



## AE94.3A flexibility upgrade: field test campaign outcomes

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➤ **Introduction**

➤ **Target**

➤ **La Casella Unit 1**

➤ **Test Results**

➤ **Conclusion**

# Company Overview

## Introduction



Open and Combined  
Cycles Power Plants



Thermal Power Plants



Equipment: Gas Turbines,  
Steam Turbines  
and Turbogenerators



Service  
on AEN installed fleet  
(OEM)



Service  
on third party installed fleet  
(OSP™)

- |      |                                                        |
|------|--------------------------------------------------------|
| 1853 | Giovanni Ansaldo & Co. established                     |
| 1923 | First Power Plant                                      |
| 1949 | GE license for Steam Turbines & Generators             |
| 1962 | First supercritical 600 MW Power Plant                 |
| 1989 | ABB licence for Steam Turbines & Generators            |
| 1991 | Ansaldo Energia established                            |
| 1991 | Siemens licence for Gas Turbines                       |
| 1995 | First Combined Cycle plant based on Ansaldo Energia GT |
| 2004 | New Global Service Strategy                            |
| 2005 | Total technological independence                       |
| 2007 | OSP™ concept launch                                    |
| 2008 | 100 <sup>th</sup> Gas Turbine in commercial operation  |
| 2010 | 150 <sup>th</sup> Gas Turbine manufactured             |
| 2011 | Agreement with First Reserve Corporation               |



Ansaldo Energia  
Genoa (Italy) manufacturing plant



Ansaldo Thomassen  
Rheden (NL) workshop



Gulf  
Abu Dhabi (UAE) repair

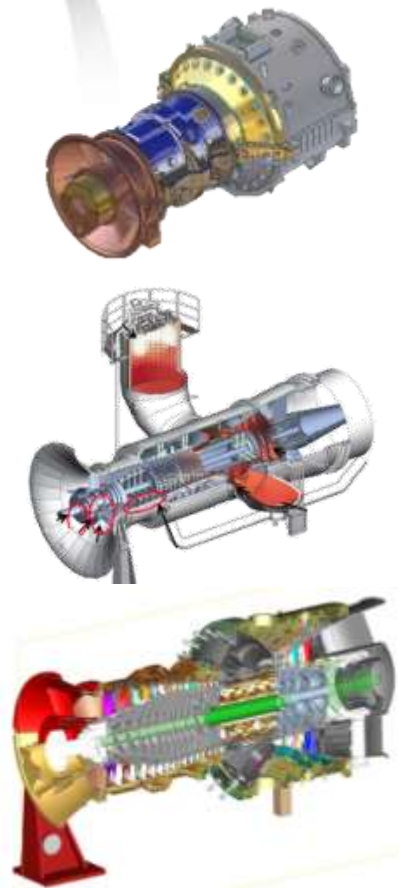


# Ansaldo Energia Gas Turbines

*Introduction*

A complete portfolio for medium-large power plants

| Model                                  | Power  | Class   | Reliability          |
|----------------------------------------|--------|---------|----------------------|
| AE64.3A                                | 75 MW  | F class | > 98%                |
| AE94.2                                 | 172 MW | E class |                      |
| AE94.3A                                | 294 MW | F class |                      |
| Ansaldo Energia independent technology |        |         | Widely proven models |



## Gas Turbines references & performance

**46 in Combined Cycle - 6 in Open Cycle**

Belgium (1)  
France (1)  
Italy (30)  
Spain (4)

Algeria (6)  
Tunisia (1)



**M'Sila (first firing August 2009)**  
**27835 EOH – 850+ starts**

**52 Gas Turbines**  
**Cumulated 1,900,000 EOH**

Greece (1)  
Hungary (1)

Turkey (2)

Syria (4)



**Introduction**



**Target**



**La Casella Unit 1**



**Test Results**



**Conclusion**

## OPEN GATE PHASE: OPPORTUNITIES FOR CO-DEVELOPMENT

### SERVICES

- A – “Which services do you expect will improve/change in the future?”*
- B – “Which services do you envision will be critical for the support & delivery of your offering?”*
- C – “Which services would you be willing to jointly co-develop with AEN?”*

**1 – FLEXIBILITY UPGRADES**

**2 - LIFE EXTENSION**

### TECHNOLOGIES

- A – “Which technologies do you expect will improve/change in the future?”*
- B – “Which technologies do you envision will be critical for the support & delivery of your offering?”*
- C – “Which technologies would you be willing to jointly co-develop with AEN?”*

**1 – OPERATIONAL FLEXIBILITY  
UPGRADES**

**DISCUSSION FOR PROJECTS’ START-UP WITH 3 CUSTOMERS  
INTERESTED IN IDENTIFIED THEMES!**

## TEST TARGET: HIGHER FLEXIBILITY

### TURN DOWN CAPABILITY

12 units: TD < 50%BL ; NOx < 20 ppm

9 units TD < 43% BL ; NOx < 15 ppm

➤ **cumulated 300 000 + EOH**

Turn Down Target below 40% GT load

### LOAD RAMP

Basic value: 13 MW/min

20 units operated at **22 MW/min**

4 units operated at **30 MW/min** ➤ **cumulated 370 000 + EOH**

1 unit operated at **30+ MW/min**

Load Ramp Target > 40 MW/min

## TEST TARGET: HIGHER STABILITY & LOW EMISSIONS

### ENVIRONMENTAL MODE

28 units: NO<sub>x</sub> < 15 ppm

**cumulated 500 000 + EOH**

### PERFORMANCE MODE

34 units: NO<sub>x</sub> < 25 ppm

**cumulated 1 400 000 + EOH**

**Ems & Pfc Target: EV Nox in Performance Mode Power**



**Introduction**



**Target**



**La Casella Unit 1**



**Test Results**



**Conclusion**

## **ENEL LA CASELLA UNIT 1**

- **AE94.3A 50 000+ EOH featured by retrofitable solutions**
- **1 SAS upgrade (“SAS up”) application for optimized combustor cooling (reduced needs)**
- **9 upgraded combustion system configurations at different development stage (from conceptual to commercial)**
- **Additional instrumentation for monitoring and protection**
- **Upgraded flexible hoses for easy burners in /out**
- **5 months testing availability and 60+ testing days**
- **30+ specialist involved on site and remote monitoring**

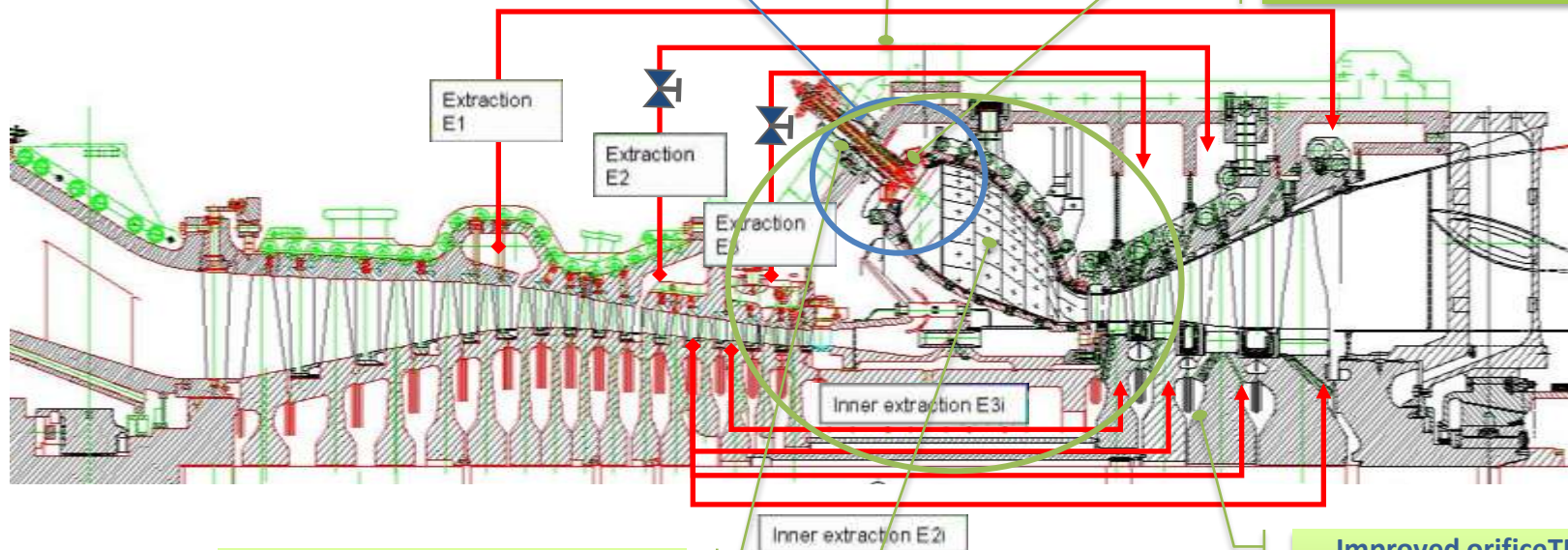
## SAS Upgrade

*La Casella Unit 1*

Upgraded combustion system

Control Valves GV2-3  
Variable setpoint connected with Load  
& Ambient Temperature.

Burner insert optimized  
cooling holes path with  
TBC



Combustion Chamber  
Internal housing Cooling Holes  
optimization to cool the tile  
holders

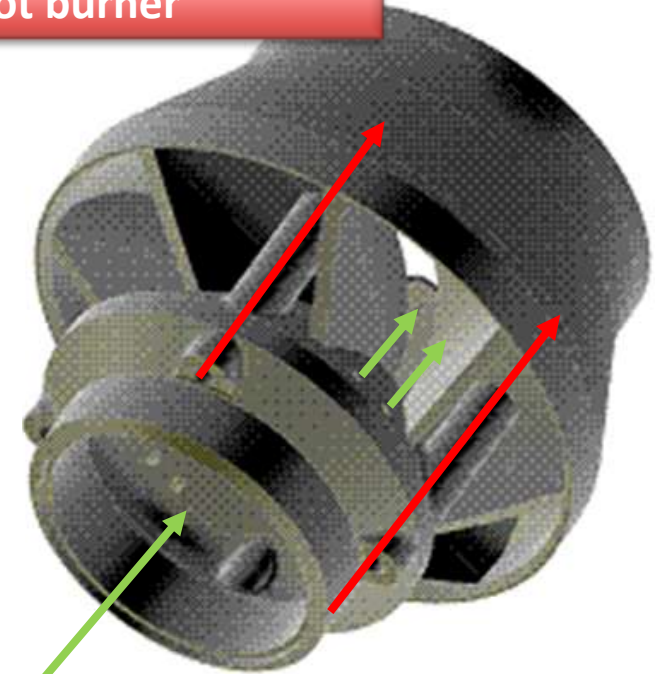
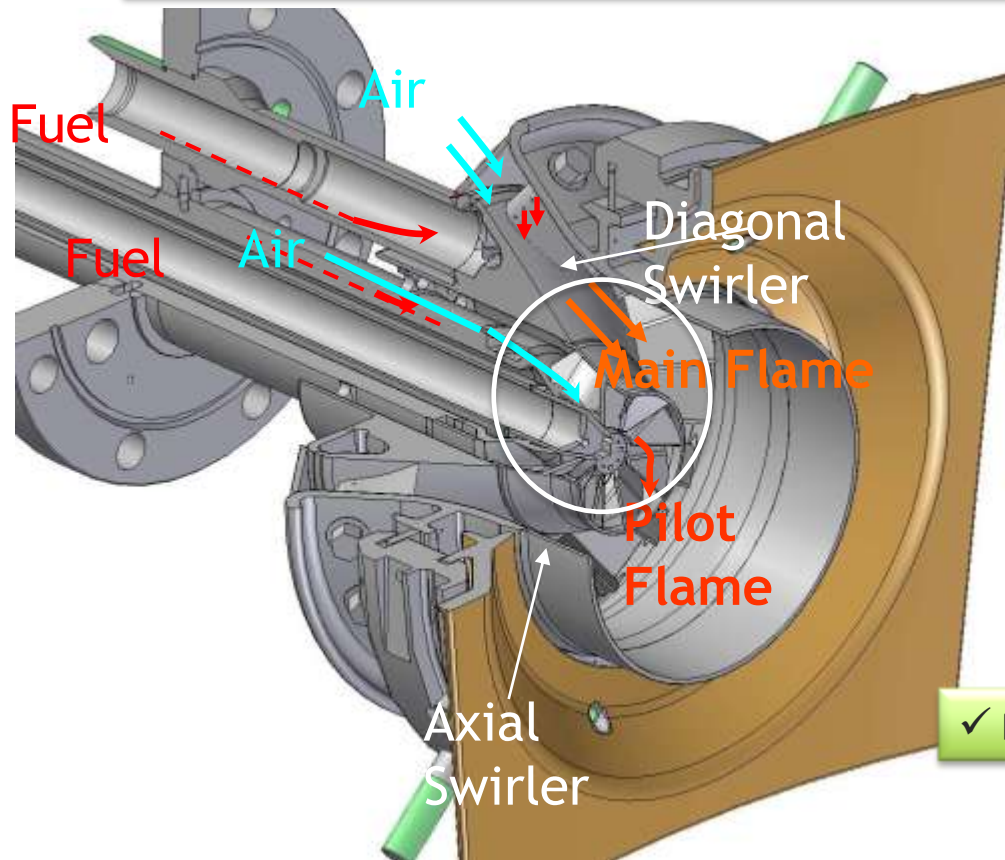
External Housing Combustion Chamber  
Holes Path Optimization

Improved orifice TB2 & TB3  
Blades

## Combustion System

Environmental mode ( $\text{NO}_x < 30 \text{ mg/Nmc}$ ) → premix pilot burner

Power Mode ( $\text{NO}_x < 50 \text{ mg/Nmc}$ ) → diffusion pilot burner



✓ Premixed Pilot

✓ Diffusion Pilot



**Introduction**



**Target**



**La Casella Unit 1**

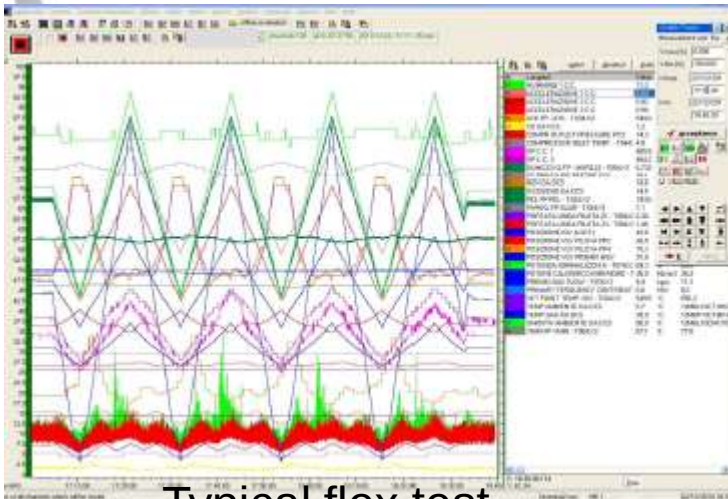


**Test Results**



**Conclusion**

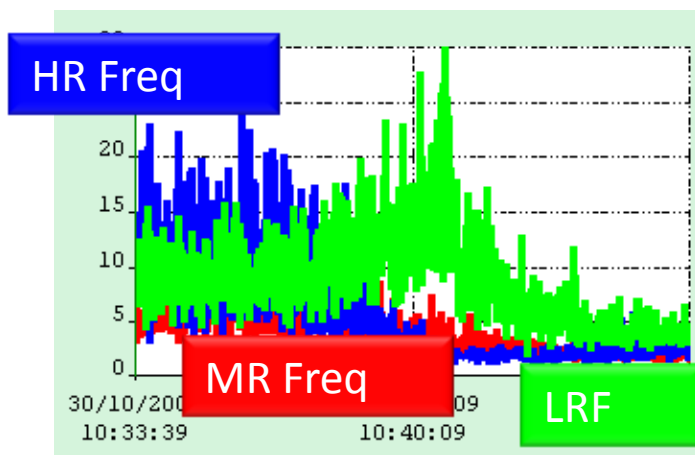
## Gas turbine fine tuning



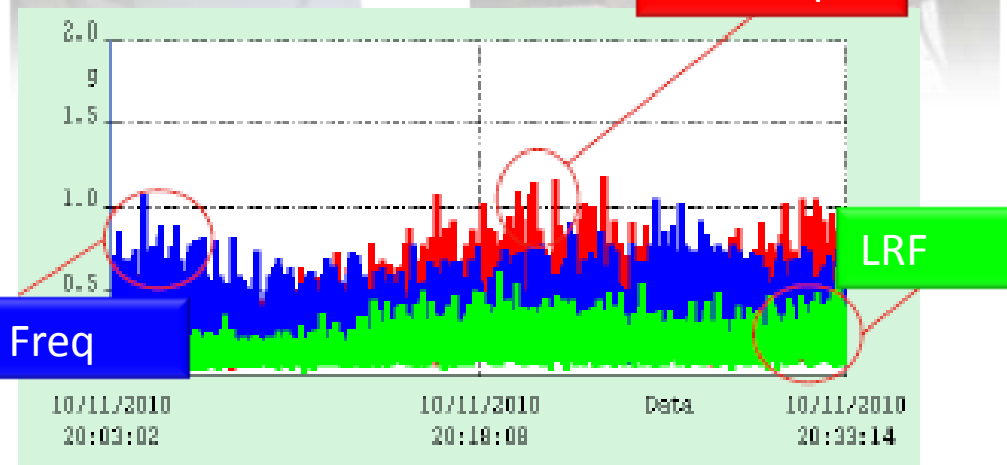
Typical flex test



Combustor overboard MR Freq

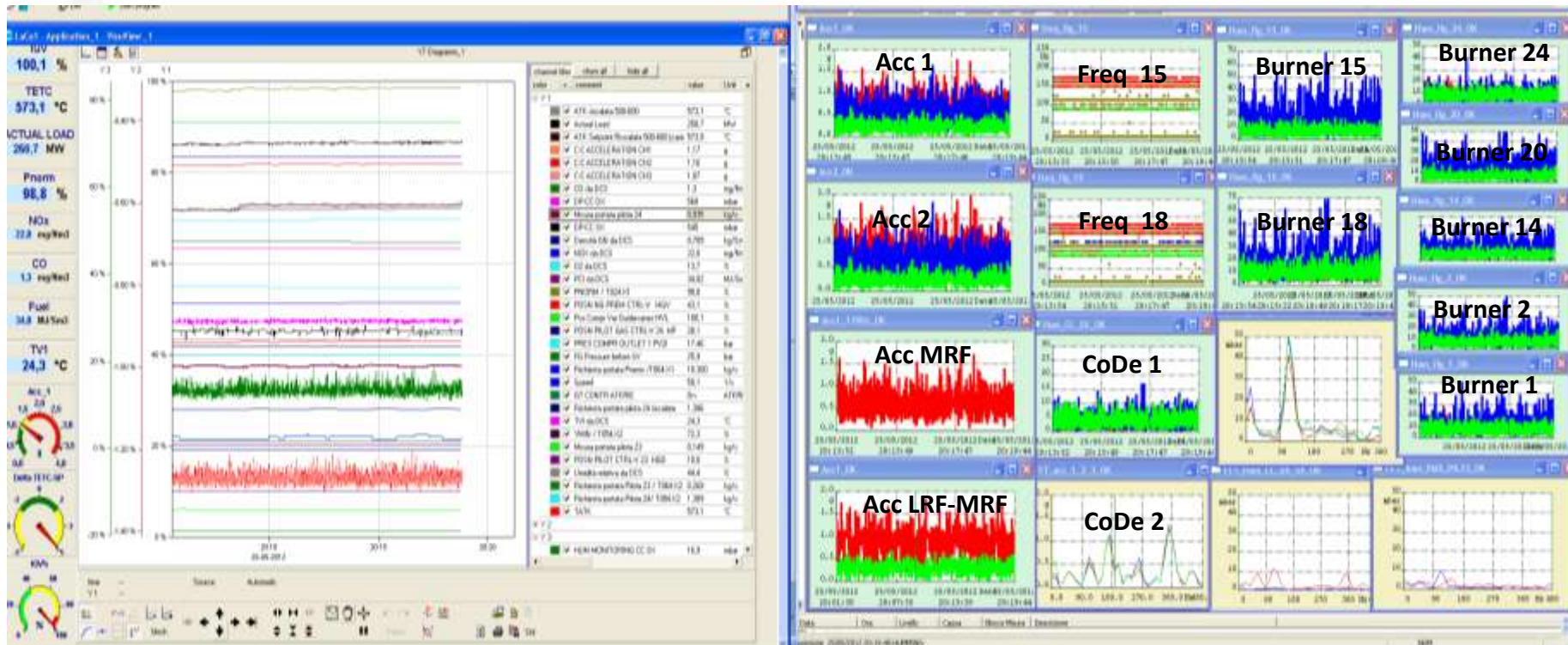


Burner dynamics



Combustor vibrations

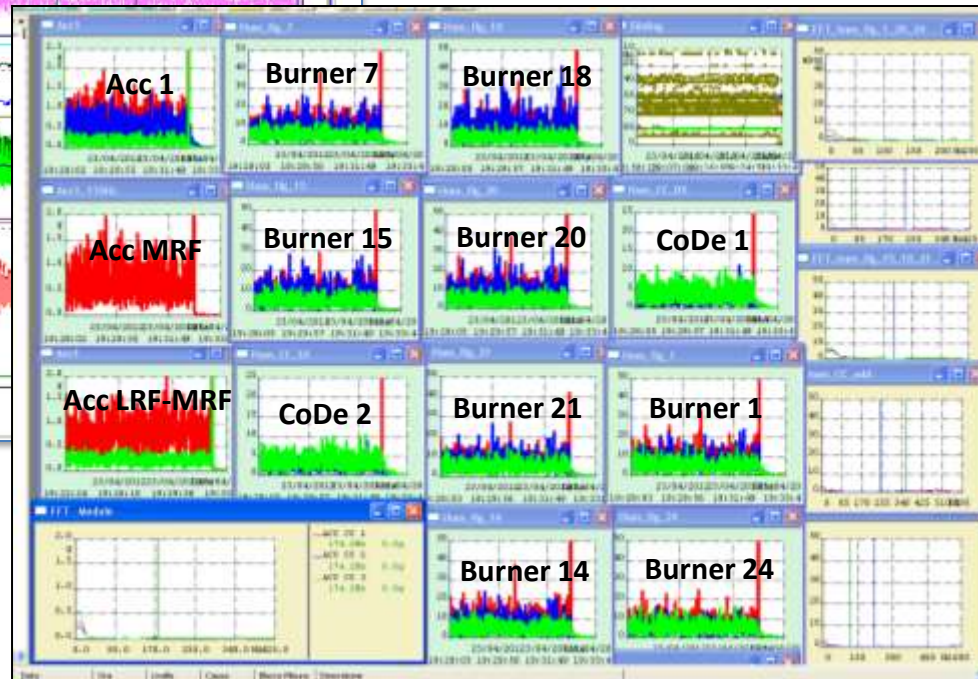
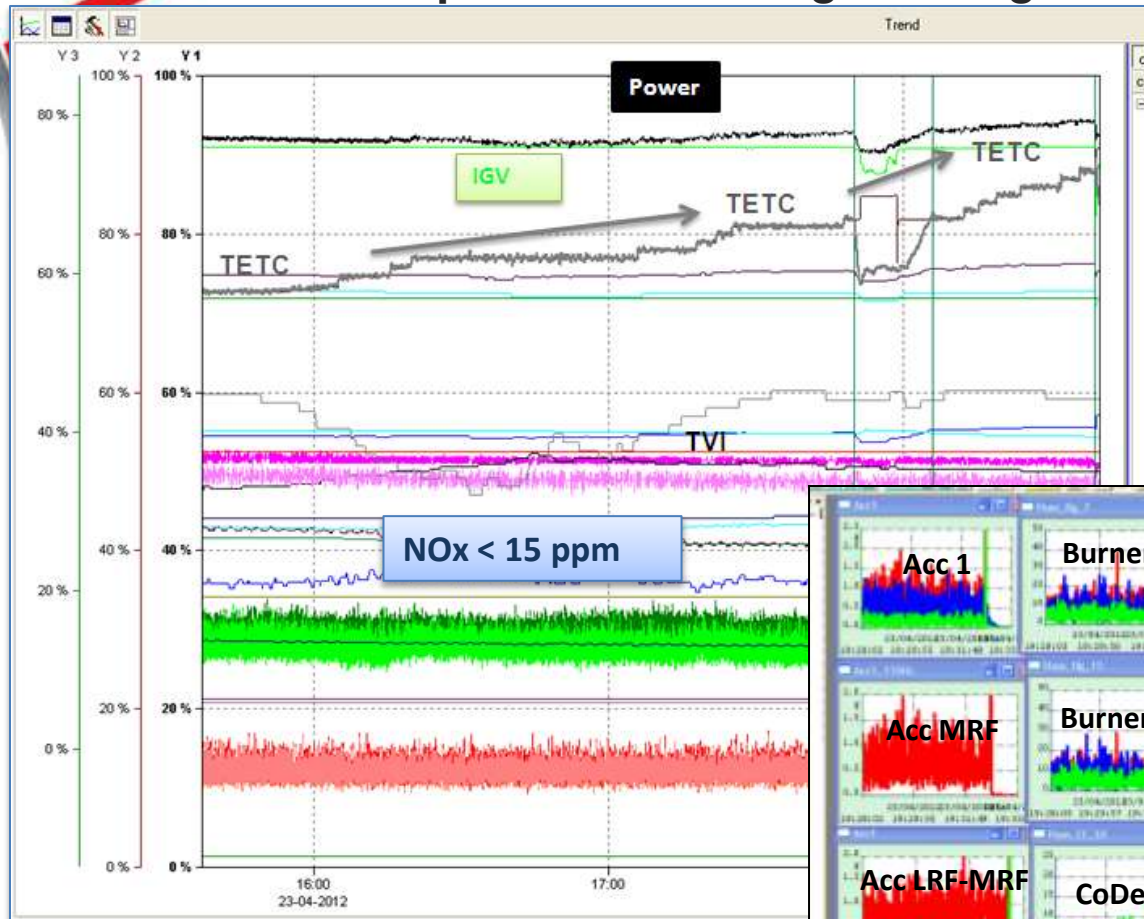
# Premixed Pilot Low Swirl High Mixing Main Burner at max base load



**NOx < 12 ppm but dynamics tends to get unstable condition: stability limit is near!**

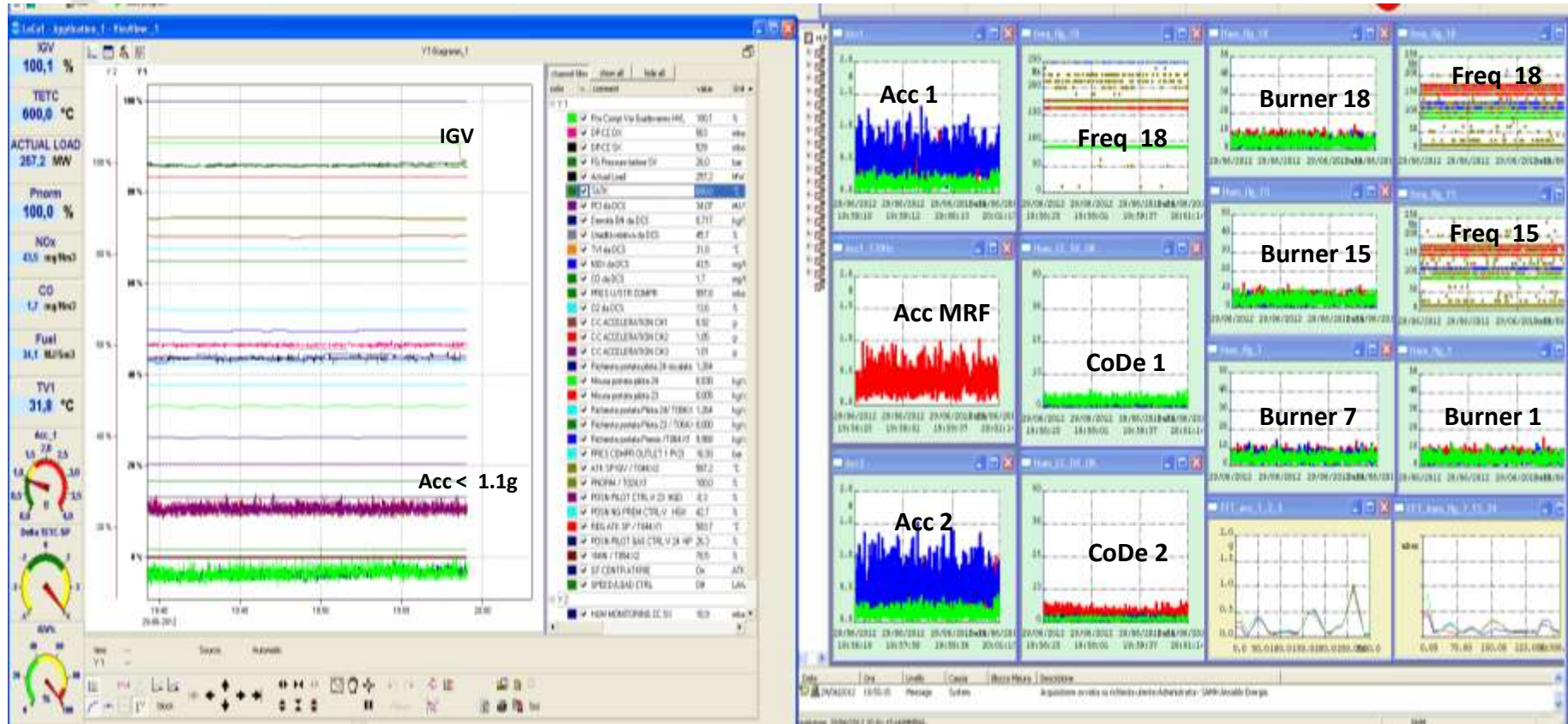
**TIT ISO achieved far away from target...**

## Diffusion pilot low swirl high mixing main burner at max base load



**Power output consistent with current diffusion pilot system with NOx < 15 ppm. Target achieved with good safety margin vs dynamics**

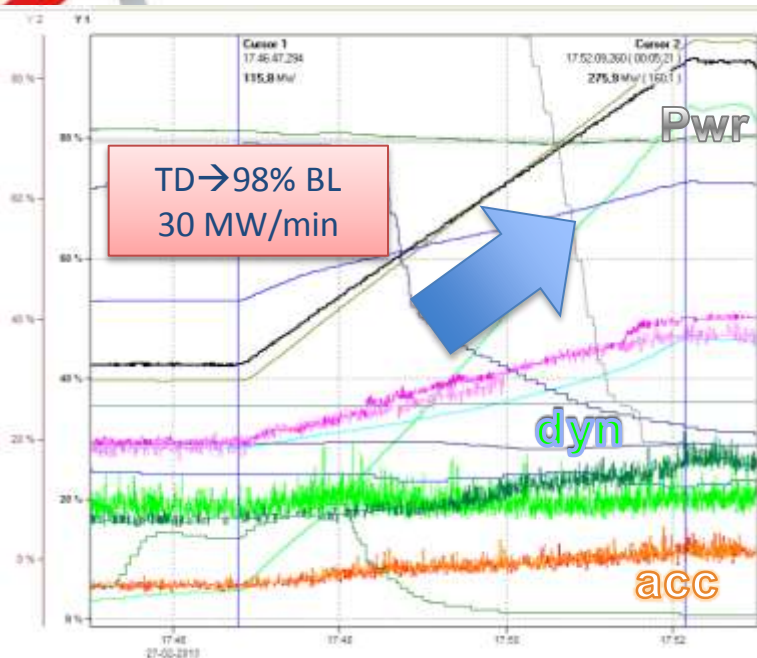
# Diffusion Pilot Low Swirl Low Mixing Main Burner at max base load



**Highest Power output achieved with NOx < 25 ppm with very low dynamics: test stopped due to boiler limitations**

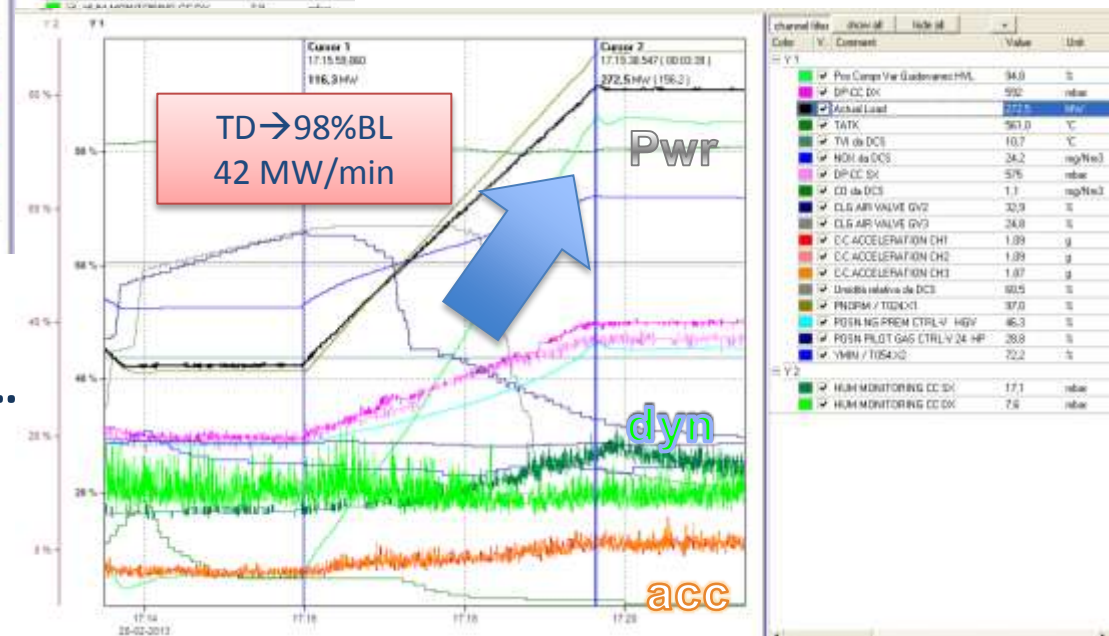
## Diffusion Pilot Low Mixing Main Burner: Load Ramp

**Very stable conditions:  
Low emissions and  
negligible dynamics**



| Channel | Var.                         | Comment | Value | Unit   |
|---------|------------------------------|---------|-------|--------|
| Y1      |                              |         |       |        |
| ✓       | Pwr Comp Var GuideVanes HVL  |         | 99.1  | %      |
| ✓       | DP-CC DSI                    |         | 887   | mbars  |
| ✓       | Actual Load                  |         | 275.9 | MW     |
| ✓       | TATK                         |         | 560.3 | °C     |
| ✓       | TVI de DCS                   |         | 5.3   | °C     |
| ✓       | NOx de DCS                   |         | 22.0  | mg/Nm3 |
| ✓       | DP-CC SX                     |         | 585   | mbars  |
| ✓       | CO de DCS                    |         | 0.6   | mg/Nm3 |
| ✓       | CLG AIR VALVE GV2            |         | 32.0  | %      |
| ✓       | CLG AIR VALVE GV3            |         | 28.6  | %      |
| ✓       | C-C ACCELERATION CH1         |         | 1.09  | g      |
| ✓       | C-C ACCELERATION CH2         |         | 1.03  | g      |
| ✓       | C-C ACCELERATION CH3         |         | 1.01  | g      |
| ✓       | Unstabil relative de DCS     |         | 79.5  | %      |
| ✓       | PNORM / T024X1               |         | 66.4  | %      |
| ✓       | POSH NG PREM CTRLV HGV       |         | 47.0  | %      |
| ✓       | POSH PILOT GAS CTRLV 24 HP   |         | 26.3  | %      |
| ✓       | YMIN / T054X2                |         | 72.7  | %      |
| Y2      |                              |         |       |        |
| ✓       | HUM MONITORING CC SX         |         | 16.0  | mbars  |
| ✓       | CC NEULA AIR FLOW RATE 24 HP |         | 0.14  |        |

From TD up to 98% BL in 3'40"...



| Channel | Var.                        | Comment | Value | Unit   |
|---------|-----------------------------|---------|-------|--------|
| Y1      |                             |         |       |        |
| ✓       | Pwr Comp Var GuideVanes HVL |         | 94.0  | %      |
| ✓       | DP-CC DSI                   |         | 592   | mbars  |
| ✓       | Actual Load                 |         | 372.5 | MW     |
| ✓       | TATK                        |         | 563.0 | °C     |
| ✓       | TVI de DCS                  |         | 10.7  | °C     |
| ✓       | NOx de DCS                  |         | 24.2  | mg/Nm3 |
| ✓       | DP-CC SX                    |         | 576   | mbars  |
| ✓       | CO de DCS                   |         | 1.1   | mg/Nm3 |
| ✓       | CLG AIR VALVE GV2           |         | 32.0  | %      |
| ✓       | CLG AIR VALVE GV3           |         | 24.0  | %      |
| ✓       | C-C ACCELERATION CH1        |         | 1.09  | g      |
| ✓       | C-C ACCELERATION CH2        |         | 1.09  | g      |
| ✓       | C-C ACCELERATION CH3        |         | 1.07  | g      |
| ✓       | Unstabil relative de DCS    |         | 80.5  | %      |
| ✓       | PNORM / T024X1              |         | 37.0  | %      |
| ✓       | POSH NG PREM CTRLV HGV      |         | 46.3  | %      |
| ✓       | POSH PILOT GAS CTRLV 24 HP  |         | 26.8  | %      |
| ✓       | YMIN / T054X2               |         | 72.2  | %      |
| Y2      |                             |         |       |        |
| ✓       | HUM MONITORING CC SX        |         | 17.1  | mbars  |
| ✓       | HUM MONITORING CC CX        |         | 7.6   | mbars  |



**Introduction**



**Target**



**La Casella Unit 1**



**Test Results**



**Conclusion**

## COMBUSTION SYSTEM

### Pilot Burner:

- ✓ Diffusion pilot best solution for stability and flexibility: due to SAS up 25+°C TIT ISO upgrade and lower NOx
- ✓ Premixed pilot low performance: a different air split between pilot and main burner has been designed to be tested on 4Q/2013.

### Main Burner:

- ✓ Low Mixing MB better stable than High Mixing MB: higher TIT ISO, higher NOx
- ✓ Staged combustion gives higher stability on premixed pilot tests: promising concept to be further investigated. Next test on 4Q/2013

### SAS Up

- ✓ Heat Loads on combustor is distributed according to design values
- ✓ No Issues on combustion chamber tiles

## Overall Performance

### ➤ Environmental mode by Diffusion Pilot High Mixing Main Burner:

- ❖ NOx < 15 ppm
- ❖ Turn down below 40% BL

### ➤ Performance mode by Diffusion Pilot Low Mixing Main Burner

- ❖ NOx < 25 ppm
- ❖ Turn down below 37% BL

### ➤ 7 units released

- 1 in operation (Env Mode)
- 3 in commissioning (1 Perf Mode and 2 Env Mode)
- 3 ordered (3 Perf Mode)

## AE94.3A flexibility upgrade: field test campaign outcomes



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