



EDF'S EXPERIENCES IN HIGH-PERFORMANCE THERMAL POWER GENERATION

Jordan - 5 September 2016
EDF Thermal Engineering Center (JH Paris)



AGENDA

1. **A QUICK GLANCE AT EDF GROUP – THERMAL GENERATION**
2. NEW TECHNOLOGY OF COMBINED CYCLE : CASE OF BOUCHAIN POWER PLANT
3. REPOWERING OF EXISTING POWER PLANTS : CASE OF MARTIGUES POWER PLANT
4. E-MONITORING : SOLUTIONS AND EXAMPLES



EDF GROUP, AN INTEGRATED ENERGY AND SERVICES PROVIDER



EDF KEY FIGURES (2015)

€ 75 billion
turnover

€ 17.6 billion
EBIDTA

≈ 37.6 million
customers

≈ 159,112
employees worldwide

134.2 GW
installed capacity worldwide

619.3 TWh
of electricity generated a year

EDF THERMAL GENERATION AND ENGINEERING

With a **44 GWe** gross installed capacity across the world, EDF is a leader in **thermal generation and engineering**.

EDF Group expertise as technical advisor has been successfully proven in projects involving the most efficient technologies.



10,000 THERMAL RESOURCES IN EDF AROUND THE WORLD (2015)

THERMAL ENERGY-GENERATION WITHIN EDF GROUP:

~ 80TWh/an

44 GW
Installed capacity

35% **coal**

35% **natural gas**

13% **oil**



Nuclear
54%



Hydropower
16%



Fossil-fuel thermal plants
16%



Combined Cycle Gas Turbines & Combined Heat and Power Plants
9%



Renewable
5%

22 SERVICES SUITED FOR THE LIFE CYCLE OF THE POWER PLANT

EDF can act both as **Owner's Engineer** and **O&M contractor**.

It's unique expertise as operator allows a better communication regarding the needs of the O&M, easier management of LTSA contract and a greater involvement of the O&M team during important engineering phases.

STRATEGY

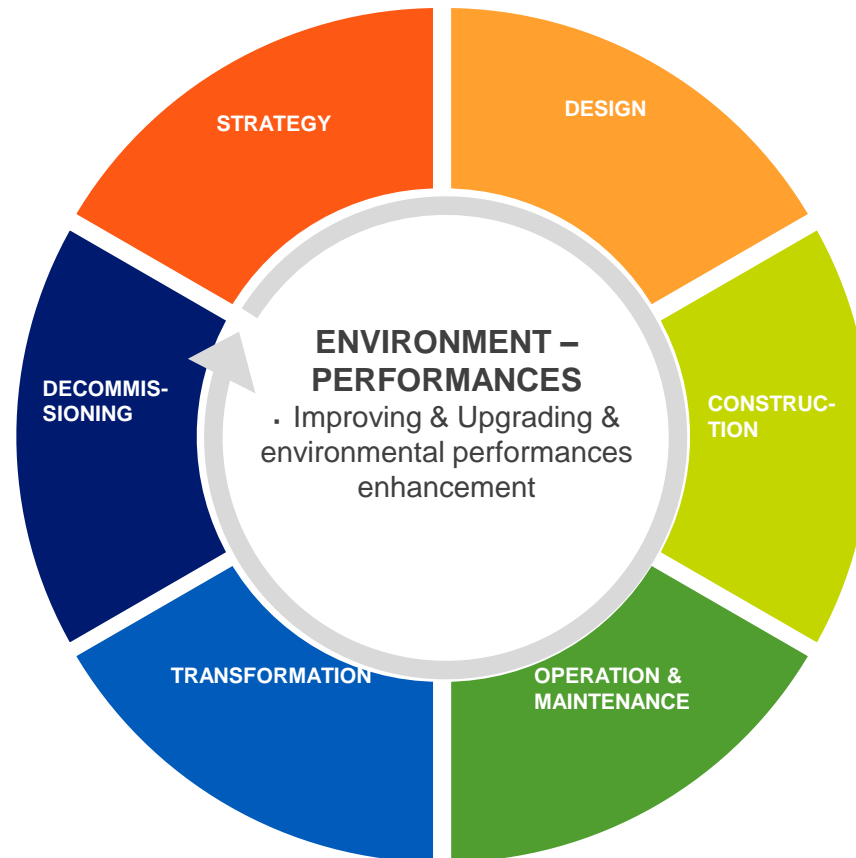
- Masterplans and grid consultancy
- Power project pre-development/consultancy and feasibility studies

DECOMMISSIONING

- Safety and environment focused final shutdown
- Asbestos removal
- Dismantling

TRANSFORMATION

- Lifetime extension
- Upgrading
- Conversion
- **Repowering**
- Relocation
- Mothballing and Recommissioning



DESIGN

- Power project development/**basic engineering**/bid evaluation

CONSTRUCTION

- **Construction & commissioning** supervision

OPERATION & MAINTENANCE

- Full O&M management
- Organization improvement
- Technical assistance and performance improvements
- Training programs and skills development
- **eMonitoring**

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BOUCHAIN, SHOWROOM FOR A NEW GENERATION OF COMBINED CYCLE PLANT

EDF and GE have built a CCGT with the brand new GE Gas Turbine (9HA) more powerful and reactive :

- **A partnership based on performance and innovation :**
 - Combination of GE and EDF competencies
 - Definition of a new reference for performances

- **A plant in line with EDF group objectives :**
 - Modernisation of the thermal park
 - International development

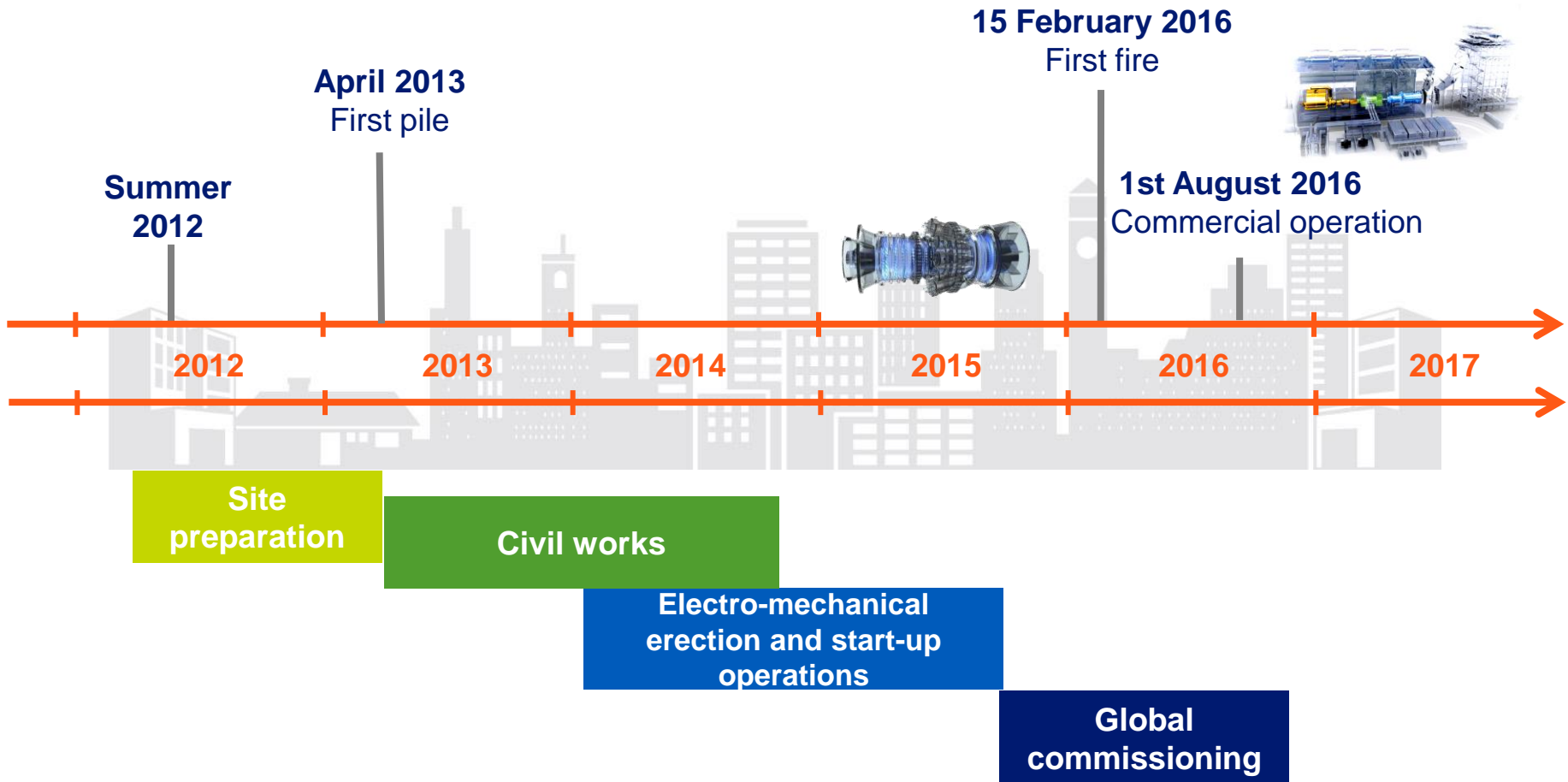
- **A showcase for GE innovation :**
 - New technologies design
 - Smart grid principle applied to the electrical and I&C systems
 - An answer to the needs created by the intermittent energies development (such as wind or solar farms)

PERFORMANCES OF THE PLANT

- **Large capacity**
 - Guaranteed 575 MW (site conditions), able to supply 600 000 homes.-
 - Demonstrated 605 MW
- **High efficiency**
 - Over 61 %
 - demonstrated Power Island efficiency : 62,2% (World record)
- **High flexibility**
 - Able to start and stop every day to suit to network needs
 - Full power reached in 30 minutes
- **Environment**
 - Low level of emissions, better than current regulation



TIME SCHEDULE OF THE PROJECT



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REPOWERING

The « repowering » process consists in using existing installations renovated and associating them with new equipment, such as gas turbines.



- ✓ **Audits and expertise :**
 - Equipment and systems
 - Malfunction analysis, investigation on incidents
 - Equipment degradation and behavior analysis
- ✓ **Advisory on renovation**
- ✓ **Economical and technical feasibility study**
- ✓ **Assistance with contracting and project management,**
- ✓ **Training and skills enhancement for operating staff**

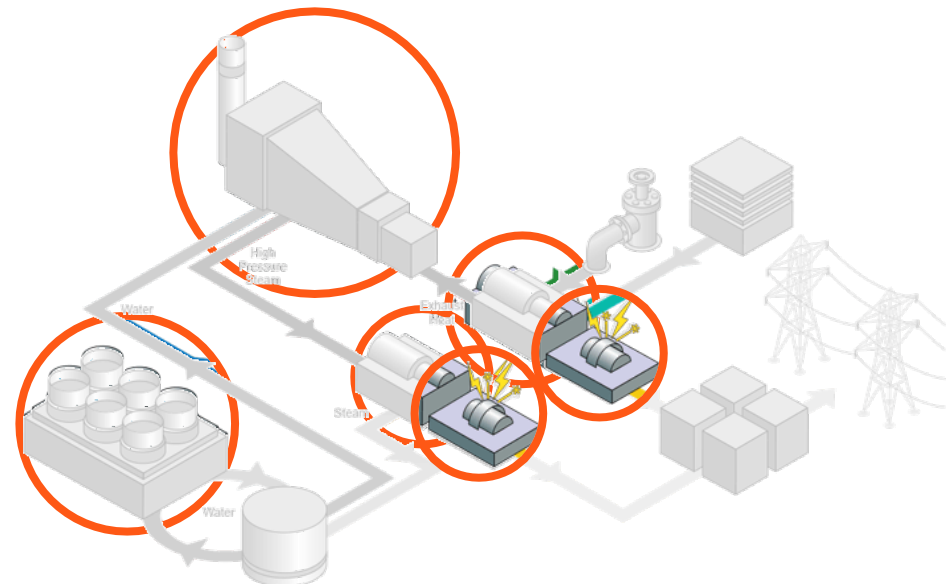
For example:

Can be kept and renovated:

- ✓ Steam turbines
- ✓ Pumping station
- ✓ Cooling systems

Can be added new:

- ✓ Gas turbines and auxiliaries
- ✓ Heat Recovery Steam Generators
- ✓ Generators...



MARTIGUES

First Combined Cycle Power Plant repowering, in Martigues, a 40-years old EDF asset.



1970 to 2008:

Heavy fuel oil power plant

150 employees



2008 to 2013:

A huge challenge and a construction site with epic proportion

- ✓ 500 M€ investment
- ✓ 52 months works
- ✓ Up to 900 workers on-site
- ✓ Frequency rate = 2.09
- ✓ No heavy injury

**AFTER COD IN 2013:**

Increase in efficiency
from 37% to 57%

Start-up time reduced
2 to 7 hours

Substantial lowering of CO₂, NO_x and
SO_x emissions

940 MWe : 2 x 470 MWe

Lifetime extension: 25 years

THANKS TO REPOWERING:

20% savings on project costs

No new permits needed

The 61 personnel of the future operating
team has been involved in the process





THE BENEFITS:

- ✓ Lifetime extension of the plant and equipment
- ✓ Performances enhancement
- ✓ Reduction of the plant environmental impacts

KEY SUCCESS FACTORS

- ✓ Accurate Feasibility & Basic design :
- ✓ Spare parts available (ST)
- ✓ Safety management
- ✓ O&M staff involvement during construction : commissioning



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EMONITORING – ORGANIZATION & SERVICES

- eMonitoring is a service of remote analyses of power plant process data
- Two main objectives are targeted
 - Performance monitoring

Detect and analyze the power plant performance degradation

Tools: CSP, TDY, PMAX
EtaPRO

- Early Fault Detection

Anticipate the potential equipment faults

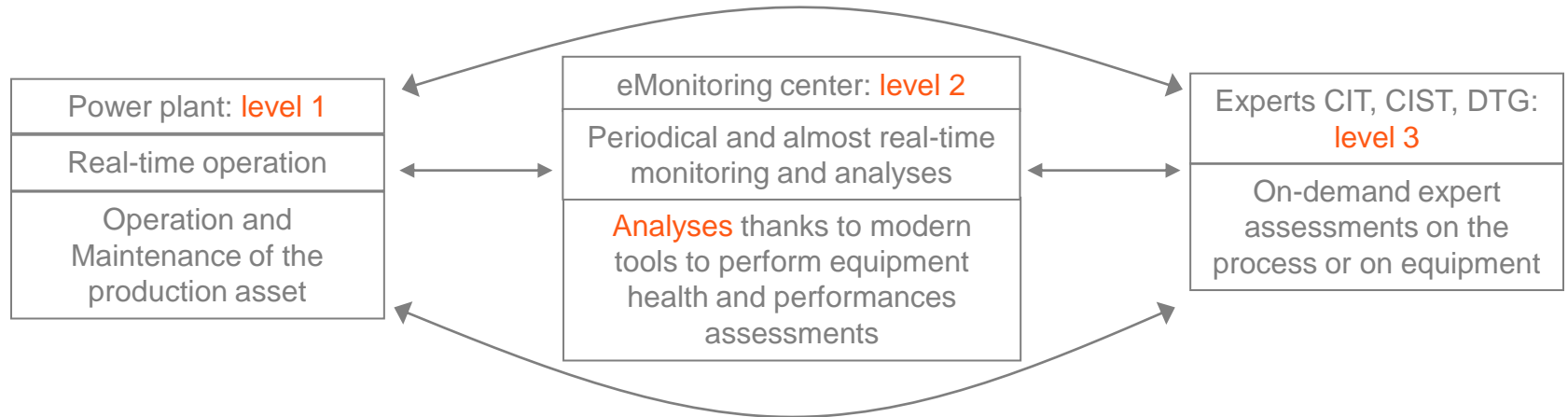
Tool: PRiSM

EMONITORING – ORGANIZATION & SERVICES

- The eMonitoring center is located at (EDF thermal Engineering center) in Paris.
- **With a dedicated team:**
 - Of about 10 people
 - With the support of EDF's process and equipment experts
 - Benefiting from the support of the other experts of the EDF Group (EDF-DTG, R&D...)
 - Within a 3 level organization
 - Independent from the manufacturers
- **A centralized monitoring enables to:**
 - Capitalize the alerts on all units of the fleet
 - Standardize and share the best practices and initiatives
 - Propose pilot sites for developments and speed up their deployment on the other units

EMONITORING – ORGANIZATION & SERVICES

THREE LEVEL ORGANIZATION

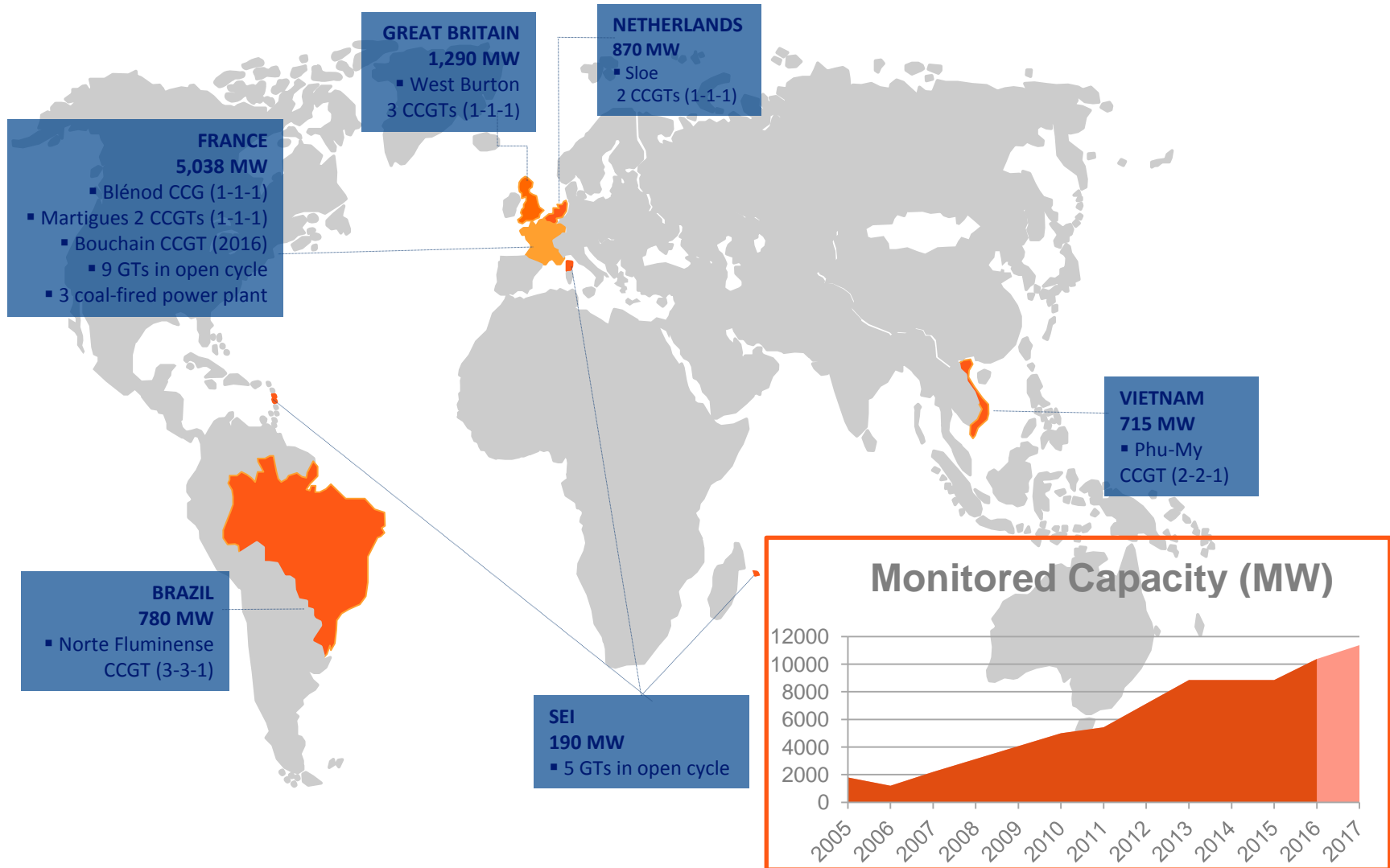


Expertise fields (on which EDF lay stress):

- ❑ Thermodynamics
- ❑ Gas Turbines
- ❑ Static machines (HRSG, condenser...)
- ❑ Rotary machines (Steam turbines, pumps,...)
- ❑ Power Generators
- ❑ Transformers
- ❑ Ancillary system / Chemistry

EMONITORING – ORGANIZATION & SERVICES

EDF THERMAL EMONITORING AROUND THE WORLD SINCE 2004



EMONITORING – PERFORMANCE

Performances Monitoring report

1 Sheet per main theme

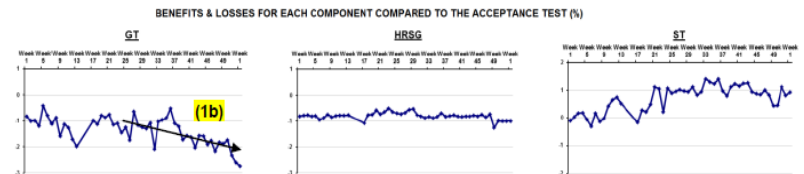
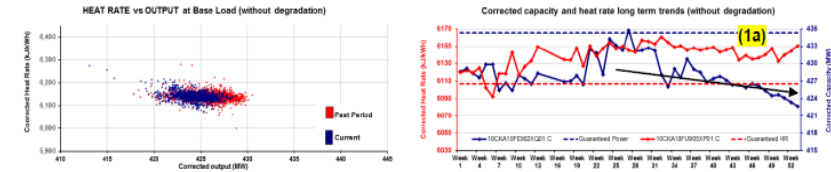
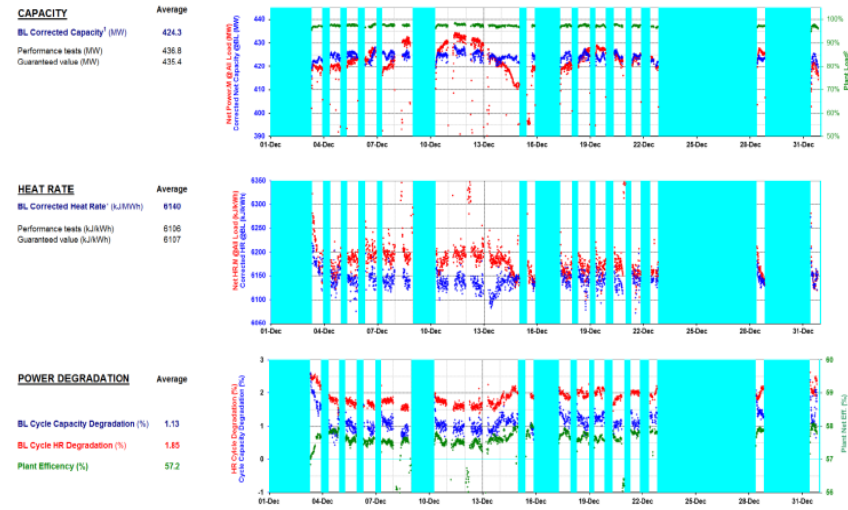
- Overall performances
- Gas turbine
- HRSG/Boiler
- Steam Turbine
- Condenser / Cooling Tower
- Auxiliary Consumptions

On each Sheet

- Trend of parameters
- Filtered average values over the monitored period
- Recommendations

Cross comparison of similar equipments

SHEET 10: U10 PLANT OVERALL PERFORMANCE



1. Corrected capacity and heat rate are the measured plant net output and heat rate corrected to design conditions using the correction curves revised by EDF-CIT for operation at base load (GT IGV Full Open).
 2. Plant instantaneous net power / Plant guaranteed capacity in actual conditions.

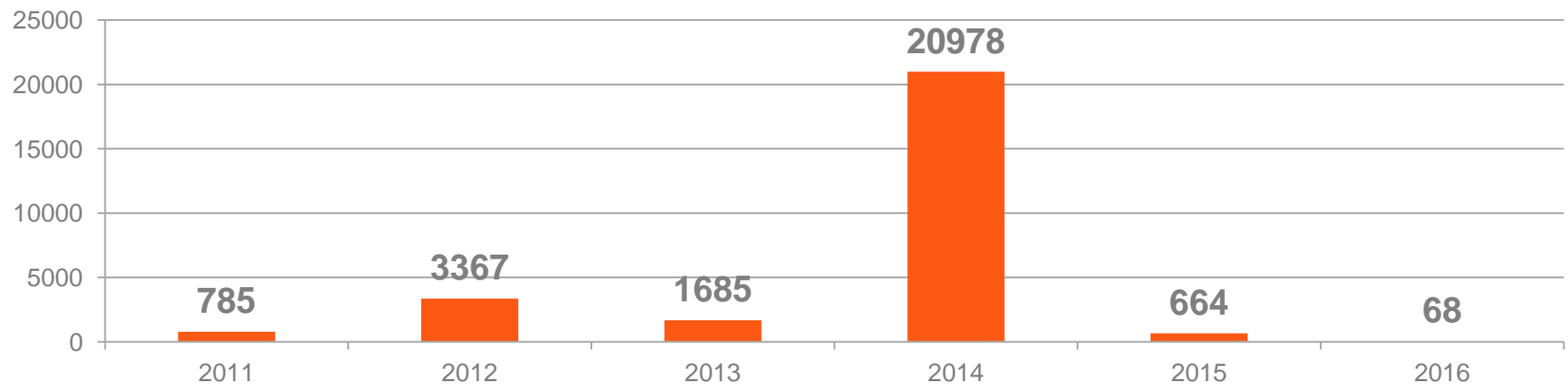
GT LOW RISK	HRSG NORMAL	ST LOW RISK	CONDENSER NORMAL
Abnormal use of the HCO due to high vibrations of the steam turbine shaft		High vibrations of the steam turbine shaft	

EMONITORING – EXPERIENCE FEEDBACK

- Thanks to **different technical and economic assumptions**, the eMonitoring team is able to **estimate the avoided costs** in 4 various categories :
 - **Avoided power loss**
 - **Avoided fuel over-consumption**
 - **Avoided unavailability**
 - **Avoided material Impact**



Total of avoided costs k€



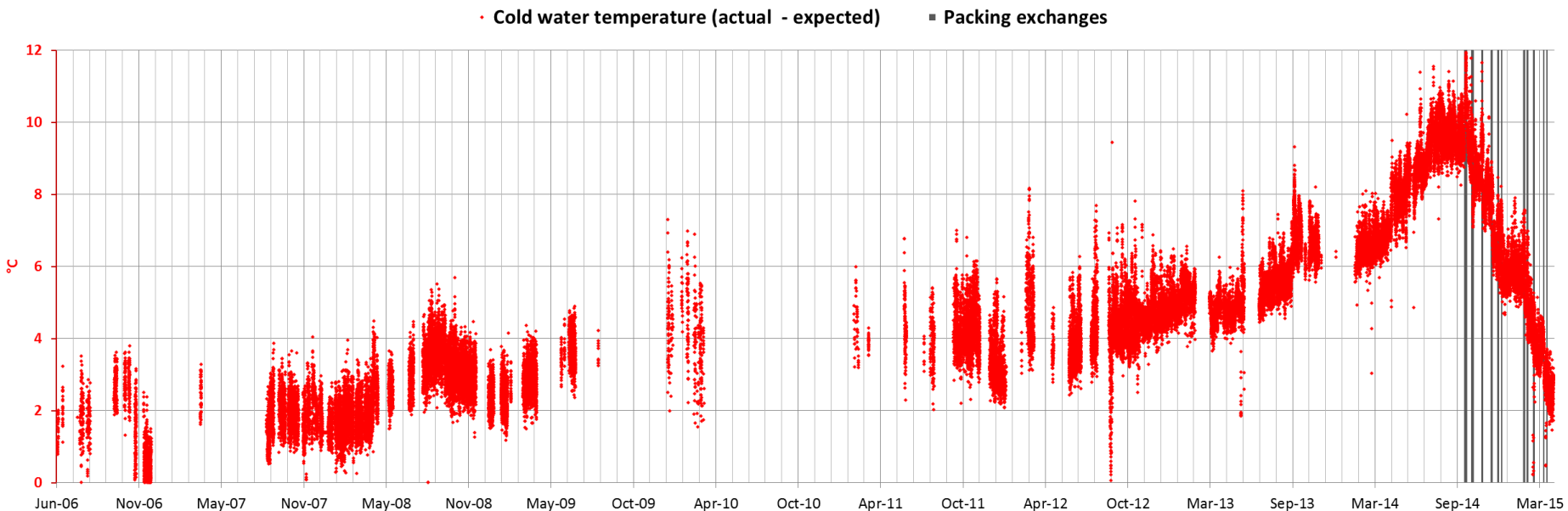
EMONITORING – PERFORMANCE CATCHES

Gain on Power production due to cooling tower fouling in CCGT Power Plant

- Example in 2013: alert after fast increase of delta temperature of cold water outlet, the fouling is suspected

Estimated impact
 $\cong 8^{\circ}\text{C}$ (cold end)
 $\cong 13$ MW on ST power

- Change of cooling tower cells packing , discovered filled with mud



Thank you