sciemus power

# Data modeling to quantify relationships between changes in maintenance and operating regime on power plant reliability

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# Agenda

- **Introduction to Sciemus Power**
- **Background  and Objectives**
- **Profit Maximising vs. Maintenance Effort**
- **Case Study**
  - **Project Approach**
  - **Calculation Model**
  - **Sample Results of the Analysis**
- **Conclusion**

# Who is Sciemus Power?

- Sciemus is a data and analytics company that provides fact-based insights into sectors that have previously relied on qualitative opinion.
- We focus on inherently complex assets in sectors where data is hard to obtain: Space and Thermal, Wind, and Solar power generation.
- Sciemus Power:
  - MGA services to insurance and reinsurance companies
  - Insurance Underwriters for Operational Power risks
  - Focus on (re)insuring the Primary risk

# Background and Objectives of the Paper

- Gas turbine power generation sector has been impacted by a number of factors:

**Market Factors**

- Growing share of renewable energy
- Decline/stagnation in electricity demand
- High fuel gas and, low electricity prices

**Impact on Power Plant Operations**

- Changes in the duty cycles on gas-turbine units
- Change in Operating Regimes *From Baseload to Two-Shifting or Peaking*

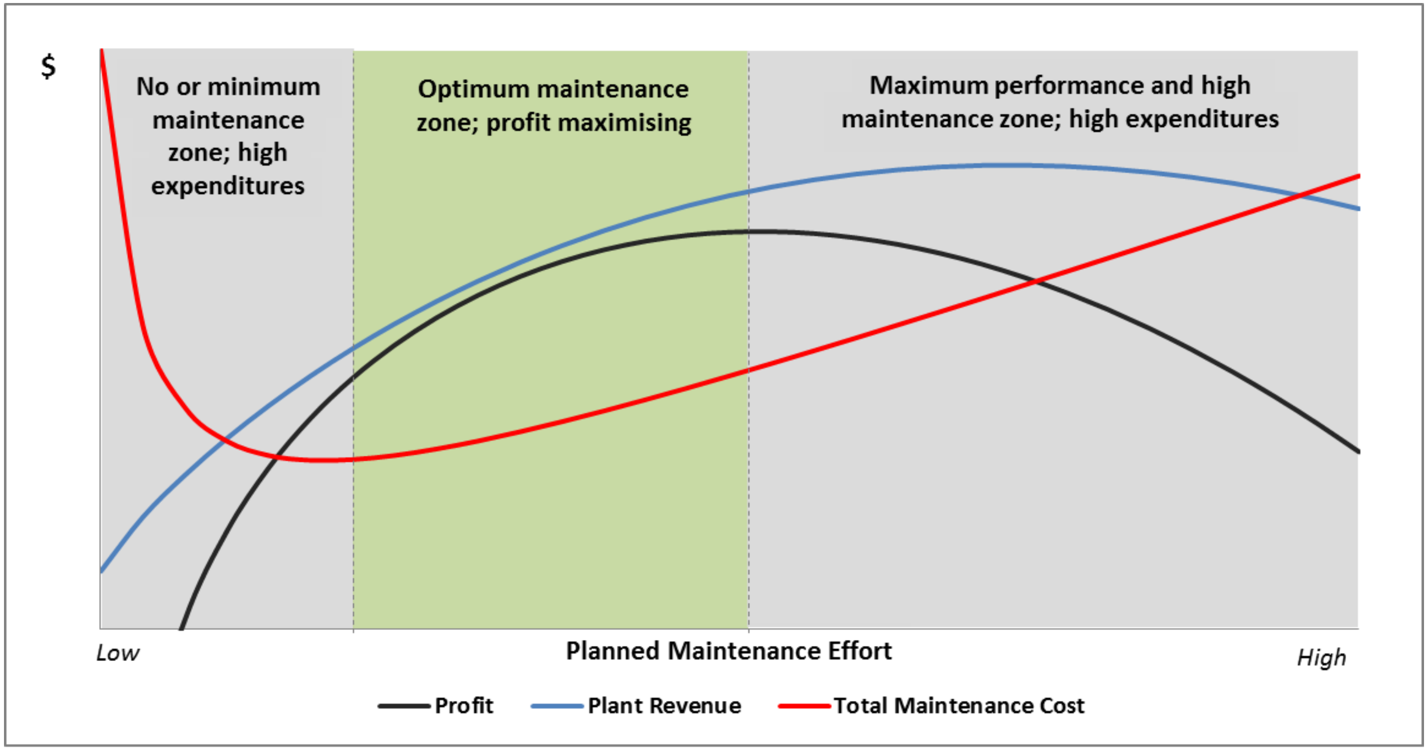
**Impact on Utilities**

- Review current business models
- Optimise costs whilst maintaining high reliability and availability.

- Through a data-driven modelling approach, this paper presents the work that Sciemus has completed for a power plant operator to

***quantify the impact of changes in maintenance levels and operating regimes on their power plant's reliability***

# There is an optimum level of preventive maintenance that maximises both plant performance and performance




- If no preventive maintenance is performed, the operator is likely to be faced with high unplanned costs from machinery breakdown
- Running the plant at minimum maintenance effort is likely to increase risk of plant failure and reduce its availability
- Any increase in preventive maintenance effort leads to higher expenditures, thus impacting plant’s profits.

# Case Study: Facts

## The Power Plant Operator

- Power Plant Operator owns and operates a number of thermal power stations and hydropower plants
- The operator wanted to determine whether operational savings could be achieved in two areas – ***maintenance spend and operating regime*** in which their plants are being run

## Power Plant Description

- Commissioned in the 1980s, coal-fired power plant has 4 units with a combined capacity of 4 GW
- Plant has not suffered large insurance claims due to its extensive redundancies

# Our methodology is built around three distinct steps

## 1. Data Collection and Normalisation

- For each critical component comprising the Plant, maintenance and operational history, combined with the Operator's expected operational hours and planned maintenance outages, was collected
- Data collection process involved extensive interaction with the plant's engineers
- Plant and component-specific data was then combined with Sciemus's database of power plant losses that details the reliability and maintenance history of a large number of thermal-fired power plants

# Our methodology is built around three distinct steps

## 2. Risk Profiling

- Sciemus analysis was based o a bottom-up approach (i.e. firstly independent components were defined)

- The second stage involved analysing how each of the components' performance changed in time with variations in maintenance levels and operating regimes that were unique to the Plant. For each and every component in the Plant, three independent profiles of risk failures were generated:
  - Probability of failure with time
  - Outage Duration versus probability. The outage duration involves the time that the component is not in use given that it has first failed
  - Repair Cost versus probability. The repair cost is expenditure used to repair the failed component given that it has first failed

# Our methodology is built around three distinct steps

## 3. Power Plant Modelling

- Once the risk profiles have been generated, a detailed plant configuration was implemented
- The configuration's structure also allowed for an analysis through nested levels of plant performance, unit performance, component performance and finally sub-component performance
- Once the detailed plant configurations were finalised, a power plant model was developed to show the interdependencies between the sub-components, components and units in the Plant.

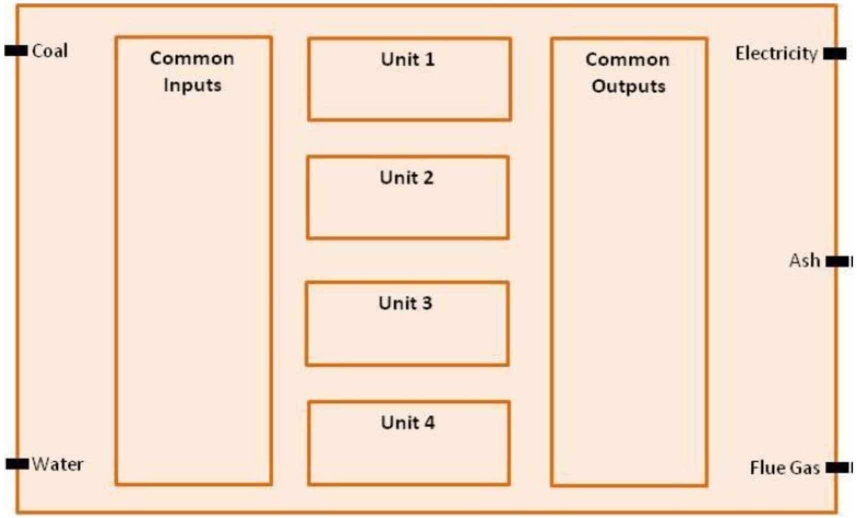



**Figure 2: Simplest Level of the Plant**

- Component risk profiles (specifically Mean Time to Failure and Mean Time to Repair) were built into the plant model to assess the effect of component failure on the power plant's output
- Component inputs relating to the maintenance and operating regime were loaded into the model.

# Monte Carlo analysis is at the core of our calculation engine

- Repeated analyses of simulated periods of operations to determine a distribution of possible outcomes of the Plant's reliability and availability
- Results were interrogated based on several performance metrics of interest and at various levels of detail (i.e. plant level, unit level, system level and sub-system level). These metrics included the following:
  - Plant or unit availability given the maintenance and operating regime inputs
  - Plant, unit or component forced outage factor given the maintenance and operating regime inputs
  - Probability of failure frequencies
  - Probability of outage duration

# Effect of Maintenance Effort on Forced Outages Frequencies

- Figure 4 shows the impact of different preventive maintenance levels (hours) on likelihood of number of failures for a unit of the Plant in the next 12 months
- In Scenario 1, the probability that the unit is likely to experience greater number of failures is higher than if it were to undergo preventive maintenance hours in the next 12 months as defined in Scenario 2
- By the same token, in Scenario 1, it is likely to experience a maximum of ~17 failures in the next 12 months compared to ~13 failures if it were to undergo increased preventive maintenance

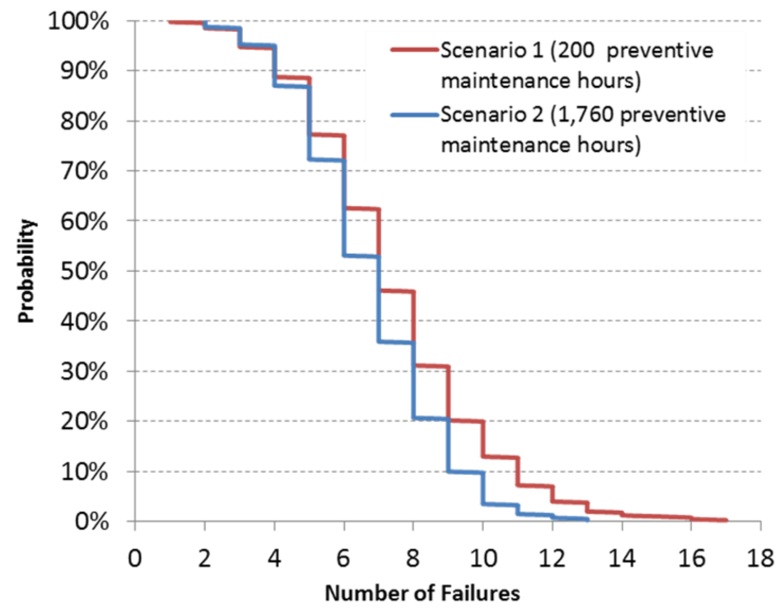



**Figure 4: Preventive Maintenance Hours vs Number of Unit Failures**

# Effect of Maintenance Effort on Outage Duration

- Figure 5 demonstrates that higher preventive maintenance hours performed on a unit of the Plant significantly reduce its outage duration per failure event
- In Scenario 1, the probability that a unit in the Plant will have an outage of 500 hours is higher at ~5% compared, to ~2.4% probability in the second scenario.

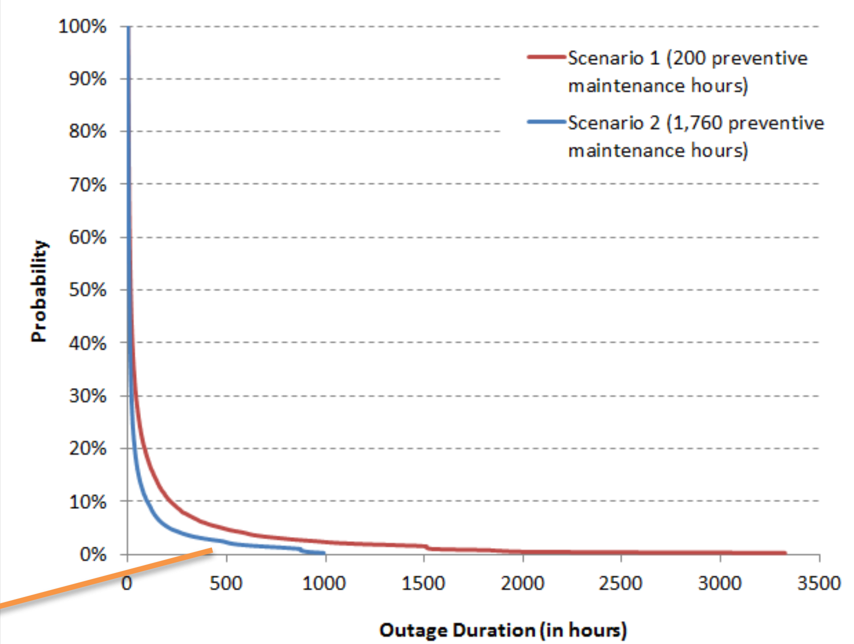
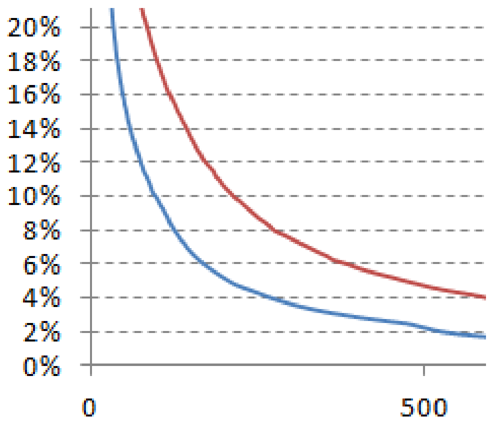



**Figure 5: Preventive Maintenance Hours versus Outage Duration per Failure**





- In Scenario 1, the probability that a unit in the Plant will have an outage of 500 hours is higher at ~5% compared, to ~2.4% probability in the second scenario.

# Effect of Maintenance Effort on Outage Duration

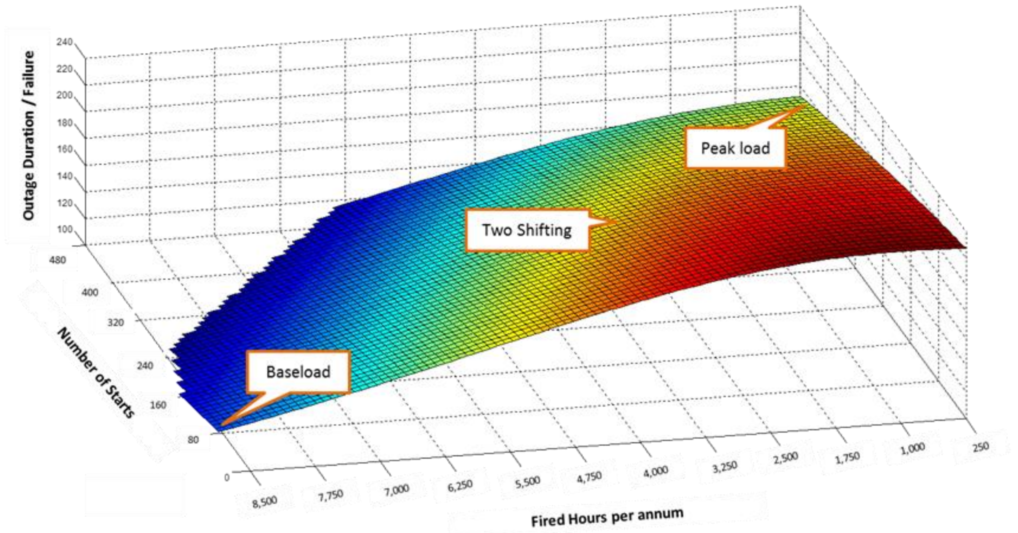



**Figure 6: Relationship between Outage Duration and Operating Regimes**

- If the Plant is operated in baseload mode, it is expected to have shorter outage durations than if it were to run under a two-shifting or peak load regime
- This quantification enabled the Operator to forecast their unit's outage duration based on changes in the number of starts and fired hours
- Operator was able to devise a scheduled maintenance strategy designed directly around the plant's operating regime.

# Effect of Operating Regimes on Forced Outage Frequencies

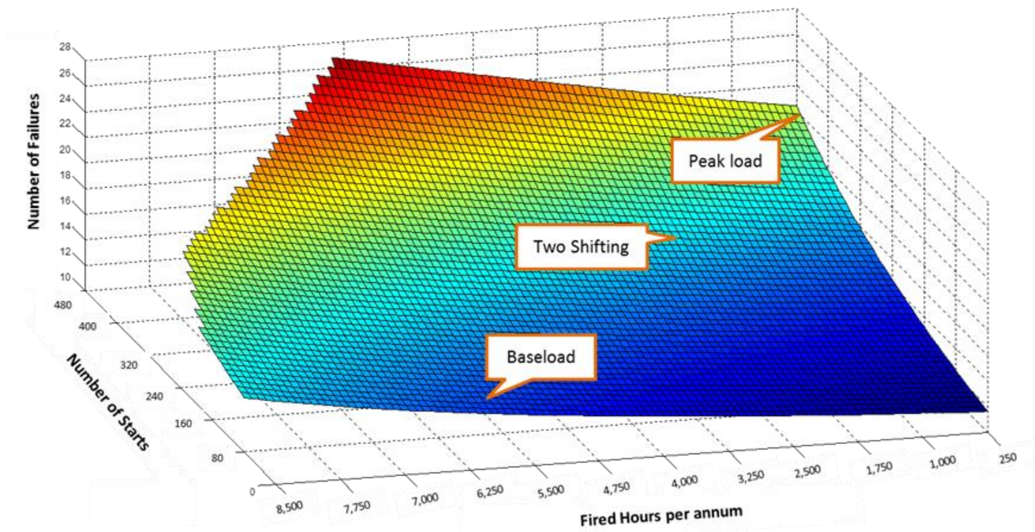



**Figure 7: Relationship between Failure Frequencies and Operating Regimes**

- When the plant is operated in peak load mode it is expected to encounter a higher number of failures consistent with the increased number of starts.
- Analysis provided the Operator with the ability to select the most profitable operating regime under market constraints and at acceptable cost levels

# Conclusion

- Whilst this report has focussed on an analysis of a coal-fired power station, the analysis and methodology employed also apply to other types of power plants including gas turbines.
- When the impact of changes in maintenance levels and operating regimes on a power plant's reliability is quantified and well-understood, power generating companies are able to make informed operational decisions that maximised profits while maintaining availability and reliability of their assets. These include:
  - creating a maintenance strategy designed directly around their power plant's operating regimes,
  - optimising plant availability whilst minimising breakdowns
  - justifying maintenance spend

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# Thank you!

# Any questions?

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