **Real Time.**

**PI Infrastructure** for the Enterprise.

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# A New Approach to Plant Performance Improvement, Leveraging Data in OSI PI

María José Aniorte
Antonio Calvo

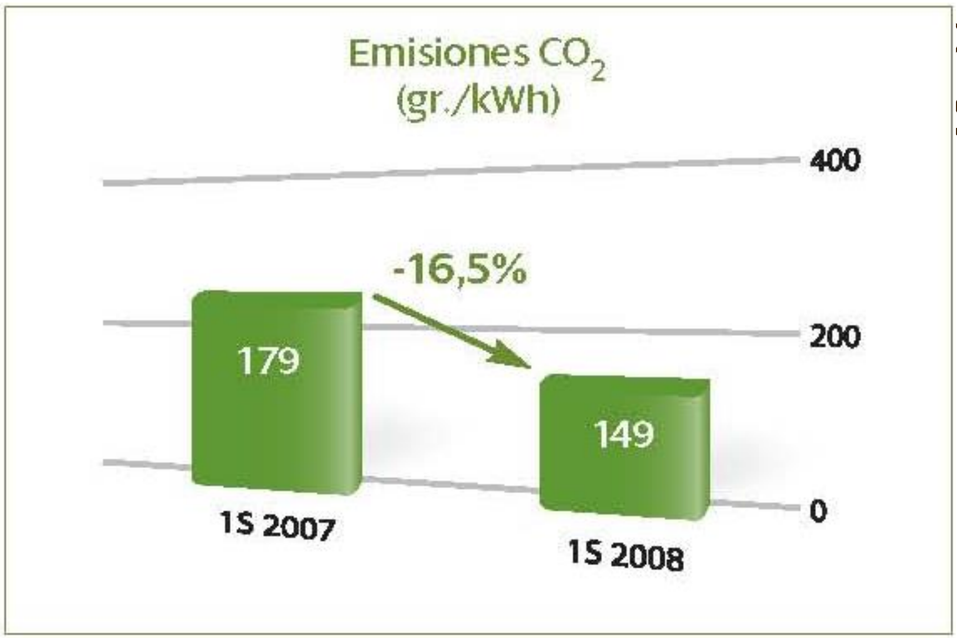
# Agenda

1.- IBERDROLA & CMDS Overview
2.- Monitoring PIDs
3.- PID Analysis
4.- Looking for a solution PI-Plant Triage
5.- Expert Tune Plant Triage PROJECT
6.- Initial findings and control strategies improvement
7.- Models
8.- Conclusions & key lessons learned
9.- Questions and Answers

# IBERDROLA OVERVIEW

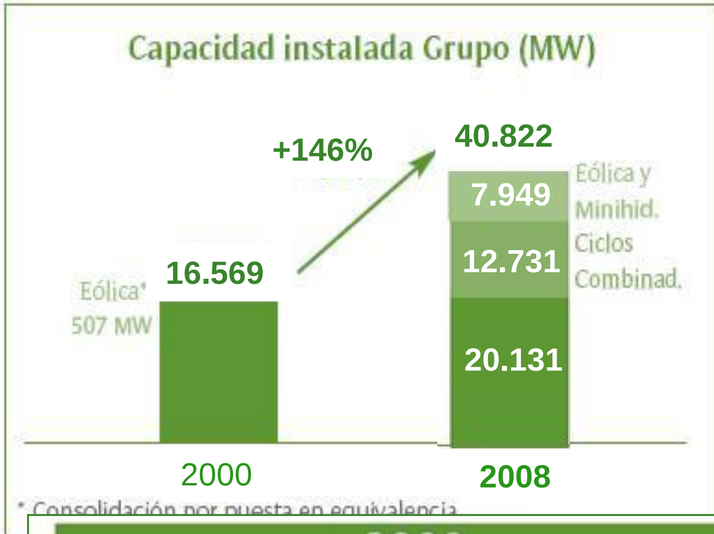
IBERDROLA

- Electric P … distribution.
- The most … Spain
- One of the … mpanies in Europe
- €52 Billior
- €5.5 Billio
- Shareholc … in 5 years

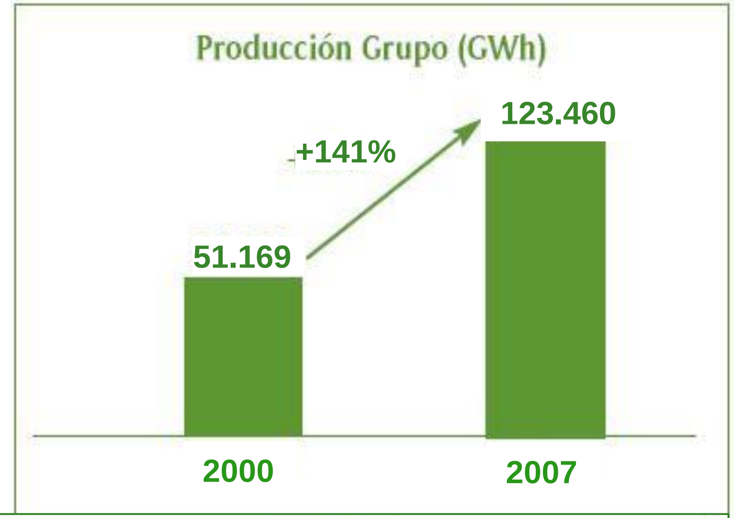


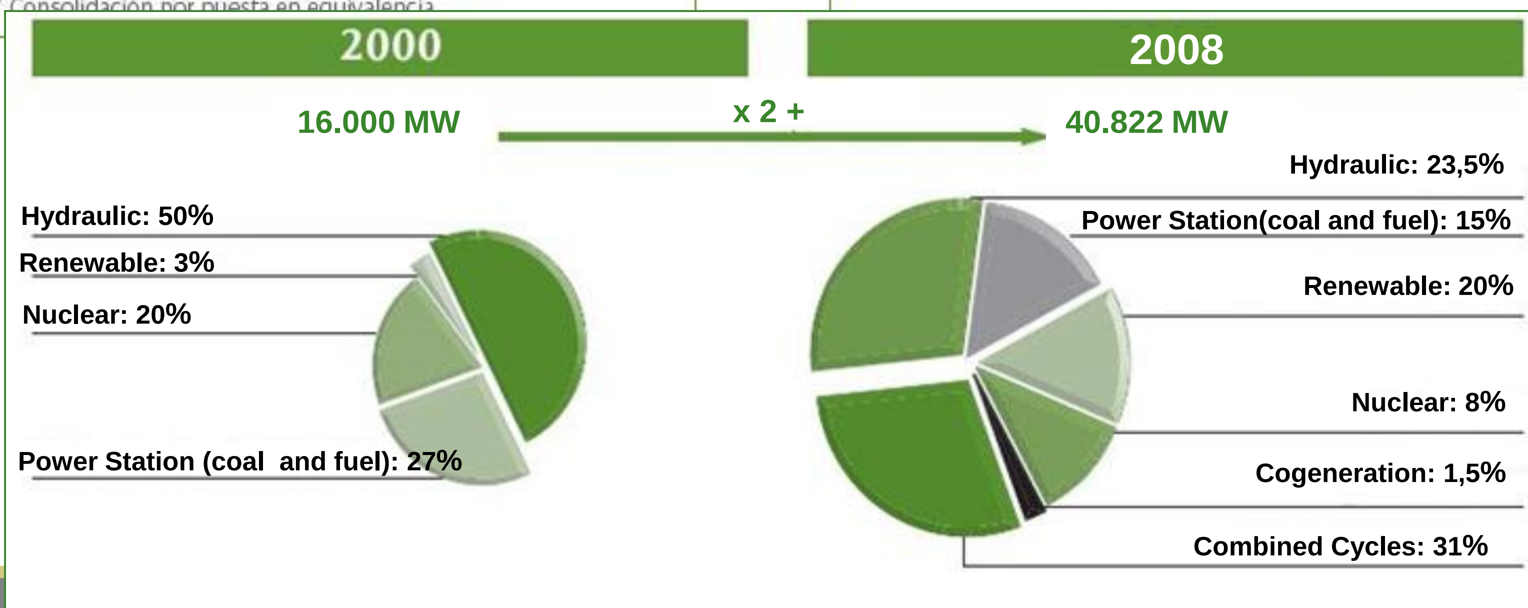
# IBERDROLA OVERVIEW

## Installed Capacity



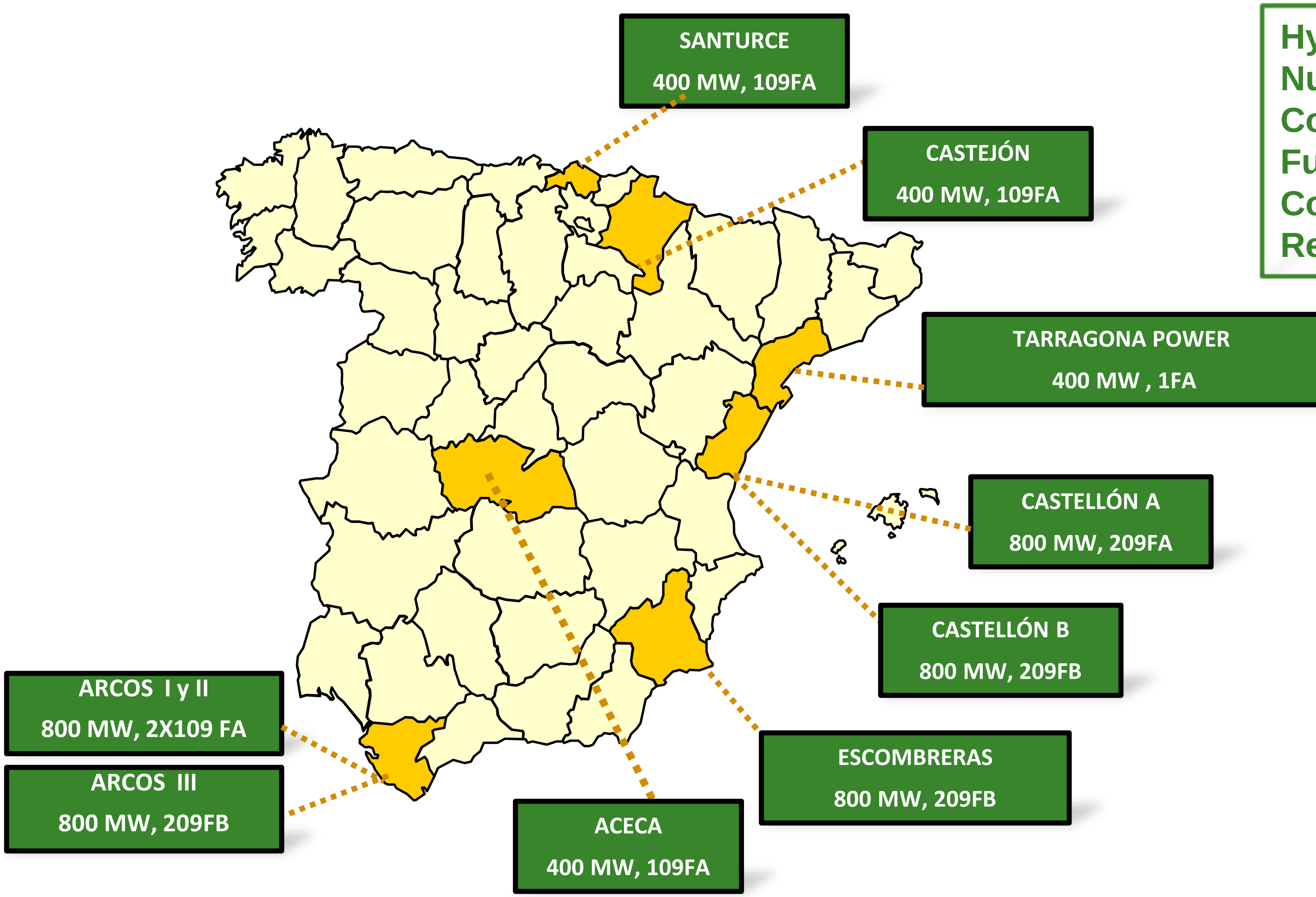

## Total Production



# IBERDROLA in Spain

## We lead the construction of combined cycle power plants in Spain…




| | | |
|---|---|---|
| Hydraulic: | 8839 | MW |
| Nuclear: | 3344 | MW |
| Coal: | 1253 | MW |
| Fuel Oil: | 1803 | MW |
| Cogen.: | 380 | MW |
| Renewable: | 4725 | MW |

## …5.600 MW since 2007

# IBERDROLA in the world

## We lead electric private producer in México


| Combined Cycles | |
|---|---|
| Enertek | 120 MW |
| Monterrey | 1.040 MW |
| Altamira III y IV | 1.036 MW |
| La Laguna II | 500 MW |
| Altamira V | 1.121 MW |
| Tamazunchale | 1.135 MW |
| **Eolic** | |
| Oaxaca | 100 MW |

**… near 5.000 MW contracted power**

OSIsoft.

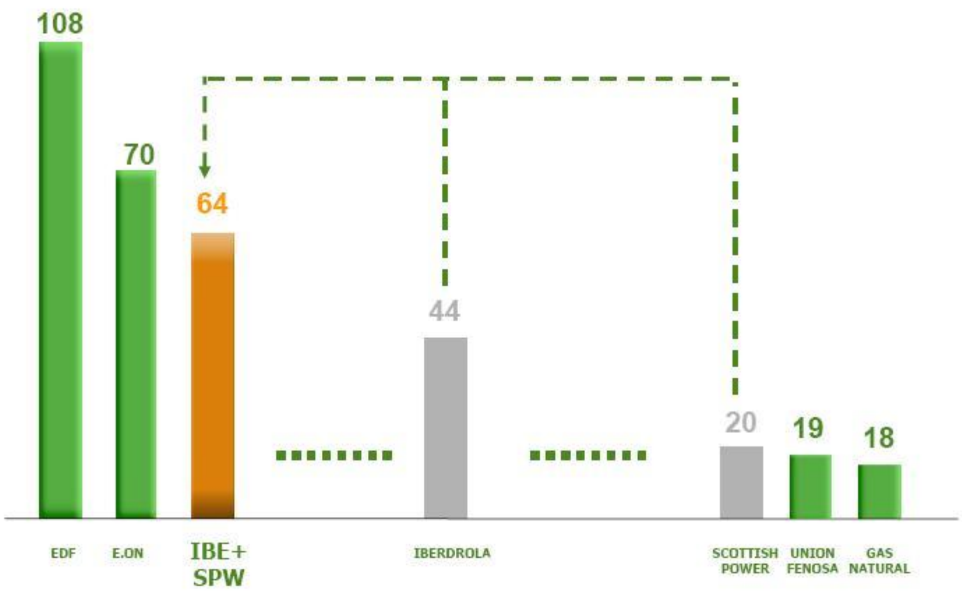
# IBERDROLA in the world

IBERDROLA + Scottish Power

60.000 Million Euros Total Value

Renewable World Leader


3rd European Utility



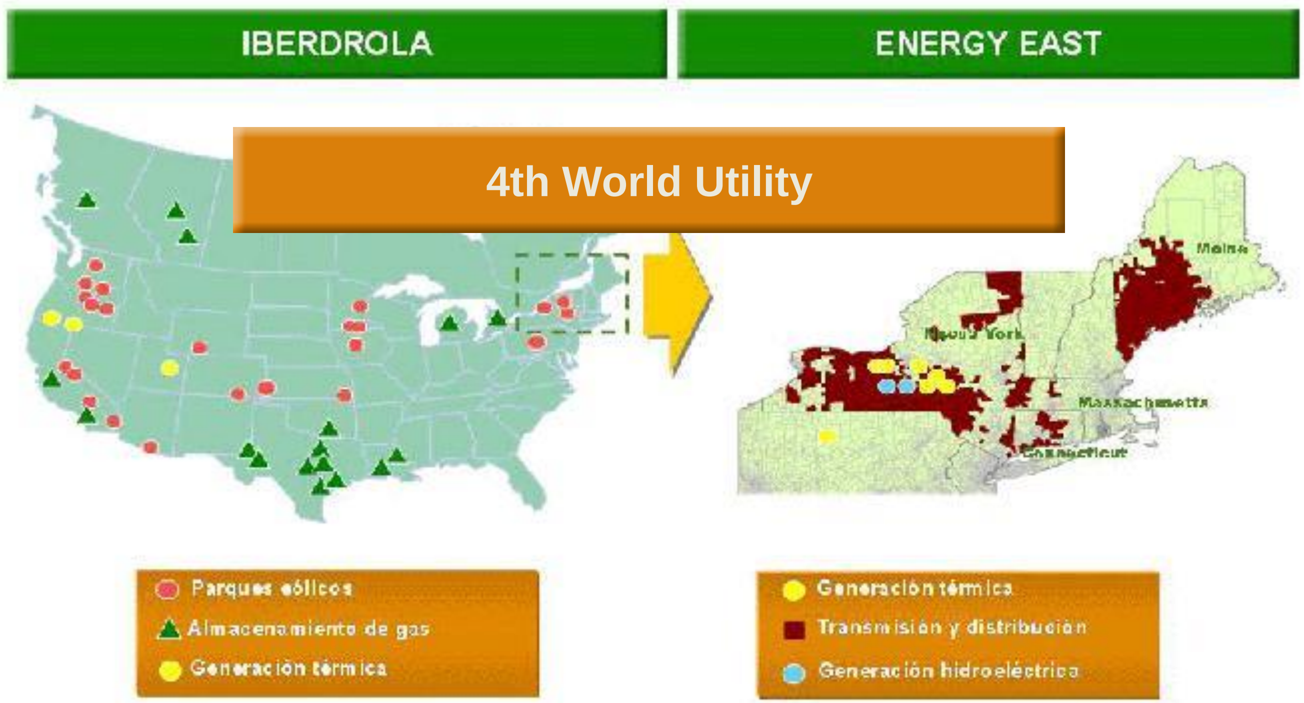
# IBERDROLA in the world

## IBERDROLA + Energy East

**65.000 Millions Euro Total Value**

**Up to 42.000 MW Installed Capacity**

**4th World Utility**



# CMDS – Monitoring Diagnostic and Simulation Center

Technology Center for Combined Cycles since 2002

## MAIN GOALS

- **Maximize efficiency, availability and reliability**
- **Support power plants to:**
  - **O&M in an optimum way**
  - **Minimize costs**
  - **Unify technology management**

## POWER PLANTS O&M OPTIMISATION

## ADDITIONAL PROFITS

- **Common O&M model for all stations : Fleet approach**
- **O&M on-site and on-line support**
- **Share operational experiences and best practices**
- **Center of Excellence**
- **Reduce OEM dependency**

# CMDS Organization

**CMDS**
**Manager**

16

**TEDIC**
**Técnicas de Dlagnóstico y Control**

- Performance Analysis
- Vibration Analysis
- PDA Analysis
- Early Warning A&D
- Control Systems

10

**AEMA**
**Apoyo a la Explotación y al MAntenimiento**

- Incident Analysis
- Maintenance Support
- Simulators

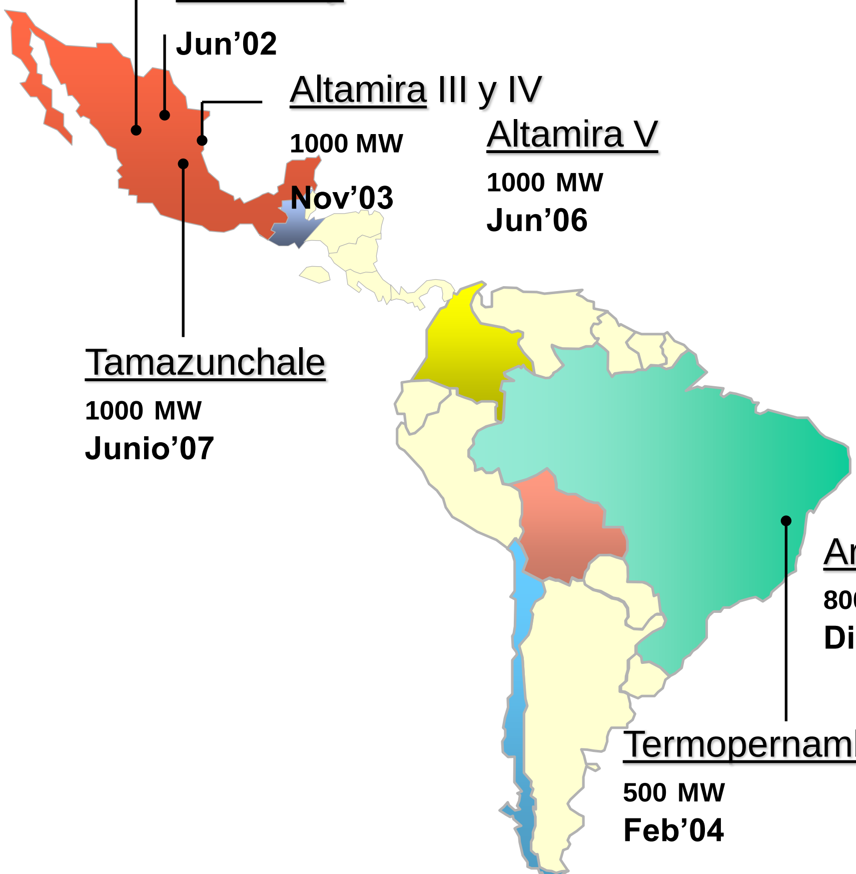
6

**SERIT**
**SERvicios de Infraestructura Tecnológica**

- Information Security
- SW Development
- Technical Support

# CMDS Scope ‘08

## Combined Cycles



La Laguna 500 MW

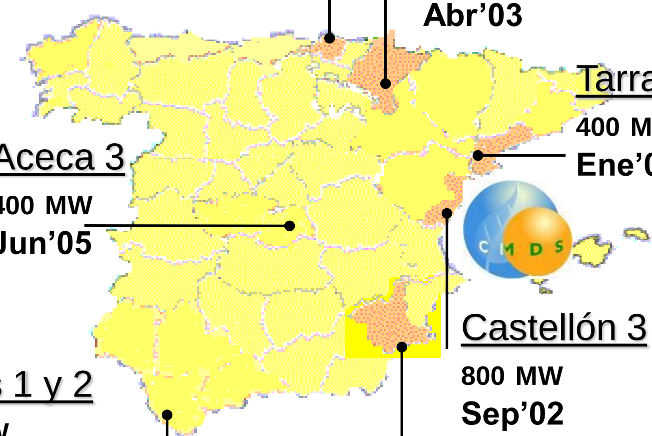
Monterrey III 1000 MW
Jun’02

Altamira III y IV
1000 MW
Nov’03

Altamira V
1000 MW
Jun’06

Tamazunchale
1000 MW
Junio’07

Termopernambuco
500 MW
Feb’04



Santurce 4
400 MW
Ene ‘05

Castejón 1
400 MW
Abr’03

Tarragona Power
400 MW
Ene’04

Aceca 3
400 MW
Jun’05

Arcos 1 y 2
800 MW
Dic’04

Arcos 3
800 MW
Jun’05

Castellón 3
800 MW
Sep’02

Castellón 4
800 MW Dic´07

Escombreras 6
800 MW
Nov’06

CC Riga
400 MW

# CMDS Future Scope

# Monitoring

- **What is monitoring?.**

  We do standard checks during start up and normal operation, focusing on key parameters in our process.

- **What do we monitor?**

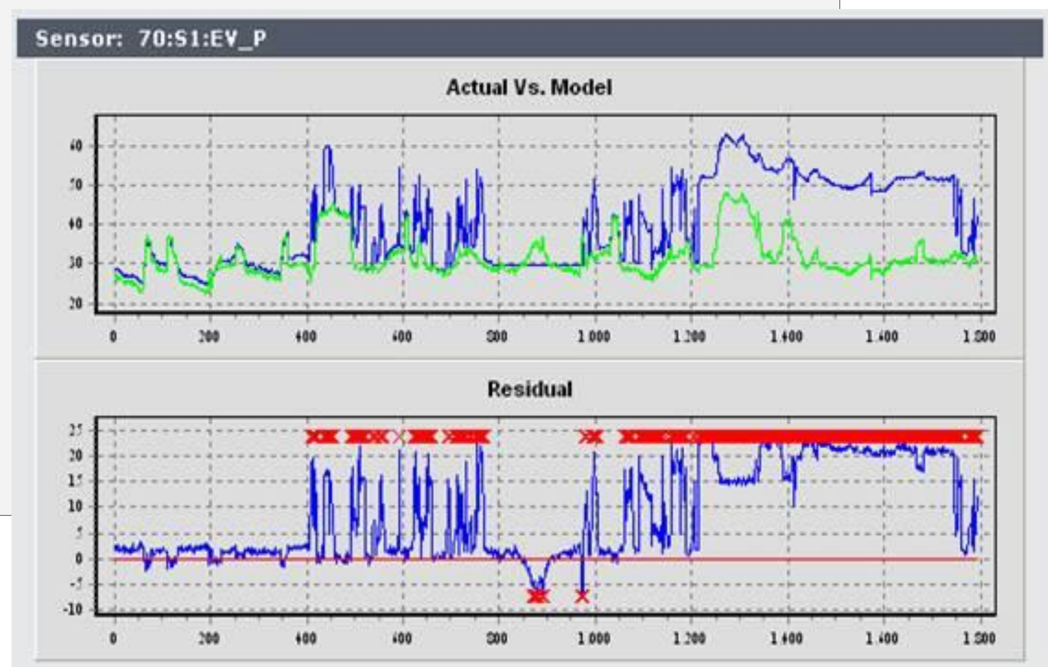
  Process signals are configured in our PI Data Bases
  - All analog signals (inputs and outputs)
  - Limit Switches
  - Valves and motors orders and feedbacks
  - Some other digital signals

**10.000 tags 2x1**
**5.000 tags single shaft**

OSIsoft.

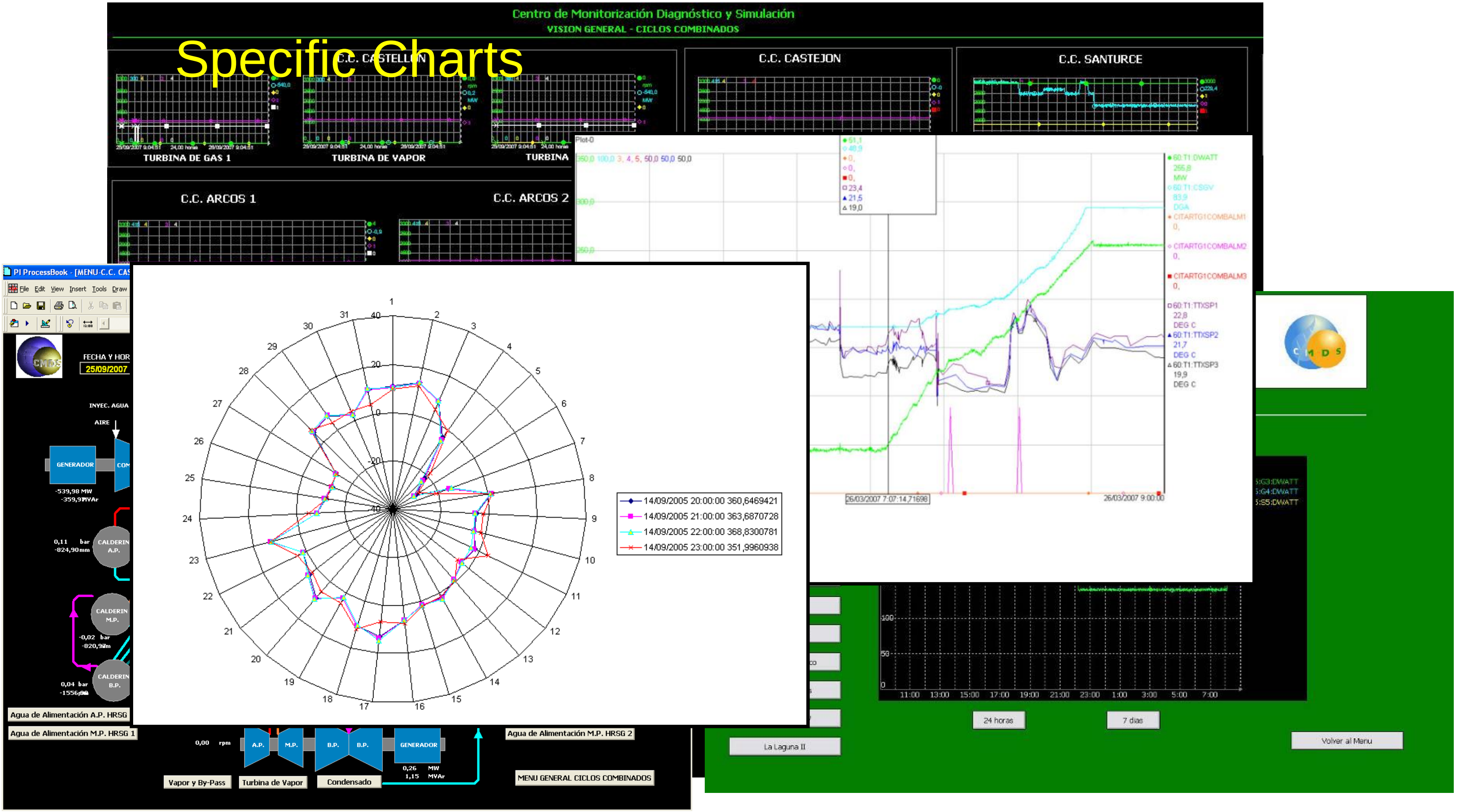
# Monitoring

- **What Tools do we use mainly?**
  - Remote a
  - Model-m
  - **PI**



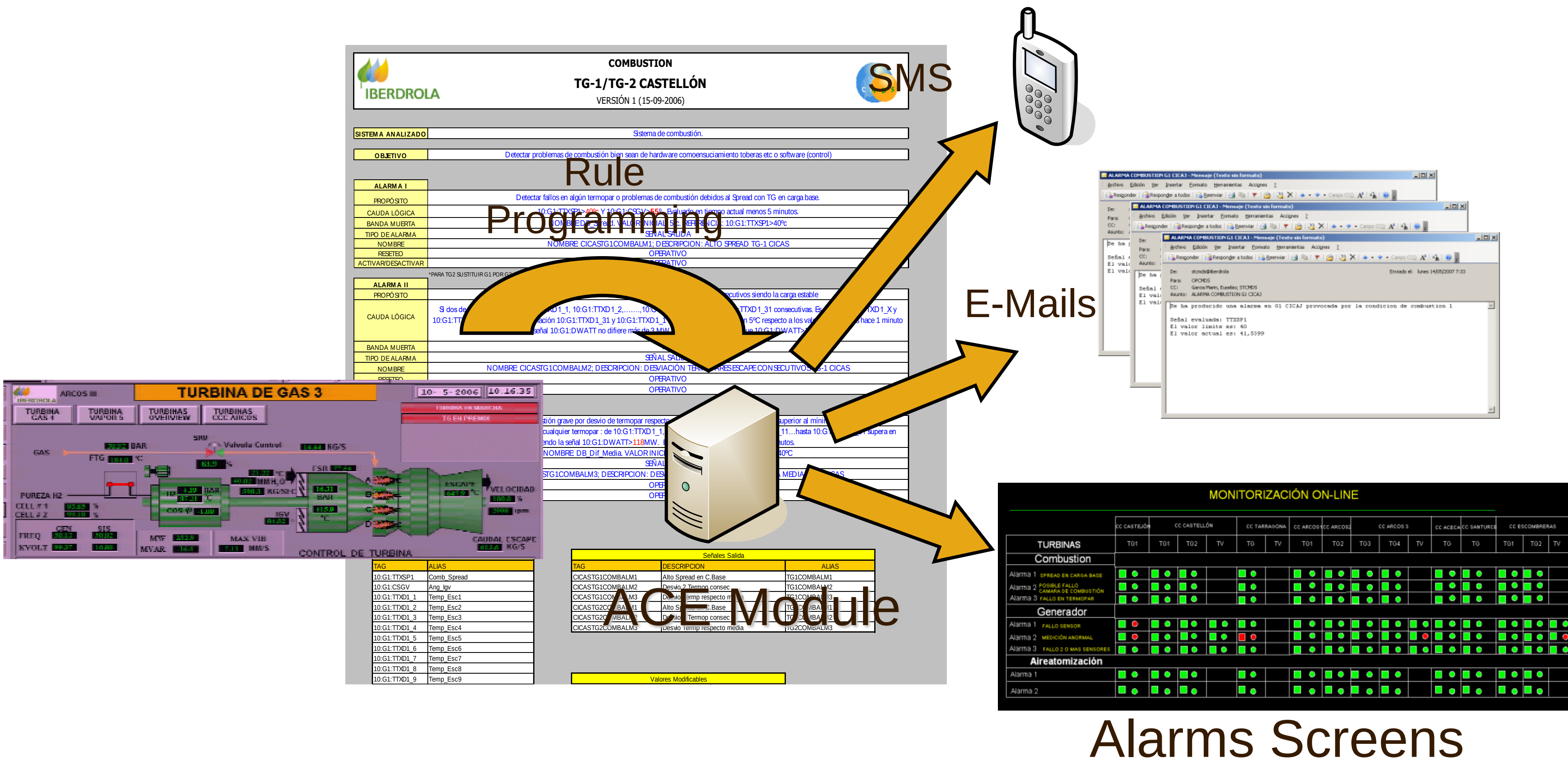
# Monitoring Tools

## PI PROCESS BOOK APLICATIONS



# Monitoring Tools

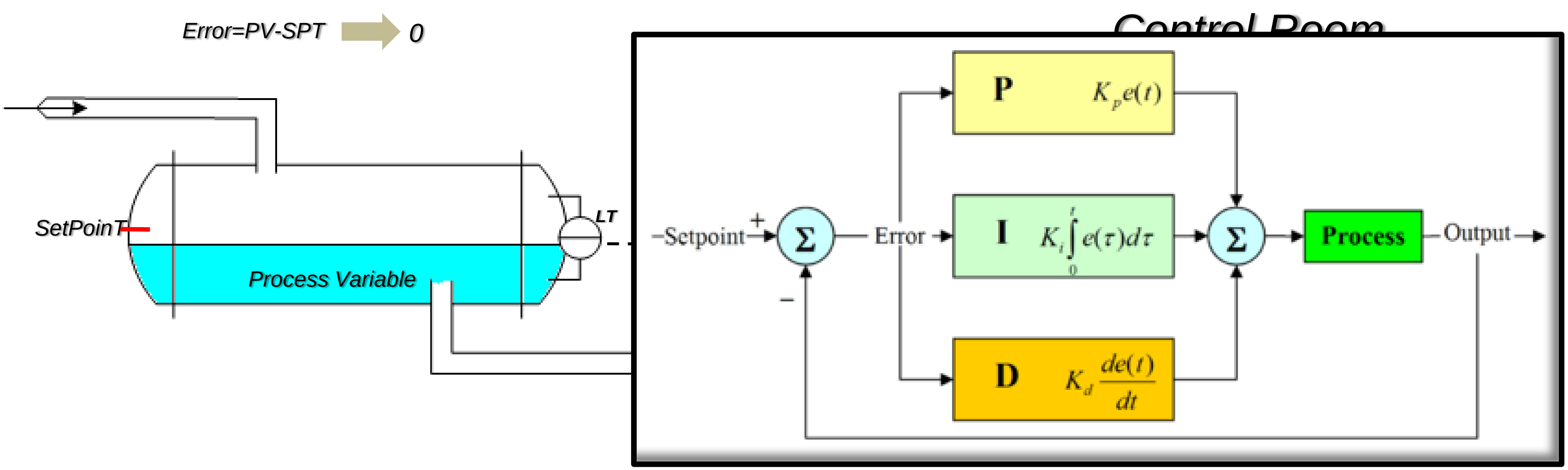
## PI - ACE APPLICATIONS



# PID Monitoring

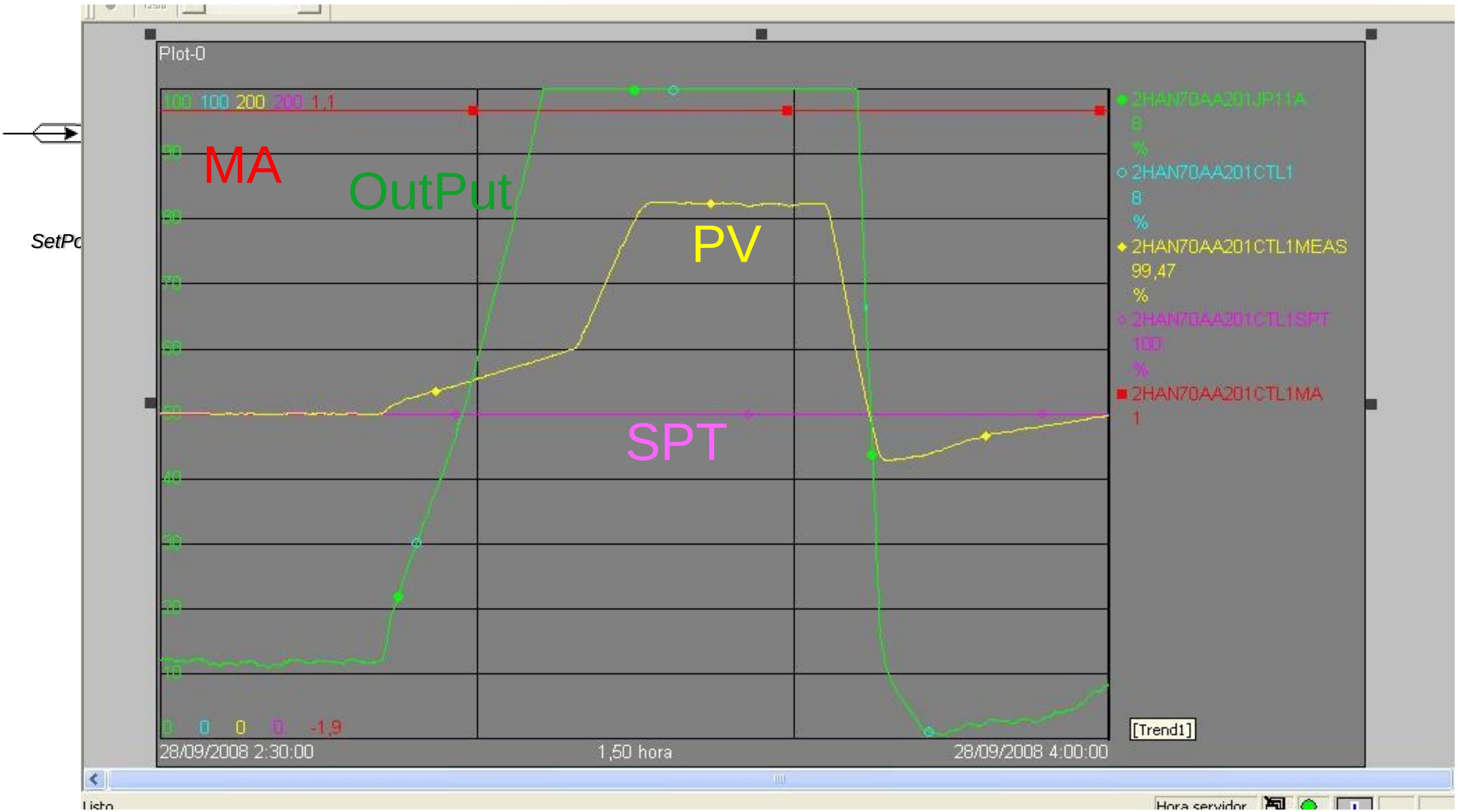
- What is a PID?

  A generic control loop feedback mechanism widely used in industrial control systems.
  A PID controller attempts to correct the error between a measured process variable and a desired setpoint by calculating and then outputting a corrective action that can adjust the process accordingly.



# PID Monitoring

- What is a PID?



# PID Analysis

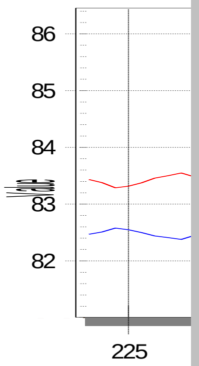
**Effects of Poor PID Control**
**What happens if the loop is not working properly?**

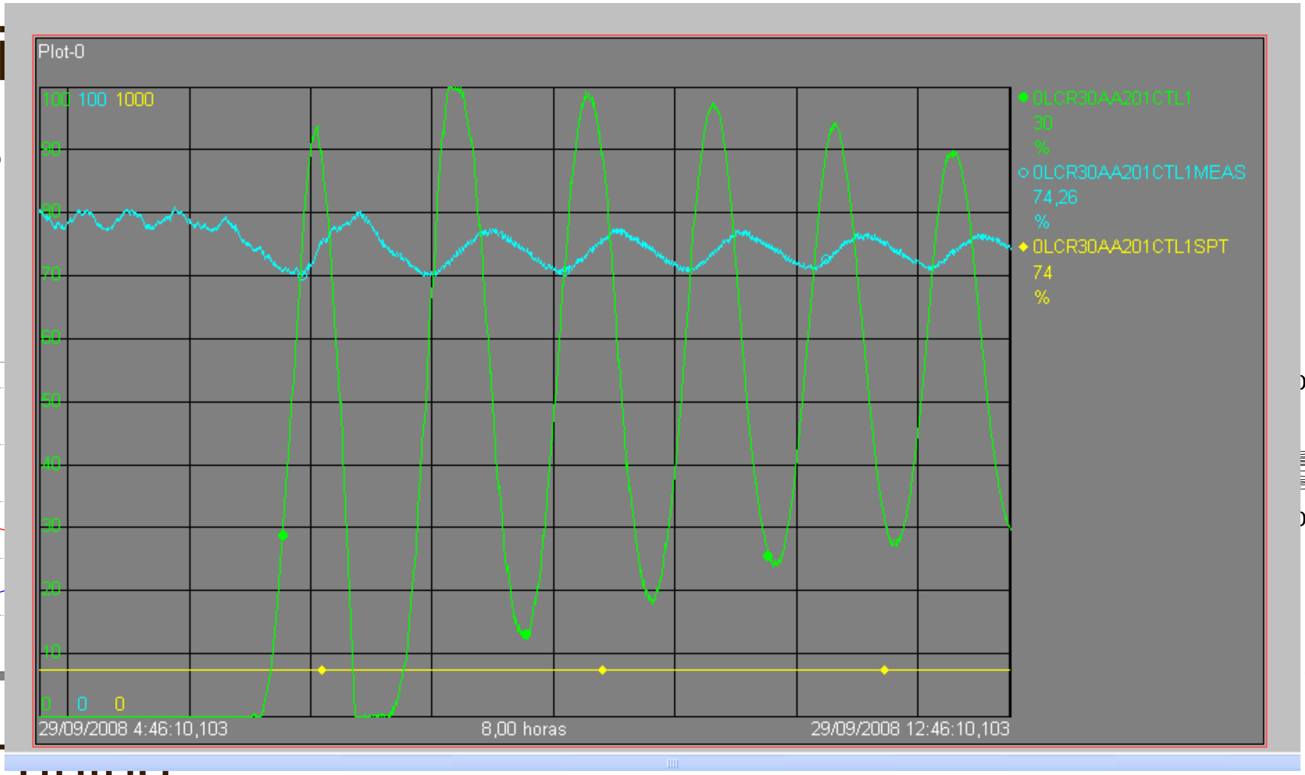
**Poor Plant Performance → Less $$**

- -Less consistent production
- -Less reliability→ Higher occurrence of plants alarms and trips
- -Higher energy cost
- -Longer time for start-ups and load changes
- -Higher maintenances cost→ valve travel, pump starts and stops
- -More operator actions

# PID Analysis – What can be found?

- Set point i
  - Warnings
    - Oscill

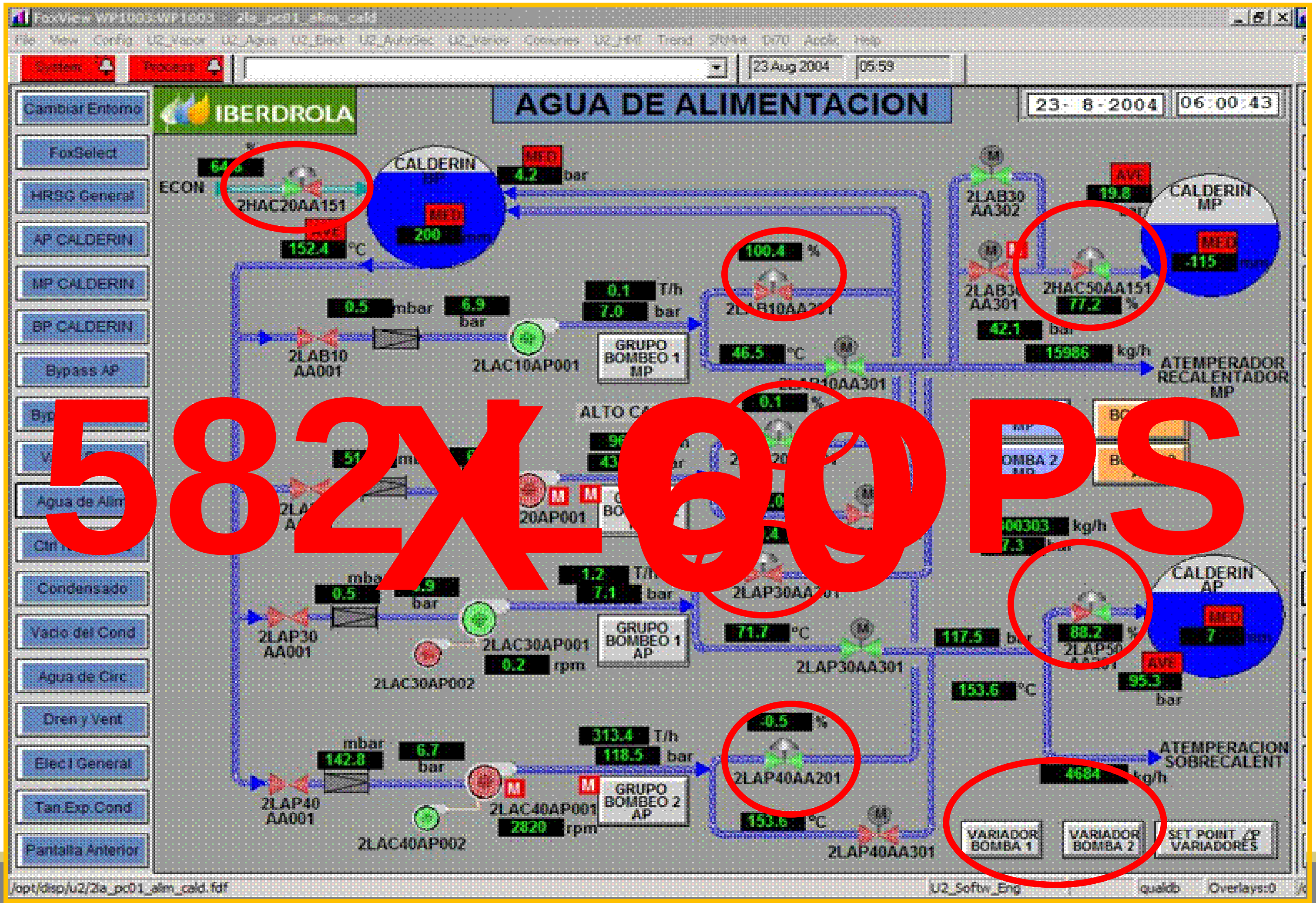



- Why
  - R
    - Bad T
    - Loop coupling
    - Disturbance

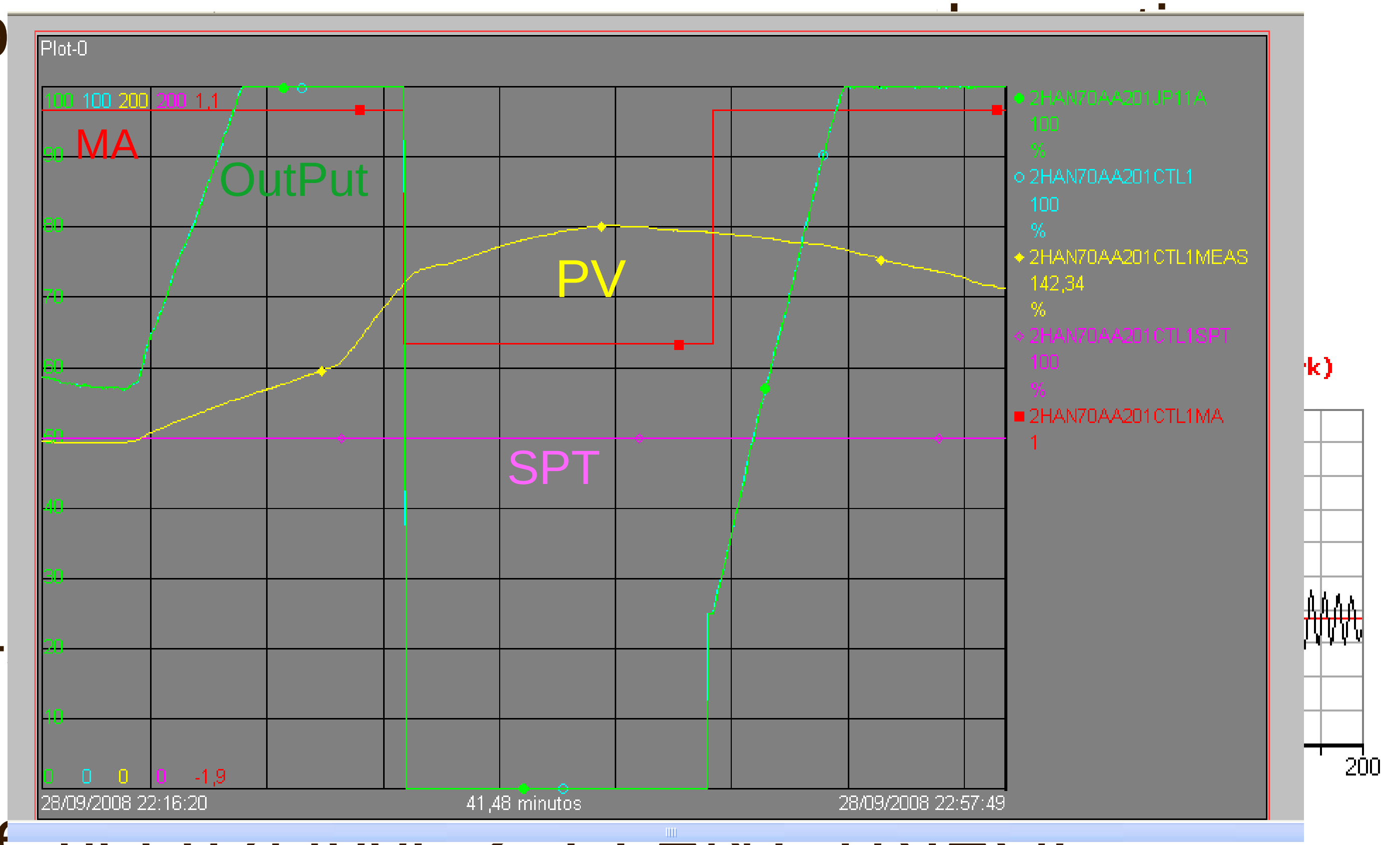
# How to manage hundreds of loops?

- How many PIDs are we talking about?

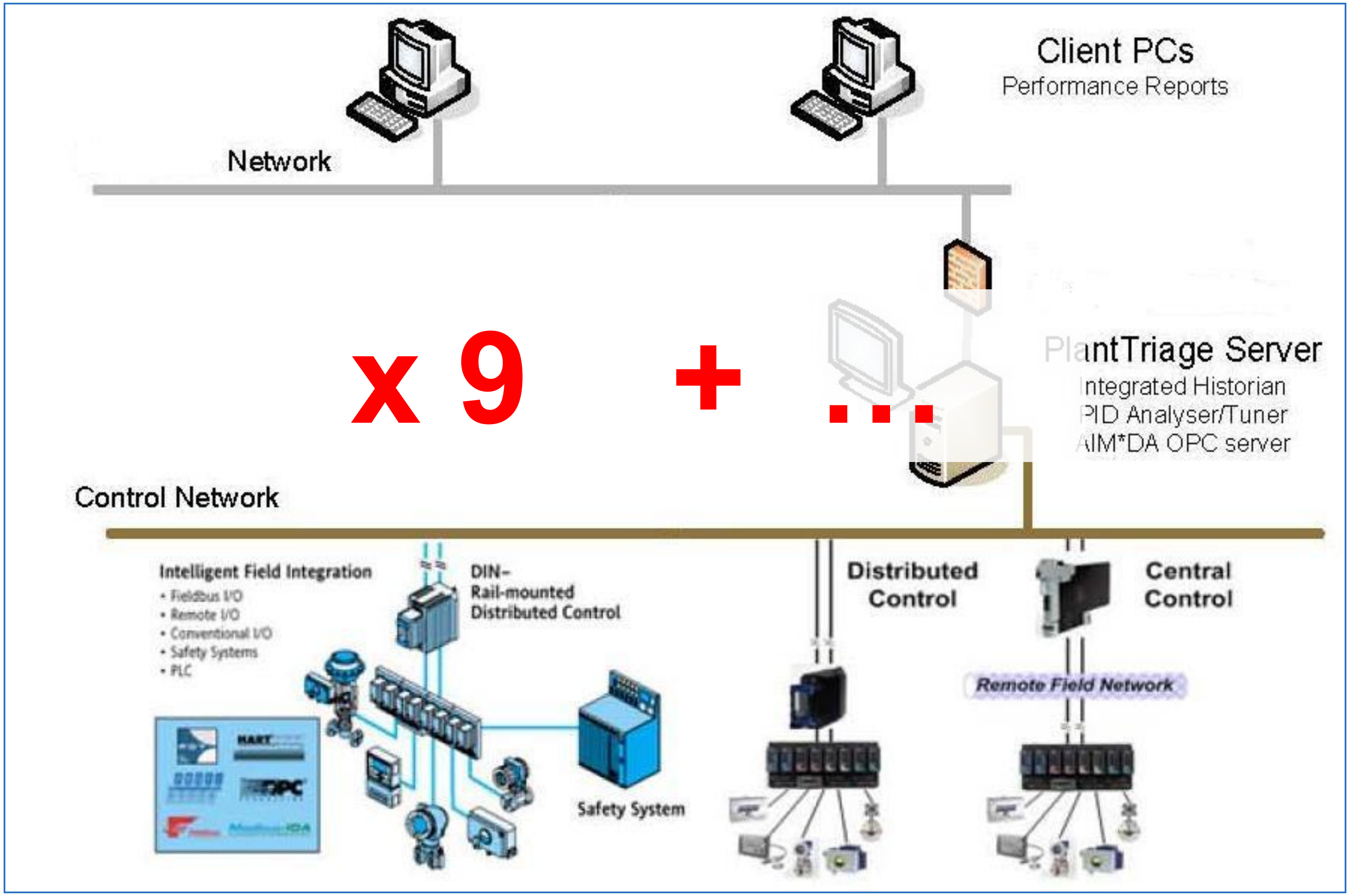


# How to manage hundreds of loops?

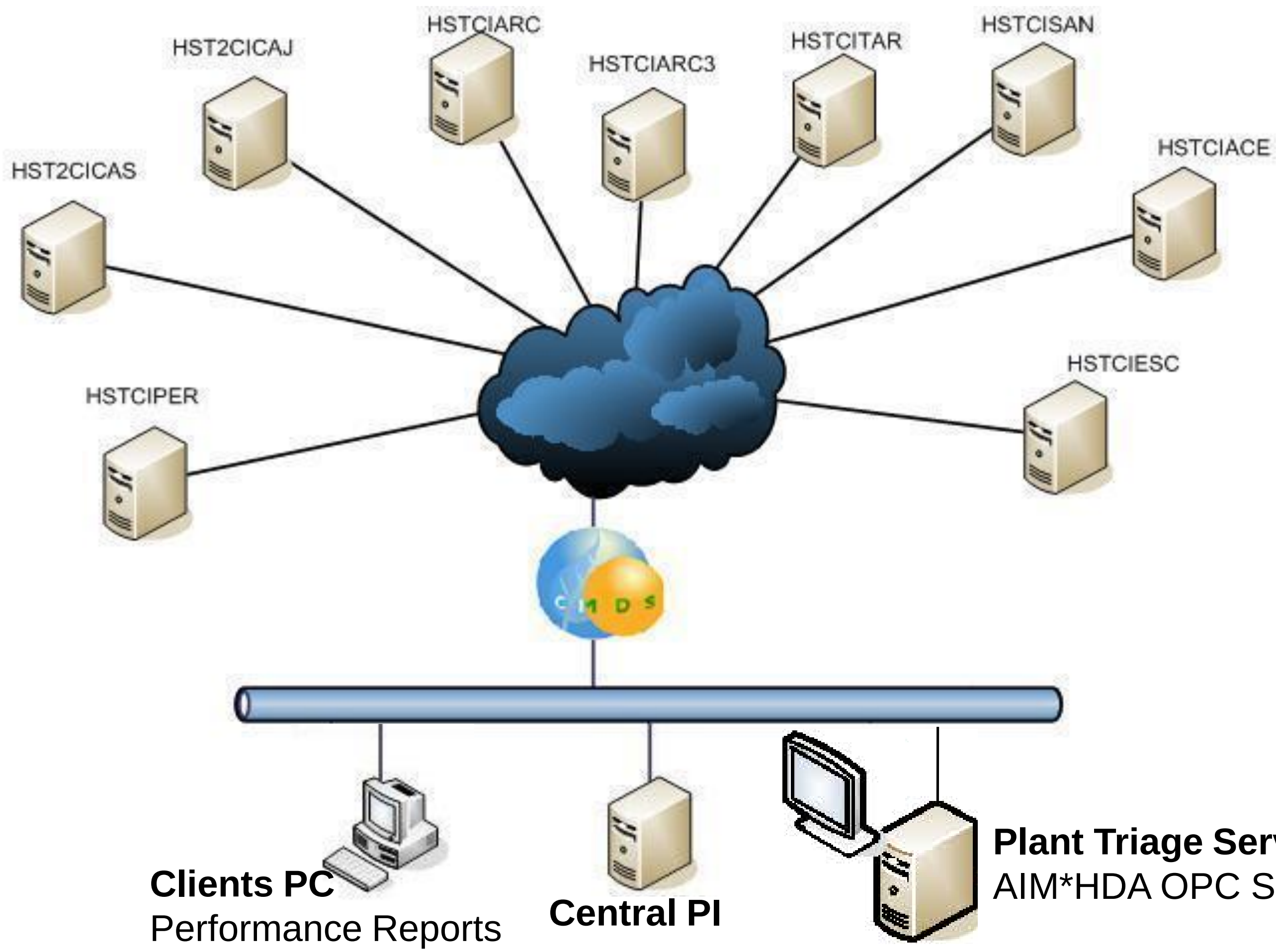
- To
- 24
- We need a tool → PLANT TRIAGE



# Looking for a solution PI-PT



# Looking for a solution PI-PT




**Clients PC**
Performance Reports

**Central PI**

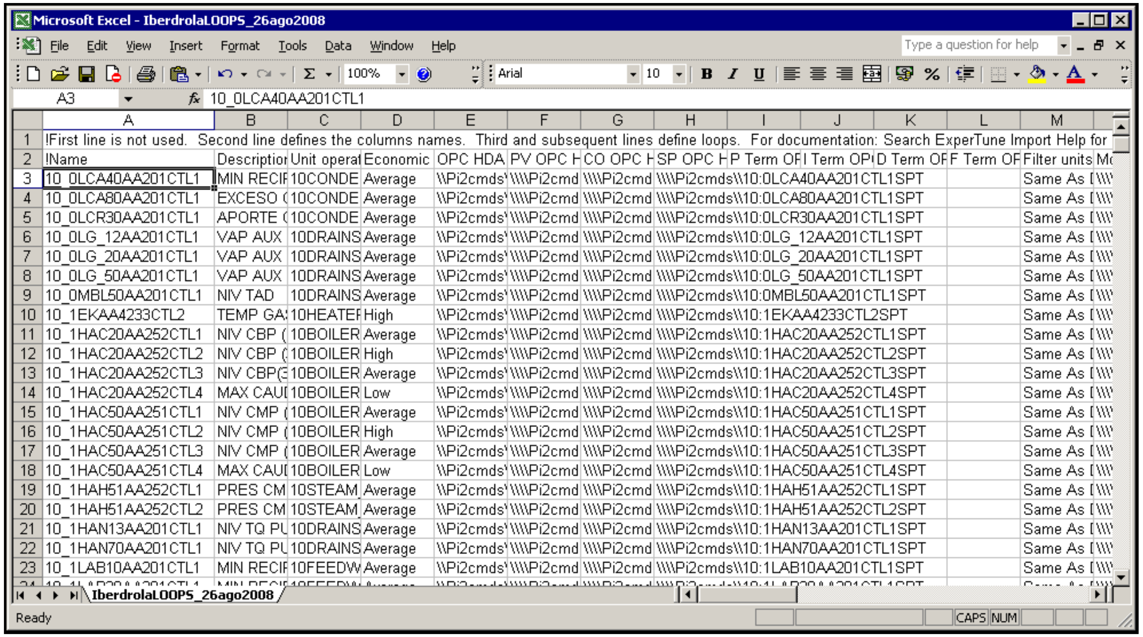
**Plant Triage Server**
AIM*HDA OPC SERVER

# ExperTune PlantTriage PROJECT

- Scope of the Project
  - OPC HDA Server communication to OSI-PI
  - PID control loops response monitoring, diagnostic and improvement
  - 9 Plants (3 multi-shaft GTCC + 6 single shaft GTCC)
  - 110 units (9 or 10 for each HRSG or GT)
  - 582 PID control loops (approx. 50 per HRSG or GT)
  - Invensys Foxboro DCS
  - PlantTriage V6 Installation, loops configuration and PT upgrade to V7.
  - On-site support from Invensys
- From now, effortless expansion to other vendors DCS's (GE mostly, but also ABB, Yokogawa,…)

# Configuration tasks

- Import file (*.csv)



Microsoft Excel - IberdrolaLOOPS_26ago2008

A3 | 10_0LCA40AA201CTL1

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | !First line is not used. Second line defines the columns names. Third and subsequent lines define loops. For documentation: Search ExperTune Import Help for | | | | | | | | | | | | | |
| 2 | !Name | Descriptior | Unit operat | Economic | OPC HDA | PV OPC H | CO OPC H | SP OPC H | P Term OF | I Term OP | D Term OF | F Term OF | Filter units | Mc |
| 3 | 10_0LCA40AA201CTL1 | MIN RECIF | 10CONDE | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LCA40AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 4 | 10_0LCA80AA201CTL1 | EXCESO ( | 10CONDE | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LCA80AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 5 | 10_0LCR30AA201CTL1 | APORTE ( | 10CONDE | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LCR30AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 6 | 10_0LG_12AA201CTL1 | VAP AUX | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LG_12AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 7 | 10_0LG_20AA201CTL1 | VAP AUX | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LG_20AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 8 | 10_0LG_50AA201CTL1 | VAP AUX | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0LG_50AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 9 | 10_0MBL50AA201CTL1 | NIV TAD | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:0MBL50AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 10 | 10_1EKAA4233CTL2 | TEMP GA: | 10HEATEF | High | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1EKAA4233CTL2SPT | | | | | Same As [ | \\\\ |
| 11 | 10_1HAC20AA252CTL1 | NIV CBP ( | 10BOILER | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC20AA252CTL1SPT | | | | | Same As [ | \\\\ |
| 12 | 10_1HAC20AA252CTL2 | NIV CBP ( | 10BOILER | High | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC20AA252CTL2SPT | | | | | Same As [ | \\\\ |
| 13 | 10_1HAC20AA252CTL3 | NIV CBP(3 | 10BOILER | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC20AA252CTL3SPT | | | | | Same As [ | \\\\ |
| 14 | 10_1HAC20AA252CTL4 | MAX CAUI | 10BOILER | Low | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC20AA252CTL4SPT | | | | | Same As [ | \\\\ |
| 15 | 10_1HAC50AA251CTL1 | NIV CMP ( | 10BOILER | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC50AA251CTL1SPT | | | | | Same As [ | \\\\ |
| 16 | 10_1HAC50AA251CTL2 | NIV CMP ( | 10BOILER | High | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC50AA251CTL2SPT | | | | | Same As [ | \\\\ |
| 17 | 10_1HAC50AA251CTL3 | NIV CMP ( | 10BOILER | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC50AA251CTL3SPT | | | | | Same As [ | \\\\ |
| 18 | 10_1HAC50AA251CTL4 | MAX CAUI | 10BOILER | Low | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAC50AA251CTL4SPT | | | | | Same As [ | \\\\ |
| 19 | 10_1HAH51AA252CTL1 | PRES CM | 10STEAM_ | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAH51AA252CTL1SPT | | | | | Same As [ | \\\\ |
| 20 | 10_1HAH51AA252CTL2 | PRES CM | 10STEAM_ | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAH51AA252CTL2SPT | | | | | Same As [ | \\\\ |
| 21 | 10_1HAN13AA201CTL1 | NIV TQ PU | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAN13AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 22 | 10_1HAN70AA201CTL1 | NIV TQ PU | 10DRAINS | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1HAN70AA201CTL1SPT | | | | | Same As [ | \\\\ |
| 23 | 10_1LAB10AA201CTL1 | MIN RECIF | 10FEEDW | Average | \\Pi2cmds' | \\\\Pi2cmd | \\\\Pi2cmd | \\\\Pi2cmds\\10:1LAB10AA201CTL1SPT | | | | | Same As [ | \\\\ |

IberdrolaLOOPS_26ago2008

Ready

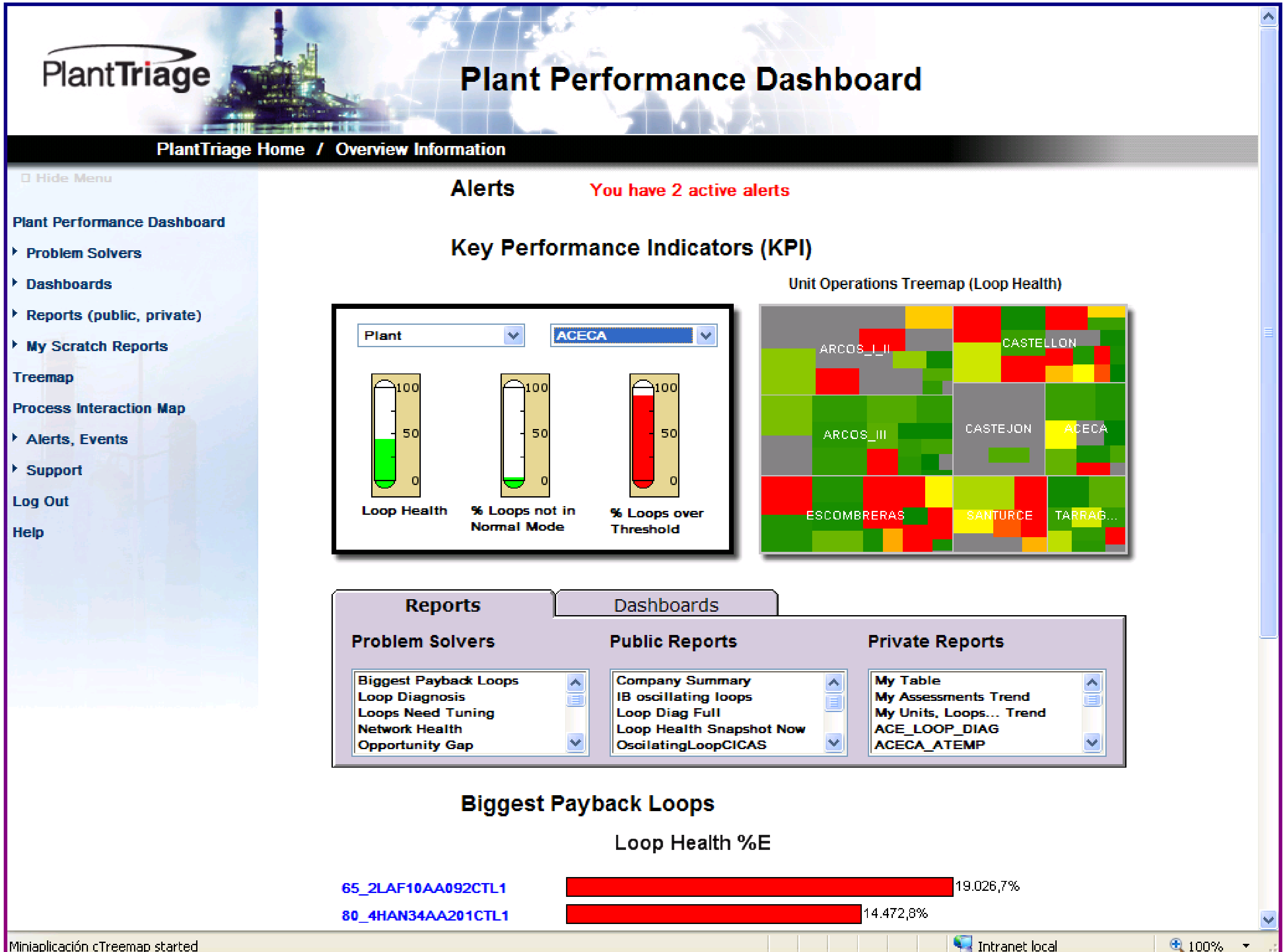
- Economic Significance (HIGH<10%; AVG 60-70%; LOW 20-30%)
- Loop type definition (Master/Slave, Ctrl'd variable, Final ctrl element,...)
- Loop & unit status bits
- 71 Baselines & Thresholds (TEMPLATES, then one by one)

*To do this configuration, but even more to analyze data afterwords, it is mandatory a deep knowledge on the plant process. <u>Not to be done only by an IT person</u>.*

# Configuration tasks

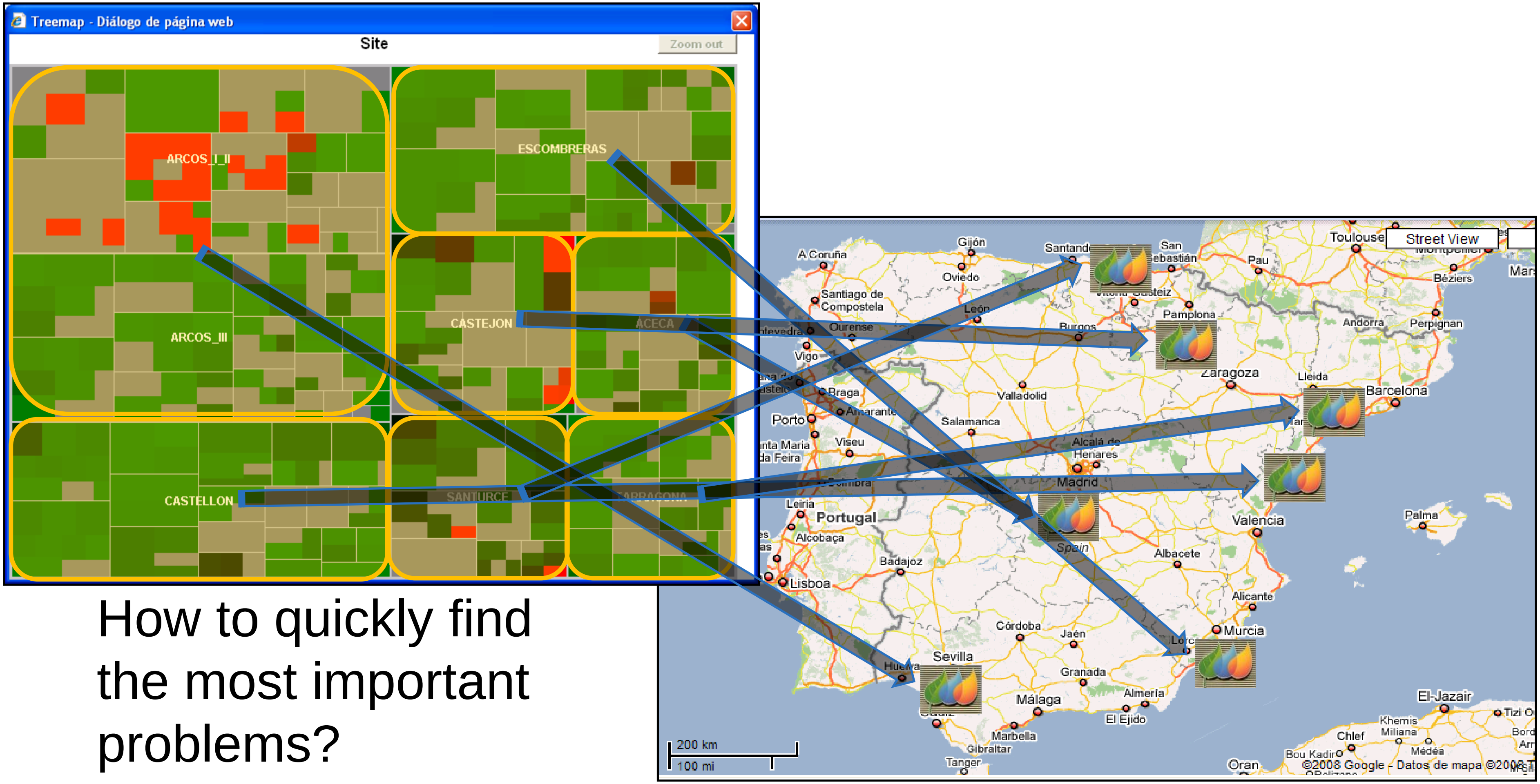
- Data that is needed to import from OSI-PI OPC HDA Server
  - Process Value (PV)
  - Set Point (SP)
  - Controller Output (OP)
  - Controller mode (Not only Auto/Man but also tracking)
- Data that is optional to import from OSI-PI OPC HDA Server
  - Proportional Band
  - Integral Band
  - Derivative Band
  - Filter
- Additional data necessary to configure each loop (PV and SPT limits, CO limits, controller type & action, control loop description, process & structure, estimated process dead time, status bit for on/offline…)
- With more structure information in PlantTriage, you will get more specific analysis.

# Browser interface



# KPI TreeMap (Loop Health)

- TreeMap and GTCC sites

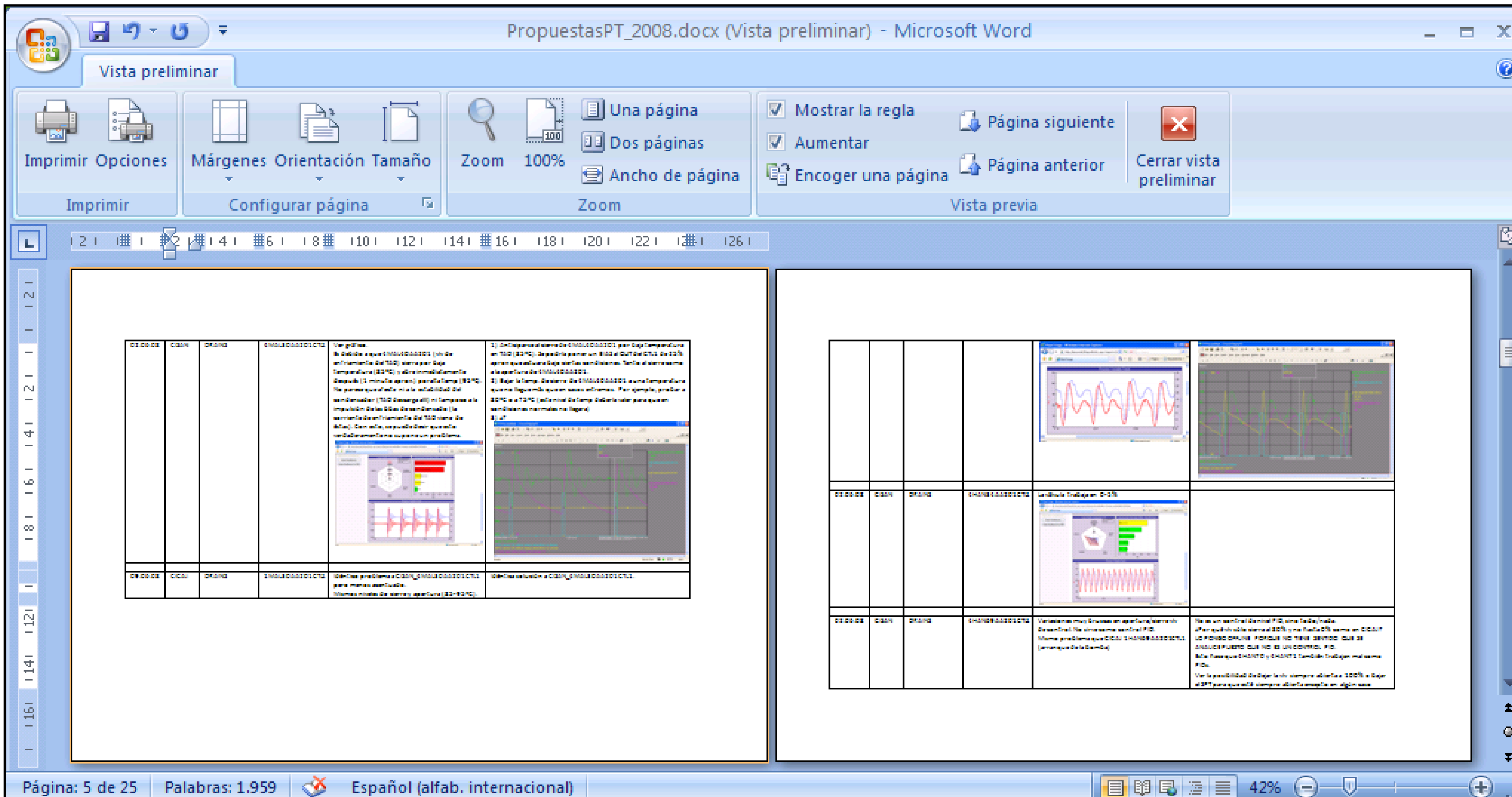



How to quickly find the most important problems?

# Initial findings

- Initial problems grouping and tracking

  At first glance, >10% loops behaviour could be improved easily



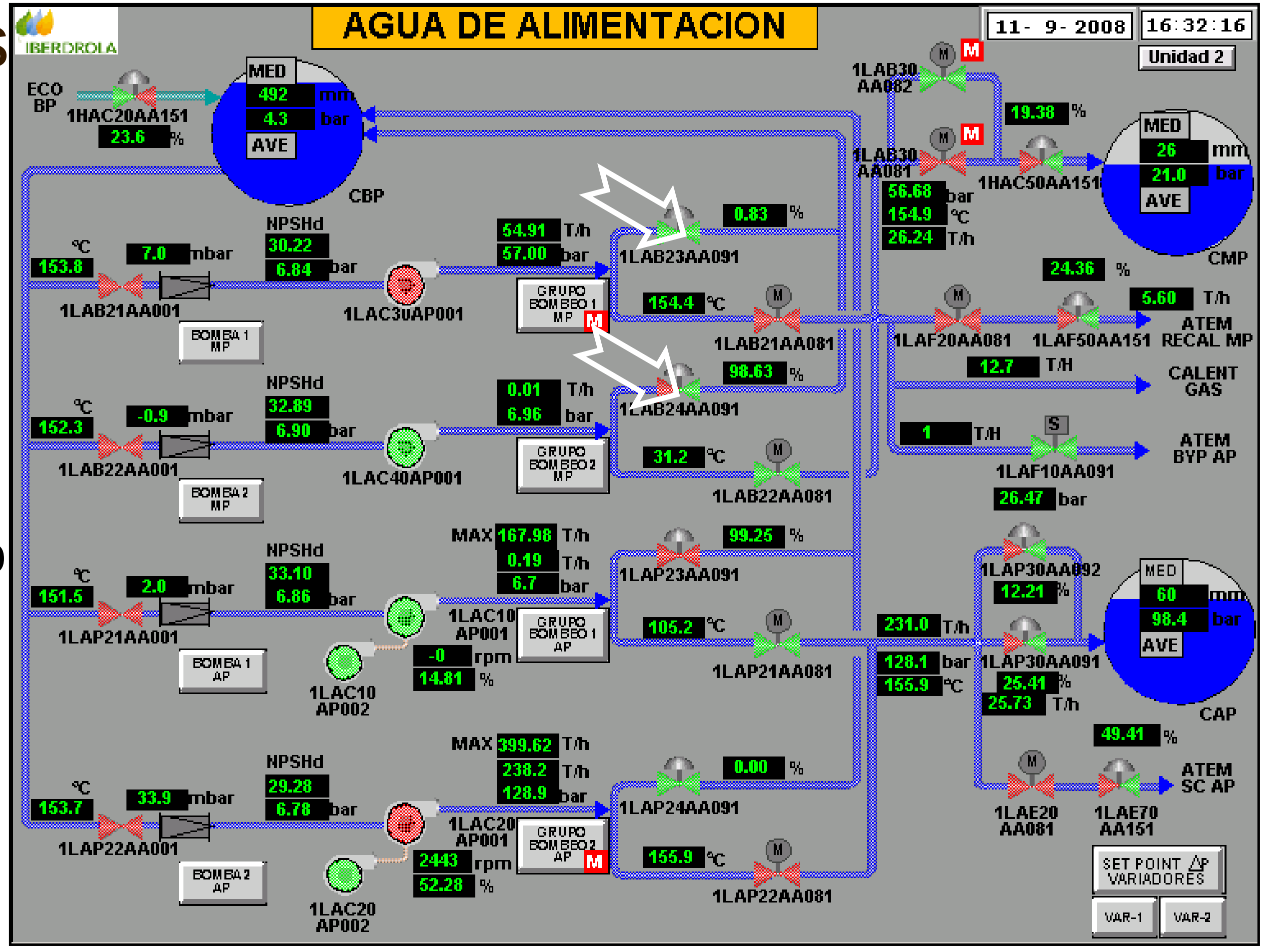
# Initial Findings. Opportunities.

- Control valve trim wear

  a) The process

  Flow rate controller to assure a minimum flow through the intermediate pressure feedwater pumps

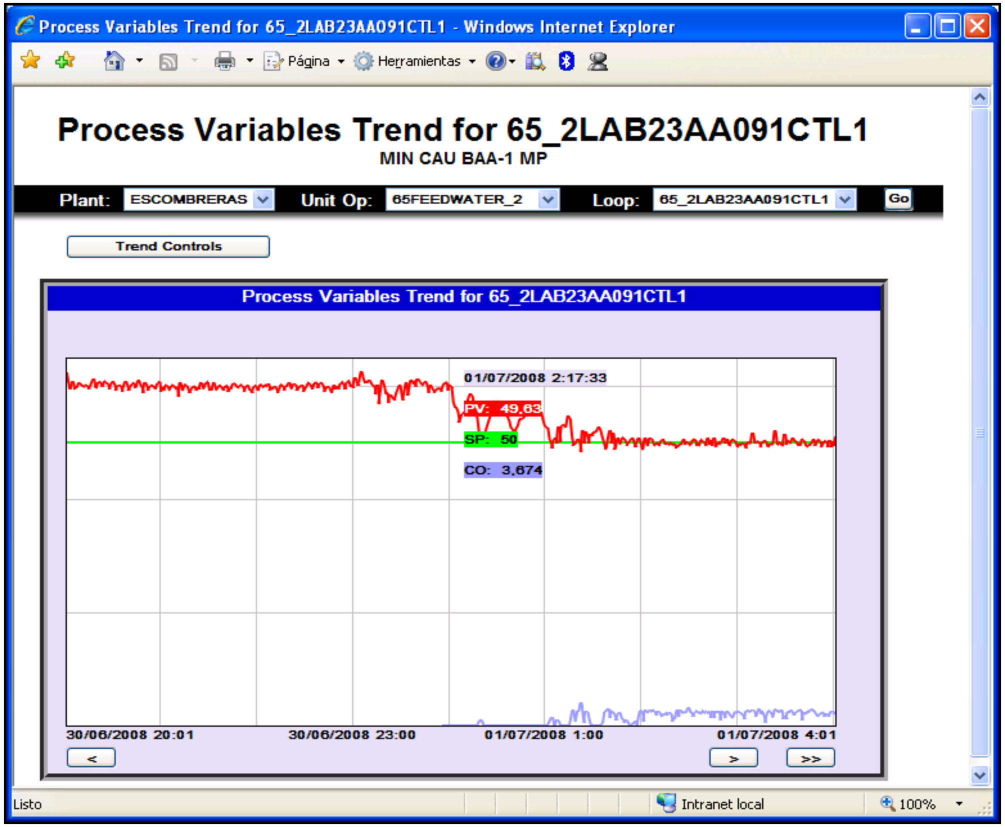
  Two pumps, then two controllers per boiler.



# Initial Findings. Opportunities.

- Control valve trim wear

  b) What was observed with PT




At minimum GT load, the flow rate controller valve opens to 3% or 4%.

As a consequence, the trim suffers from wearing.

This condition may be maintained for hours during nights or weekends.

# Initial Findings. Opportunities.

- Control valve trim wear

## c) The solution

A recalculation of minimum required flow rate for the pump was asked to the vendor.

A logic condition was implemented to the controller output to avoid too low output values:

“ *if OUT<5%, then OUT=0%* “

The same system was checked in other plants

## d) Savings

Direct savings: trim change

Indirect savings: avoid one plant trip (real problem!) HIGH COST!!!

A Single Turbine Trip may cost more than € 50,000

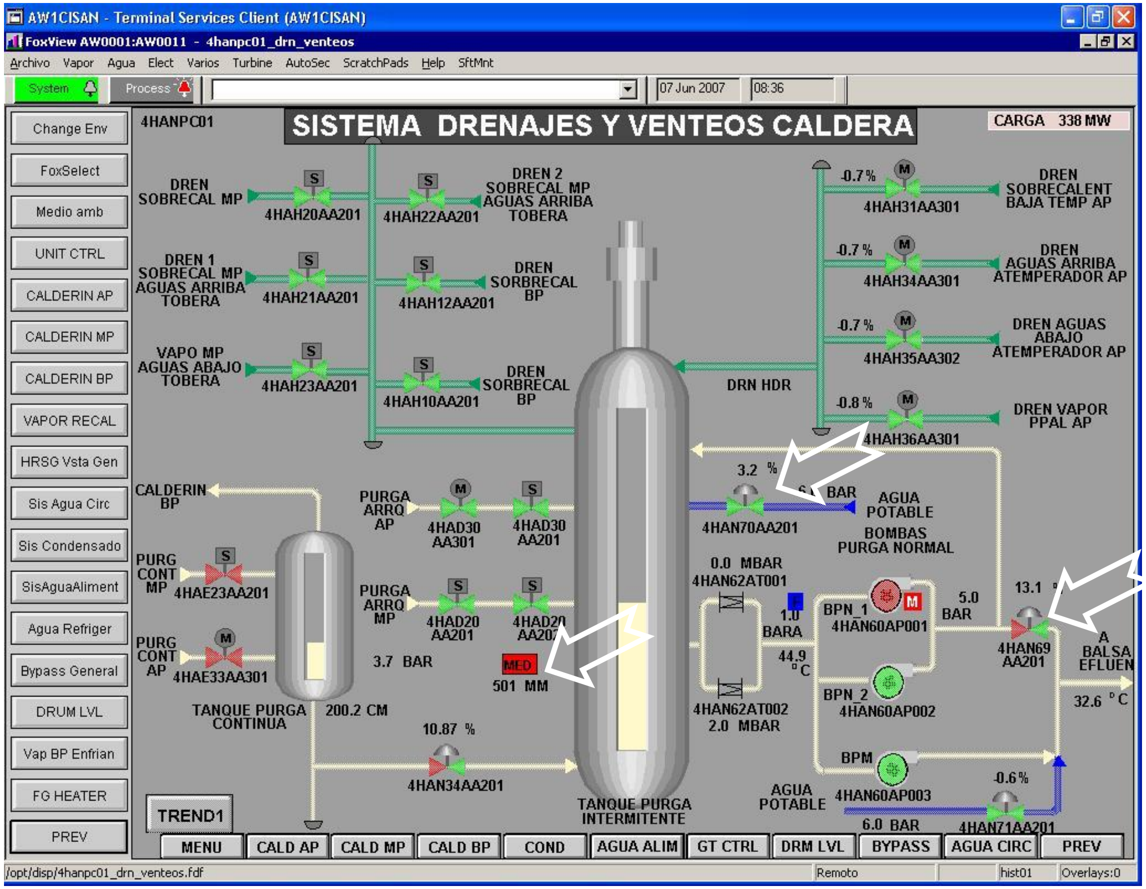
# Control strategies improvement

- Recurrent oscillating loop response

  a) The process

The drum receives condensed water and steam from multiple pipeline drainages.

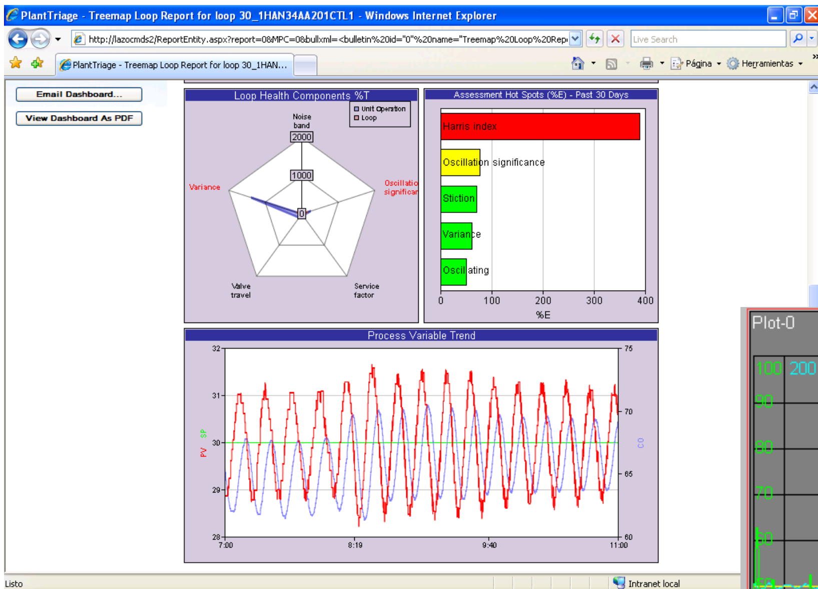
Drum level is maintained at a fixed value through PID control and temperature is kept via on/off control.

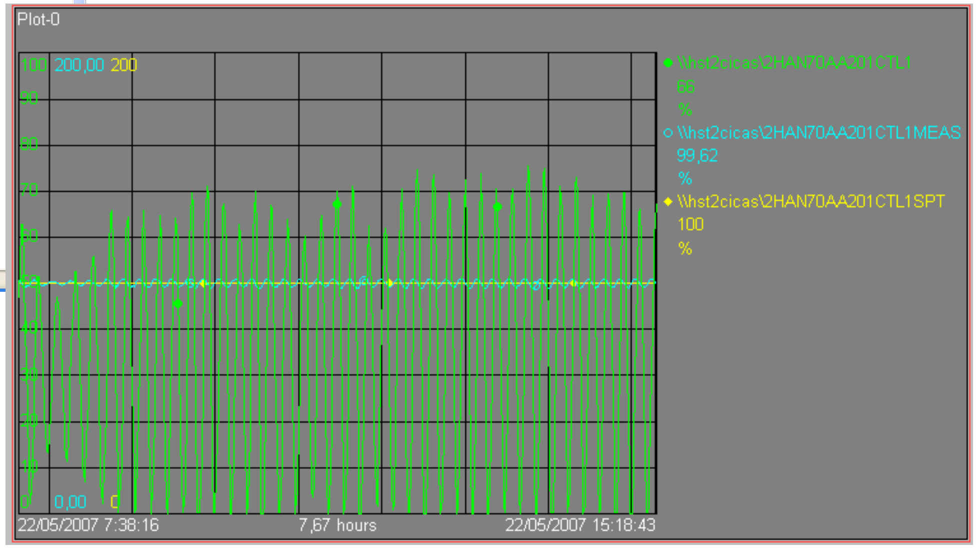


# Control strategies improvement

- Recurrent oscillating loop response

  b) What was observed with PT and OSI-PI




- The level is oscilating.
- Valve never stops

# Control strategies improvement

- Recurrent oscillating loop response

c) The proposed solutions

Ctrl strategy improvement:

→ Add a BIAS to decrease the controller output when atempe-ration valve closure is detected and to increase it as it opens.

→ Several trials to get the optimum BIAS values.

→ Retune Controller

Mechanical change:

→ Valve substitution from 1” to ¾” with lower Cv.

d) Savings

To avoid an accident is not measurable

Direct savings:

Trim Change

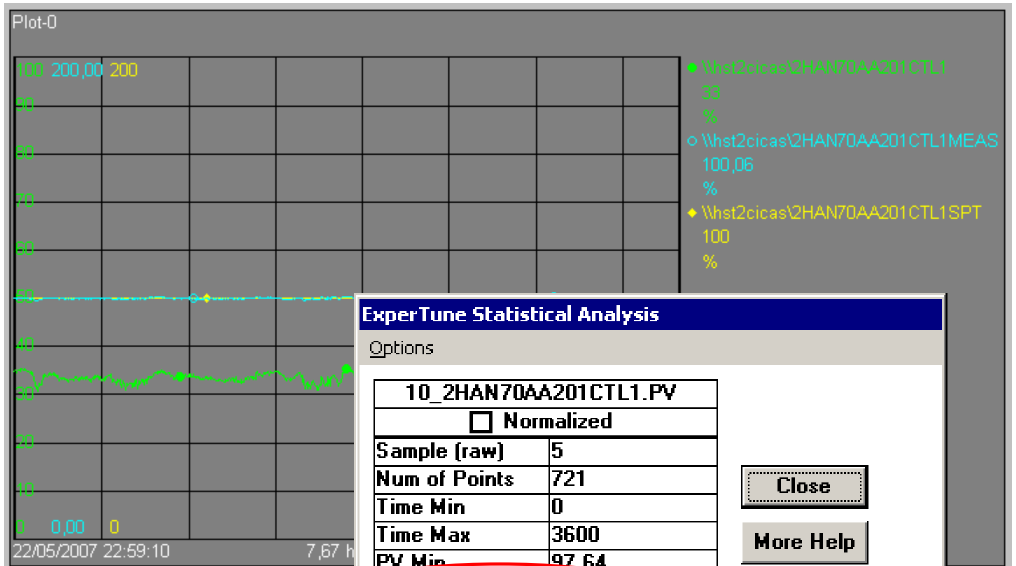
Pump maintenance

Indirect savings

Drum level HH → overflow (accident due to 90ºC water spillage)

# Control strategies improvement

## e) Results




**ExperTune Statistical Analysis** (before)

Options

| 10_2HAN70AA201CTL1.PV | |
|---|---|
| ☐ Normalized | |
| Sample (raw) | 5 |
| Num of Points | 721 |
| Time Min | 0 |
| Time Max | 3600 |
| PV Min | 97,64 |
| PV Max | 101,85 |
| Range | 4,207 |
| Mean (μ) | 99,89 |
| Standard deviation (δ) | 1,38 |
| μ±δ | 98,51 - 101,3 |
| μ±2δ | 97,13 - 102,7 |
| Variance | 1,904 |
| Variability | 2,76 % |
| Variability Index | 94 |
| IAE | 4481 |

Close | More Help

= 5,52

IAE: 108000 /day

| 10_2HAN70AA201CTL1.CO | | |
|---|---|---|
| Travel | 749 (%) | 18000(%)/day |
| Reversals | 11 | 264/day |

**ExperTune Statistical Analysis** (after)

Options

| 10_2HAN70AA201CTL1.PV | |
|---|---|
| ☐ Normalized | |
| Sample (raw) | 5 |
| Num of Points | 721 |
| Time Min | 0 |
| Time Max | 3600 |
| PV Min | 99,54 |
| PV Max | 100,52 |
| Range | 0,98 |
| Mean (μ) | 100,05 |
| Standard deviation (δ) | 0,212 |
| μ±δ | 99,84 - 100,3 |
| μ±2δ | 99,63 - 100,5 |
| Variance | 0,04494 |
| Variability | 0,424 % |
| Variability Index | 83,4 |
| IAE | 638 |

Close | More Help

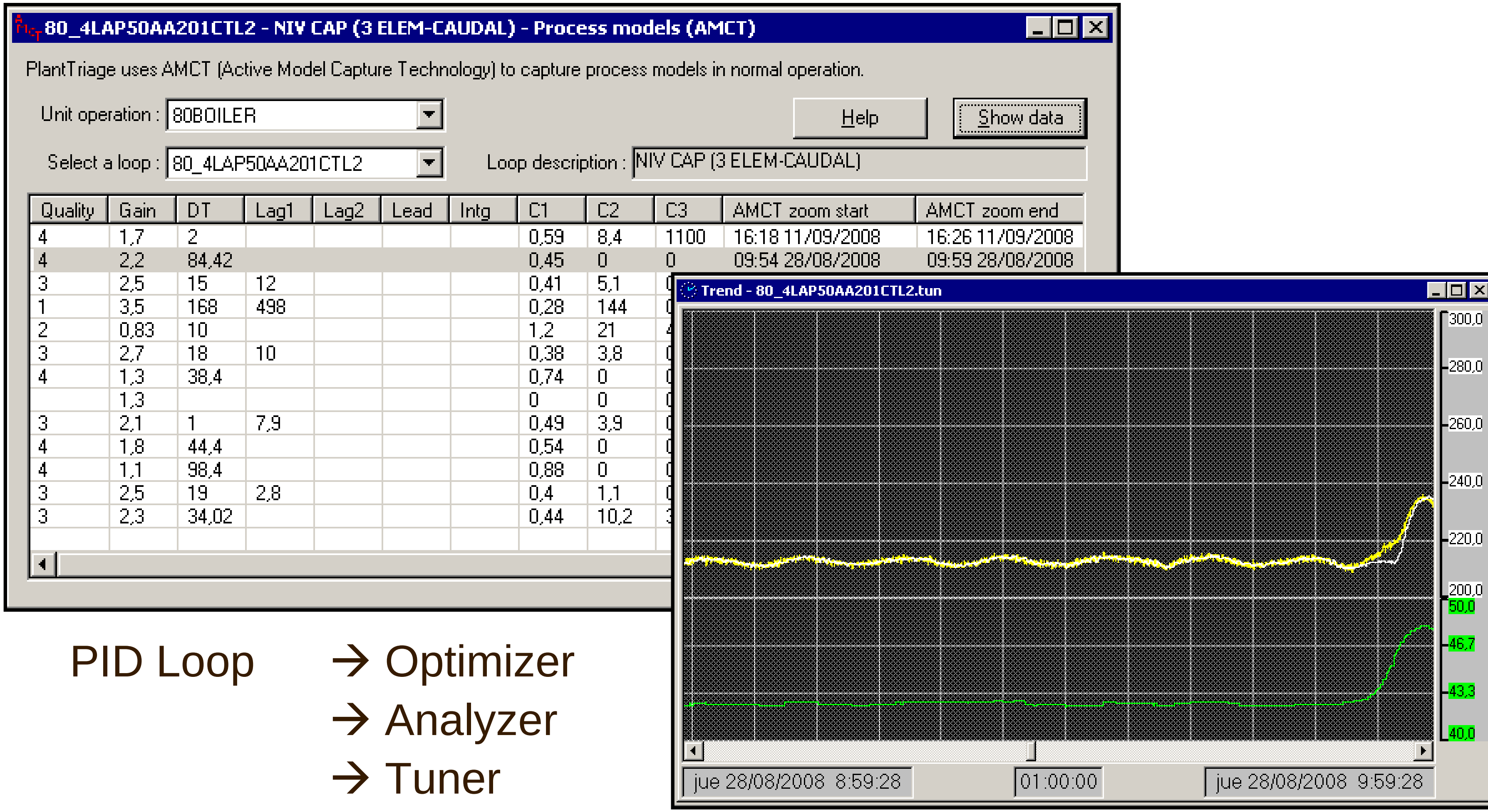
= 0,848

IAE: 15300 /day

| 10_2HAN70AA201CTL1.CO | | |
|---|---|---|
| Travel | 40,3 (%) | 968(%)/day |
| Reversals | 88 | 2110/day |

# PlantTriage Models

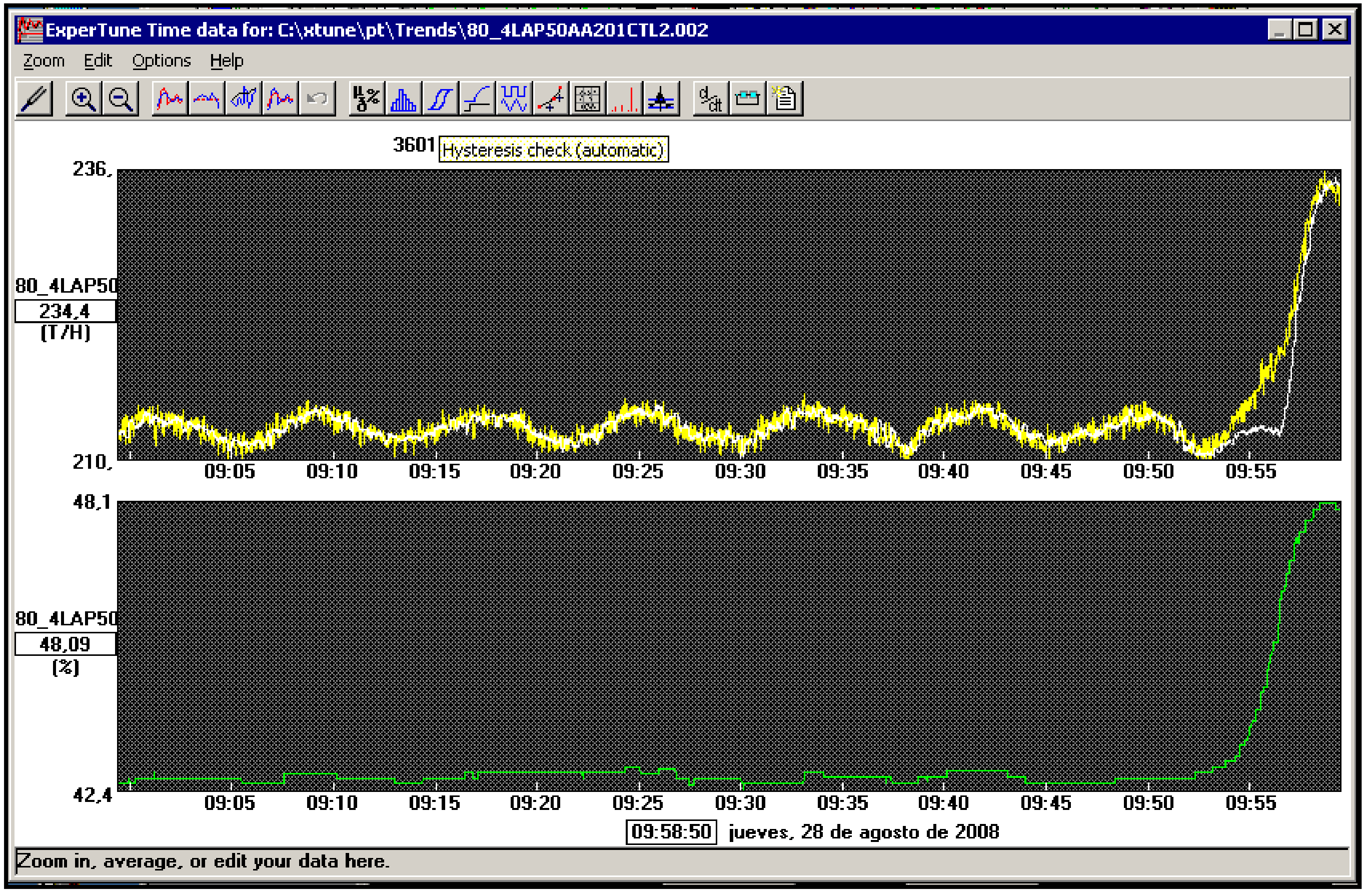
- Auto Model Capture Tool (AMCT)




PID Loop → Optimizer
→ Analyzer
→ Tuner

# PlantTriage Models

- PID Loop Optimizer




Now, working on this to make new proposals based on PID control theoretical calculations coming from real plant data.

Reduces engineering time required for loop tuning.

# Conclusions

- Take time to make a good database configuration
- Initially, focus on fixing direct problems
- Savings on final control elements maintenance (valves)
- Modifications in tuning PID parameters (variable tuning?)
- Reduce oscillation and variability
- Following-up reported problems is essential to success!
- Create and follow-up control loop quality assessments or KPI
- Review control strategies if PID control is not enough
- Success requires cooperation between operations, maintenance and engineering

# Results

- More efficient use of engineer's time
- Reduced turbine trips
- Production increase 0,5- 5MW*
- Cost Reduction >100000€/year*
- Efficiency
- ROI, 15 Months

*All this data is an estimate based in the improvements we have already achieved.

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# THANK YOU