EDF eMonitoring for Thermal Power Plants

Presented by Pierre ANDRIEUX - EDF - O&M Performance Team Manager
Nicolas DEBROIS - EDF - IT Project Manager
AGENDA

1. EDF A GLOBAL LEADER IN POWER GENERATION
2. EMONITORING ORGANIZATION AND SERVICES
3. EMONITORING PERFORMANCES
   EMONITORING PERFORMANCES CATCHES
4. EMONITORING EARLY FAULT DETECTION
   EARLY FAULT DETECTION MAIN CATCHES
5. EMONITORING EXPERIENCE FEEDBACK
6. EMONITORING DEVELOPMENT
EDF A GLOBAL LEADER IN POWER GENERATION

WORLD’S NO.2 ELECTRICITY COMPANY
- EDF Group is particularly well established in Europe, especially France, the United Kingdom, Italy and Belgium.
- A marked increase in the use of renewables is bringing change to its power generation operations, which are underpinned by a diversified low-carbon energy mix founded on nuclear power capacity.

LEADER IN LOW-CARBON POWER GENERATION
- No. 1 in the world for nuclear power generation.
- No. 1 in Europe for renewable energy generation.
- No. 3 in Europe for energy services.

EDF COVERS ALL ELECTRICITY-RELATED ACTIVITIES
- Generation
- Transmission, distribution
- Trading, supply
- Energy services
EDF A GLOBAL LEADER IN POWER GENERATION

- 37 M customers worldwide
- 155 000 employees
- €71,2 billion sales
- 584,7 TWh electricity generation

EDF GROUP in 2016

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EDF GROUP in 2016

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EDF A GLOBAL LEADER IN POWER GENERATION

EDF GROUP’S INSTALLED CAPACITY IN 2016

- 6% Other renewables
- 6% Coal
- 7% Fuel Oil
- 6% CCGT and cogeneration
- 16% Hydropower

132,3 GWe

55% Nuclear

EDF GROUP’S ELECTRICITY GENERATION IN 2016

- 2% Other renewables
- 3% Coal
- 8% CCGT and cogeneration
- 8% Hydropower
- 78% Nuclear

564,7 TWh
EDF A GLOBAL LEADER IN POWER GENERATION

EDF COMMERCIAL OFFER FOR THERMAL GENERATION BUSINESS

1. STRATEGY
   - Masterplans & Grid Consultancy
   - Pre-Development Consultancy

2. CONCEPTION
   - Project Development:
   - Feasibility study
   - Basic design
   - Preparation of tender documents and management of tender

3. CONSTRUCTION
   - Construction & Commissioning Supervision

4. OPERATION & MAINTENANCE
   - O&M Management
   - Organization Improvement
   - Technical Assistance and Performance Improvement
   - Training Programs and Skills Development
   - eMonitoring

5. TRANSFORMATION
   - Lifetime Extension
   - Equipment Upgrading
   - Conversion
   - Repowering
   - Relocation
   - Mothballing and Recommissioning

6. DECOMMISSIONING
   - Final Shutdown Preparation
   - Asbestos Removal
   - Dismantling

7. ENVIRONMENT
   - Environmental Performance Enhancement
   - Environmental Measures
   - Waste Management
   - Depollution
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eMonitoring – Organization & services

• eMonitoring is a service of remote analyses of power plant process data
• Two services are proposed
  – **Performance** monitoring
    - Detect and analyze the power plant performance degradation
      Tool: EtaPRO
  – **Early Fault Detection**
    - Anticipate the potential equipment faults
      Tool: PRiSM
EMONITORING – ORGANIZATION & SERVICES
EDF Thermal power plant eMoni
toring IT figures

32
Units monitored \(^{(1)}\)

8
eMoni
toring IT infrastructures including PI servers

9 GW
monitored

200 000
TAGs

\(^{(1)}\) 19 in mainland France
EMONITORING – ORGANIZATION & SERVICES
EDF THERMAL EMONITORING AROUND THE WORLD SINCE 2004

FRANCE
5038 MW
- Blénod 1 CCGT (1-1-1)
- Martigues 2 CCGT (1-1-1)
- Bouchain 1 CCGT (1-1-1)
- 9 OCGTs
- 3 coal fired units

UNITED KINGDOM
1290 MW
- West Burton
  3 CCGT (1-1-1)

NETHERLANDS
870 MW
- Sloe
  2 CCGT (1-1-1)

BELGIUM
Innovation VIB360
(Diesel motor health assessment)
- EDF Luminus – Diesel generators

EDF
- West Burton
  3 CCGT (1-1-1)

TURKEY
320 MW
Performance Monitoring
- Çan
  2 CFB coal fired power plants

CHINA
2000 MW
EFD
- Fuzhou
  2 coal fired power plant

NEW CALEDONIA
110 MW
Performance Monitoring
- Prony
  2 coal fired power plant

EDF
- Bouchain 1 CCGT (1-1-1)

IRON COAST
370 MW
Performance monitoring & EFD
- 1 CCGT

KSA
OE eMonitoring
- Saudi Electricity Company

IVORY COAST
370 MW
Performance monitoring & EFD
- 1 CCGT

BRAZIL
780 MW
- Norte Fluminense
  1 CCGT (3-3-1)

ISLAND ENERGY SYSTEMS
190 MW
- 5 OCGTs

KSA
OE eMonitoring
- ARAMCO / NOMAC

FRENCH GUINEA
EFD
- 1 mobile OCGT

CHILE
Performance monitoring & EFD
- El Campesino
  1 CCGT (1-1-1)

BELGIUM
Innovation VIB360
(Diesel motor health assessment)
- EDF Luminus – Diesel generators

BRAZIL
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CHILE
Performance monitoring & EFD
- El Campesino
  1 CCGT (1-1-1)
EMONITORING – ORGANIZATION & SERVICES

EDF THERMAL eMonitoring around the world SINCE 2004

- 2015
  - BRAZIL: EFD for Norte Fluminense
- 2016
  - FRANCE: Bouchain (Performance eMonitoring)
- 2017
  - FRANCE: Bouchain (EFD)
  - TURKEY: MENR (Performance eMonitoring)
  - BELGIUM: EDF Luminus (Aycyclismes eMonitoring)
  - SENEGAL: SENDOU (EFD & Performance eMonitoring)
  - KSA: Consultant for SEC Generation Operation Centre

Monitored Capacity (MW)
EMONITORING – ORGANIZATION & SERVICES

• The eMonitoring center is located at EDF-CIT in Paris La Défense.
• With a dedicated team:
  – Of about 14 people
  – Close to EDF-CIT’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
  – Working on weeks day with office hour and cannot replace the real time operators checks
• A centralized monitoring enables to:
  – Capitalize the alerts on all units
  – Standardize and share the best practices and initiatives
  – Propose pilot sites for developments and speed up their deployment on the other units
THREE LEVEL ORGANIZATION

Expertise fields (EDF):
- Thermodynamics, Gas Turbines, Static machines (HRSG, condenser...), Rotary machines (Steam turbines, pumps,...), Generators, Transformers, Ancillary system, Chemistry

Specific deliverables adapted to each power plant:
- Analyses and recommendations formalized in periodical reports
- Periodical phone meetings
- Additional or on-request studies led, if necessary, with the support of our experts
- Alerts, on the process or on a system, in case of deviation and/or prominent risk for the equipment
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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
Gain on Power production due to cooling tower fouling in CCGT Power Plant

– Site alert after fast increase of Delta temperature of cold water outlet, fouling suspected

**Estimated impact**

\[ \approx 8^\circ \text{C (cold end)} \]

\[ \approx 13 \text{ MW on ST power} \]

– Change of cooling tower cells packing, discovered filled with mud
EMONITORING – PERFORMANCE CATCHES

- Improvement of condenser backpressure due to actual decrease of cold end temperature
- Power capacity increase by 13 MW (~ 40-50 k€ / day) validated with the client
- Cooling tower beams were found damaged to overweight caused by the accumulation of mud
EDF Thermal eMonitoring based on local PI Data Archive

EMONITORING – PERFORMANCE

On site infrastructures

- Blénod (1)
- Martigues (2)
- Bouchain (1)
- Cordemais (4)
- Le Havre (1)
- Vaires/Marne (13)
- Porcheville (4)

Remote Access + Datalink

EDF-CIT LEVEL 2 eMonitoring

PI DataLink

Data

Knowledge

GAP!
EMONITORING – PERFORMANCE
EDF Thermal eMonitoring based on centralized PI DA and AF

Evolution:
Knowledge, Data, and data Processing at the same place

Efficiency
### EDF Thermal eMonitoring business TARGETS INSIDE MAINLAND FRANCE

**Assets**
- 25 EDF units
  - CCGT (4)
  - Coal (3)
  - TAC, Fioul, diesel

**Challenges**
- Less thermal units in France
- More complex analysis

**IT Solution**
- Centralized data storage for
  - Mutualized data analysis tools

**Benefits**
- Less EXCEL based analysis and reporting
- Supervision of Data Quality
  - More time for business analysis
EMONITORING – PERFORMANCE
Using PI Event Frames: vibration increase

- Request for vibration analysis from CCGT Blénod:
  - “What is the evolution of the maxima of the vibration of the circulating pump 22 during its startups since the COD (October 2011)?”

- How to find all startups automatically since 2011?
  - Simple modelling of a circulation pump
  - Creation of a analysis type “Event Frame Generation”
EMONITORING – PERFORMANCE
Using PI Event Frames: vibration increase on pumps

- for vibration analysis from CCGT Blénod:
  - "What is the evolution of the maxima of the vibrations of the circulation pump 22 during its start-ups since the COD (October 2011)?"
- How to extract only useful information to answer the request?
  - Extraction of results in PI Datalink

\[ y = 0.0013x - 44.851 \]

\[
\begin{array}{cccccccc}
\text{18/11/10} & 01/04/12 & 14/08/13 & 27/12/14 & 10/05/16 & 22/09/17 \\
\text{SRV-PI}\text{SNCC.51PAC22CY404} & & & & & & \\
\text{(mm/s)} & & & & & & \\
\end{array}
\]
EMONITORING – PERFORMANCE
Using PI Event Frames: Chemistry Monitoring

- Context
  - Monitoring of Pressure Equipment required by internal inspection service
  - Chemists on site perform monthly report
    - By hand
    - Or semi automatic (VBA)

- Problem: semi automatic version stopped working
  - Evolution of IT environment
  - 1 day of never ending computation

→ Opportunity to update/create the semi automatic report
  - Standard calculation for every power plant (EDF doctrine)
  - With PI on every plant and PI Asset framework available
EMONITORING – PERFORMANCE
USING PI EVENT FRAMES: CHEMISTRY MONITORING

- Transfer of EDF chemistry expertise into PI AF
  - Only 1 template to create
  - A second one for visualization
  - One table import in library for TAG configuration

- 1 semi automatic report in PI Datalink
  - Project to completely automate report generation
  - 2 minutes to create (from opening Datalink to the result)

- Only 1 configuration table needed to monitor a new power plant

- Facilitate the exchanges between chemists, eMonitoring engineers and IT engineers

Monthly report build in one minute instead of VBA bugs and a formerly day long process
EMONITORING – PERFORMANCE
USING PI EVENT FRAMES: FUEL CONSUMPTION AT STARTUP

• Coal fired power plant can be marginal in Merit Order
  – Startup costs are to be challenged
  – Fuel (gas, coal, heavy fuel oil) consumption is the main contributor

• PI Event Frames detects and categorizes fuel consumption
  – Successful/Unsuccessful startups
  – Support
  – Cold/Warm/Hot startups

...still under construction
eMonitoring builds and analyzes a lot of performance indicators

We provide dashboards for our client build with PI solutions
  - Main indicators for decision-makers
  - Robust and uniform calculation
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eMonitoring – EARLY FAULT DETECTION

PRiSM software as EFD tool

Historical data

System monitoring model

Statistical algorithms for prediction

Real time process data

One graph per signal

Estimation

Actual value

Alarm

Upper bound

Lower bound
eMonitoring – EARLY FAULT DETECTION

Prediction bounds

Overall Model Residual

Upper bound Lower bound

Moderate relative deviation High relative deviation

- Alarm,
- Trip,
- equipment deterioration
- performances loss

Spread
Compressor outlet pressure
Compressor outlet temperature
Turbine inlet temperature
Gas turbine power

- Alarm,
- Trip,
- equipment deterioration
- performances loss

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Early detection of GT cooling blades degradation in a CCGT power plant

**EARLY FAULT DETECTION - main catches**

- **28/10**: Site alert after important step up increase of vibration sensors on GT compressor bearing
- **28/10**: Diagnostics by EDF: unbalance evolution after suspected material loss
  - Recommendation: GT shut down for boroscopic inspection
- **10/11**: Material loss confirmed by boroscopic inspection
  - Planification of corrective action with LTSA supplier
- **10/12**: GT supplier confirms restart of the GT in safety conditions
  - Maintenance has been anticipated

Estimated gain ~400 k€
### eMonitoring – EARLY FAULT DETECTION
EDF Thermal eMonitoring business TARGETS Outside Mainland FRANCE

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<tr>
<th>Assets</th>
<th>7 Client’s units</th>
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<tr>
<th>Challenges</th>
<th>New world wide eMonitoring Clients</th>
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<tbody>
<tr>
<td></td>
<td>Integration of IIoT and Cloud opportunities</td>
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<tr>
<th>IT Solution*</th>
<th>ONE centralized PI Data Archive</th>
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<tbody>
<tr>
<td></td>
<td>Simplified data acquisition* (PI to PI, PI OPC, PI UFL)</td>
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</table>

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<th>Benefits</th>
<th>Simplified eMonitoring offer (reduce number of tools)</th>
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<tbody>
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<td>Choice of the expert tools is 100% on EDF side (no SaaS)</td>
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</table>

*including opportunity of OSIsoft connected services despite constraint at this step of having one PI interface on one server for each client
EMONITORING – EARLY FAULT DETECTION
CENTRALIZED PI FOR CONNECTED EMONITORING SERVICES

World wide Clients’ plants

- DCS
  - PI to PI interface
  - PI OPC interface
  - PI UFL interface

PI DATA ARCHIVE

- PI OPC Interface
- PI UFL Interface
- PI to PI Interface

OARTHER (mobile site for KPIs)

Dashboards

PI Web API

PI DataLink

PI Processbook

EDF TH eMonitoring
N2 analysts & experts

Clients’ Teams

Management
KPI mobile access

Operations & Analysts
eMonitoring overviews

SIMPPLICITY FOR THE CLIENT
no specific tools

SIMPPLICITY FOR EDF
generic solutions
not sharing expert tools

EDF

Corporate IT

Cyber Security Solutions for web publishing

Clients

Teams

PI SDK Performance Monitoring

Early Fault Detection

PI AF

EDF

QARTHER

Performance Monitoring

Dashboards

PI Vision

PI DataLink

PI Processbook

EDF TH eMonitoring
N2 analysts & experts

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EDF
Focus on a simplified architecture schema

Issues are here:
- Firewall configuration
- OPC Configuration

Minimum requirement: a clear RACI*

- Responsible
- Accountable
- Concerned
- Informed

**EMONITORING – EARLY FAULT DETECTION**
SIMPLEST IT « CONNECTED SERVICES » INFRASTRUCTURE FOR CLIENTS

- Digital Control Systems
- Specific sensors
- Real Time Gateway OPC DA
- PI OPC interface (provided by EDF)
- Client's SmartPhone

- Data Historian (PI)
- Web Portal (QARE)
- Early Fault Detection (Instep PRiSM)
- Performance Monitoring (GP ETApro)

EDF (datacenter in France)
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eMonitoring – EXPERIENCE FEEDBACK

- Thank to different technical and economic assumptions, the eMonitoring is able to estimate the avoided costs associated to performance monitoring and early fault detection in four categories:
  - Avoided power loss
  - Avoided fuel over-consumption
  - Avoided unavailability
  - Avoided material Impact

> 85 main detections since 2011

# 30 M€ of avoided costs, split over the last 6 years

# 5 M€ of avoided costs per year due to eMonitoring
EMONITING – EXPERIENCE FEEDBACK

Result of the 2016 survey

- Not applicable: 26%
- Very Unsatisfied: 5%
- Unsatisfied: 69%

Evolution of customer satisfaction

- 2014: Participation rate: 100%, Satisfaction rate: 90%
- 2015: Participation rate: 100%, Satisfaction rate: 90%
- 2016: Participation rate: 100%, Satisfaction rate: 90%

Some customers verbatim

- « We are satisfied with eMonitoring service which is indispensable part of the plant operation. The quality of the reports was improved. »
- Phu-My

- « Very satisfied »
- Martigues

- « Satisfied but even we need to improve the service together… »
- Sloe

- « The eMonitoring service is a complement of the work we are performing at the plant and allows us to evaluate how we are doing it and how we improve it. »
- NORTE FLUMINENSE

Phu-My
Martigues
Sloe
NORTE FLUMINENSE
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MOBILE ACESS TO REAL TIME KPI

100 % Management of the mobile site dashboard from a dedicated AF database
Thermal Services Business
- EDF Assistance to Saudi Electricity Company for their Generation Optimization Centre project
- CHILE – Octopus CCGT Project

- eMonitoring offers on going to:
  - PAKISTAN – CCGT
  - CHINA – Supercritical Coal Power Plant
  - IVOIRY COAST - CCGT
  - OMAN – CCGT
  - EGYPT – CCGT
  - KSA – Assistance for development of GOC
  - ...

SERVICE PACKAGES
A number of solutions are available for the packaging of eMonitoring services:

- **eMonitoring**
  
  Performance monitoring and early fault detection for power plant units.

- **On Line Monitoring consultancy**
  
  Consultancy work for clients to help them develop, build, commission and operate their own On Line Monitoring.

- **O&M Supervision & eMonitoring**
  
  The eMonitoring service is combined with each O&M supervision contract of 3 years or more.
CONTACT INFORMATION

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Questions

Please wait for the microphone before asking your questions

State your name & company

Please remember to...

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Case Study – Foreign Object Damage in a Steam Turbine

COMPANY and GOAL
EDF eMonitoring is a service of remote analysis of power plant process data to:
- Detect and Analyze the power plant performance degradation
- Anticipate the potential equipment faults

CHALLENGE
Analyze a brutal change of pattern during CCGT operation
- 10 bar increase noted at the HP section of the Steam Turbine
- Boiler safety valves lifted

SOLUTION
Use of dedicated eMonitoring tools and methods for Root Cause Analysis
- Analyses based on PI Data (long term and short term trends on key parameters)
- EDF Steam Turbine experts involved in the diagnostic

RESULTS
Conclusion led to a Foreign Object Damage (FOD) in the HP block
- Suspicion of Pin Ball Effect
- Confirmed by boroscopic inspection on site
- Reduced unavailability for the client (720 k€ of avoided cost)
Case Study – IP drum level regulation valve passing

COMPANY and GOAL

EDF eMonitoring is a service of remote analysis of power plant process data to:
- Detect and Analyze the power plant performance degradation
- Anticipate the potential equipment faults

CHALLENGE

Detection of a slow degradation of an equipment

- Progressive closing of the IP regulation valve for the same feed water flow

SOLUTION

Use of Early Fault Detection models based on training data from normal plant operation

- Analysis of the contributors of the alarm on the global deviation of the model

RESULTS

Conclusion led to a leaky feed water valve

- Suspicion of valve degradation: water passing on the line
- Confirmed by valve inspection on site
- 3 days of unscheduled unavailability avoided (775 k€ of avoided cost)
Benefits of Data Centralization for EDF Thermal eMonitoring Business

**COMPANY and GOAL**
EDF eMonitoring is a service of remote analysis of thermal power plant process data to:
- Detect and Analyze the power plant performance degradation
- Anticipate the potential equipment faults
EDF would like to offer this service to other electricity producers

**CHALLENGE**
- Build low cost solution
- Monitor data quality
- Standardize offer

- Formerly installed on premises, eMonitoring Tools were expensive to maintain
- As data remain in the Power Plant, the data quality is not continuously monitored

**SOLUTION**
Centralized DataCenter
PI connected services
Generic Interfaces

- Data is centralized in one PI server
- OSIsoft provides the interface between local DCS or DCS
- EDF IT dept. provides secured publication on internet/mobile site

**RESULTS**
Packaged eMonitoring Service Offer for commercial team
2 New Clients in 2017

- Pricing of the service if more simple due to standardized solution an less on-site work to do
- Time to market is faster, as most of applications are already running in the datacenter