Pampa Energia: Detection of anomalies in gas turbine with PI AF

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Pampa Energía is the leading independent and energy integrated company in Argentina.

<table>
<thead>
<tr>
<th>Power Generation</th>
<th>Power Transmission</th>
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<tbody>
<tr>
<td>Hydro</td>
<td>938 MW</td>
</tr>
<tr>
<td>Thermal</td>
<td>4,093 MW</td>
</tr>
<tr>
<td>Co-Generation</td>
<td>14 MW</td>
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<tr>
<td>Wind Power + Expansions</td>
<td>387 MW 140 MW</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil and Gas</th>
<th>Midstream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks</td>
<td>11 productive + 4</td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>10.6 million m3/d</td>
<td></td>
</tr>
<tr>
<td>Crude Oil</td>
<td>5.1 k bbl/d</td>
<td></td>
</tr>
</tbody>
</table>

| TGS                     | 9,2220 km of gas pipelines |
| NGL Capacity            | 1 million ton/year     |

| Blocks                 | 11 productive + 4 |
| Gas                    | 10.6 million m3/d |
| Crude Oil              | 5.1 k bbl/d       |

Transener 21,697 km of high voltage lines
Our history with AVEVA

- Pampa Energia signs Enterprise Agreement with AVEVA™
- PI System™ Rollout @ CTLLL
- 27,000 data points

- Creation of main assets models in Asset Framework

- Started creating advanced predictive models for fault detection with AVEVA experts

- Deploying cutting-edge predictive models for gas turbine commissioning
- Developing Operation predictive dashboards

2020 2021 2022 2023
Loma de la Lata Thermal Power Plant

- Built in 1994
- 3 GE Frame 9E GT
- 125 MW each
- Pampa Energía acquires CTLLL.
- Completed the combined cycle.
- 3 HRSGs
- 1 Siemens ST
- 180 MW
- Installed first LMS100 105 MW
- Installed second LMS100 105 MW
- Capacity 780 MW
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Capacity: 780 MW
Loma de la Lata Thermal Power Plant

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- 180 MW
- Installed first LMS100
- 105 MW
- Installed second LMS100
- 105 MW
- Installed Capacity
- 780 MW
Description of the issue with the LMS100
Description of the issue with the LMS100

TG5: HPC Stall / 4B Bearing Failure

• Jan 9, 2017 4:00hrs

• Catastrophic failure of 4B bearing causing a stall in the HPC
• HPC, Combustor, HPT, IPT and PT hardware go to scrap.

• 1 year later, they are installed again.
TG4: Creep Failure IPT Stage 2 Nozzle

- Oct 22, 2019 17900 h
- Catastrophic failure in IPT 2nd Stage nozzle partition.
- IPT and PT hardware go to scrap.
- Serious damage on the TRF.
Solution

1. Analyzing LMS100 behavior through historical data

Analyzed historical data to understand the machine behavior across various downtime scenarios.

The critical variables selected to insight in a LMS100 downtime were:

- Vibrations
- Power
- Performance metrics
2. Defining Variable Limits for Quality Control

Establish variable limits using a Statistical Quality Control (SQC) model, enabling the clear demarcation of acceptable and unacceptable levels.

Trigger alerts when a variable’s value deviates from the established limits for a specified duration.
3. SQC Model Implementation in AF

Incorporated the SQC model into the PI Asset Framework, enabling automated and efficient monitoring and analysis of vibration data.
Solution

3. SQC Model Implementation in AF

Integration of the SQC model into PI Asset Framework allowing for automated monitoring and analysis of vibration data. Implemented the following analytics:

- Failure Curve
- Power Statistics
- Deviation Event
Solution

4. Defining Polynomial Regression for Statistical Analysis

Incorporated polynomial regression, a powerful statistical method in data analysis and statistics, to model the intricate relationship between an independent variable (predictor) and a dependent variable (response).

PI WEB API was leveraged to seamlessly transmit historical data to Python for in-depth analysis and modeling.
Solution

5. Implemented polynomial regressions in AF

Define third-degree polynomial regressions, a mathematical model, to further.

This was done in Python, using data form PI System.

Implementing the model in PI AF.

\[ Y = C_1 + C_2X_1 + C_3X_2 + C_4X_3 + C_6X_1^2 + C_7X_2^2 + C_8X_1X_2 + C_9X_1X_3 + C_{10}X_2X_3 + + C_{11}X_1^3 + + C_{12}X_2^3 + C_{13}X_3^3 \]
6. Dashboard Development

Dashboards are developed displays in PI Vision with the information related to vibrations and power data in a user-friendly and easily accessible format.

Alert System Implementation:

An alert system is integrated into the displays to notify operators in real-time when variables perform outside of the established limits. These alerts serve as early warning signs of potential equipment failures.
## Summary

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Solution</th>
<th>Results or Impact</th>
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<tbody>
<tr>
<td>• Our current gas turbine control systems at CTLL lack advanced analytics.</td>
<td>• Leverage historical LMS100 turbine data combined with real-time information (PI Web API)</td>
<td>• With just <strong>three months</strong> of operation, the <strong>models detected a deviation</strong> in the turbine’s behavior.</td>
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<tr>
<td>• Operators rely on basic alarms, which offer limited lead time for proactive interventions.</td>
<td>• Build PI AF model with predictive analytics (SQC / Python) to monitor performance, pressure, and vibrations of LMS100 turbine.</td>
<td>• The following preventive actions were taken:</td>
</tr>
<tr>
<td>• Seeking alternatives to enable early failure detection in aeroderivative turbines.</td>
<td>• Create alerts when LMS100 behavior deviates from the expected.</td>
<td>• Properly stopped the LMS100 turbine.</td>
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<tr>
<td></td>
<td>• Build displays for the operators to take preventive actions.</td>
<td>• Conduct an inspection</td>
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<td></td>
<td></td>
<td>• <strong>A small crack in a blade was detected</strong>, preventing a catastrophic failure and extended downtime.</td>
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Questions?
Please wait for the microphone.
State your name and company.

Please remember to...
Navigate to this session in the mobile app to complete the survey.

Thank you!
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