LTIMindtree

WHITEPAPER

A Linear Optimization Solution for a **Power Plant's Fuel Supply Chain**

Introduction

The prospect of clean electrical energy generation has recently driven companies to make massive investments on renewable power, which has subsequently affected the operations and profits of existing traditional thermal power plants. Moreover, the coal quality and supply chain in India has severely impacted the bottom line of thermal power plant operators. This has necessitated robust supply sourcing strategy and improving the efficiency of such plants beyond the paradigm of supercritical technology. Power generating companies are looking to optimize their entire coal supply chain, with the most critical aspects being sourcing, blending, and firing, to achieve the ultimate objective of reducing generation cost per unit of power generated.

In this whitepaper, we will discuss the optimization approaches implemented in a leading power plant using our AI engine.

Problem Definition

One of our esteemed clients, a leader in the power industry, has indigenously developed an excel-based model, which they call 'Decision Support System' to optimize fuel costs and achieve maximum utilization. This model aims to integrate the four most critical components of the supply chain, viz fuel sourcing, coal handling, operations and commercial on to a single transparent platform to make informed decisions. The model has three components, namely demand forecasting (user input), optimized coal sourcing and blending, and optimized coal firing. Inputs corresponding to various transactional and operational parameters / constraints are fed into this model manually for optimized results, which are highlighted on some dashboards for the concerned departments for their actions.

The client has benefited from this model immensely as they have been able to realize cost savings to the tune of 30% in the past using this model.

To make this solution more robust and efficient, the client wanted LTIMindtree to convert the excel model as-is into a packaged Python solution, which will manage three concerns.

- Excel Solver-based logic has a limitation on the number of variables that can be processed at a time.
- Feed the input data and click one button to get the optimization results, instead of the present way of uploading info and clicking on multiple buttons to arrive at the results.
- Enable an option to integrate the Python-based solution with SAP data so that the solution can be automated in the future.

Beyond the points coined above, there is another benefit in the form of live dashboards showing real-time model predictions with regards to sourcing and firing. The operations team need this visualization to align their actions keeping in line with the overall objective of optimizing the cost per unit of generation.

Scope

The scope of work is as follows:

- Convert the existing model in the excel sheets to Python modules.
- Replicate (or refine) the optimization process.
- Creating a UI for ingesting the necessary inputs (can have an option to upload excel, text boxes and radio buttons for user entry and choice).
- Creating a web-based application and give access to the customer through a secured URL.
- Develop and host the necessary dashboards for visualization.

System Architecture

The following diagram represents the system architecture, while Table 1 summarizes each component present.

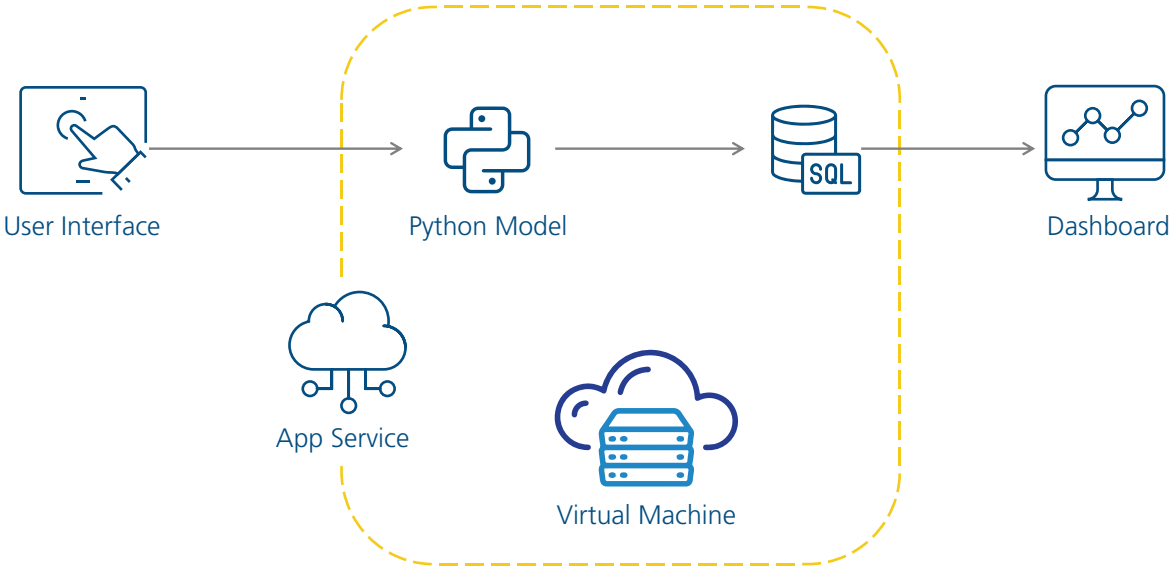


Figure 1: System Architecture

Components	Description
User Interface	The end user interacts with the underlying application with the user interface.
Virtual Machine	The virtual machine gives the solution a platform to host necessary micro-services.
App Service	The API service interacts with the Python model and the database.
Python Model	The Python model replicates the excel model and runs necessary optimization process to cater to the client requirements.
SQL Database	The database holds all the data generated by the application.
Dashboard	The dashboard interacts with the database helps to visualize the output of the optimization process.

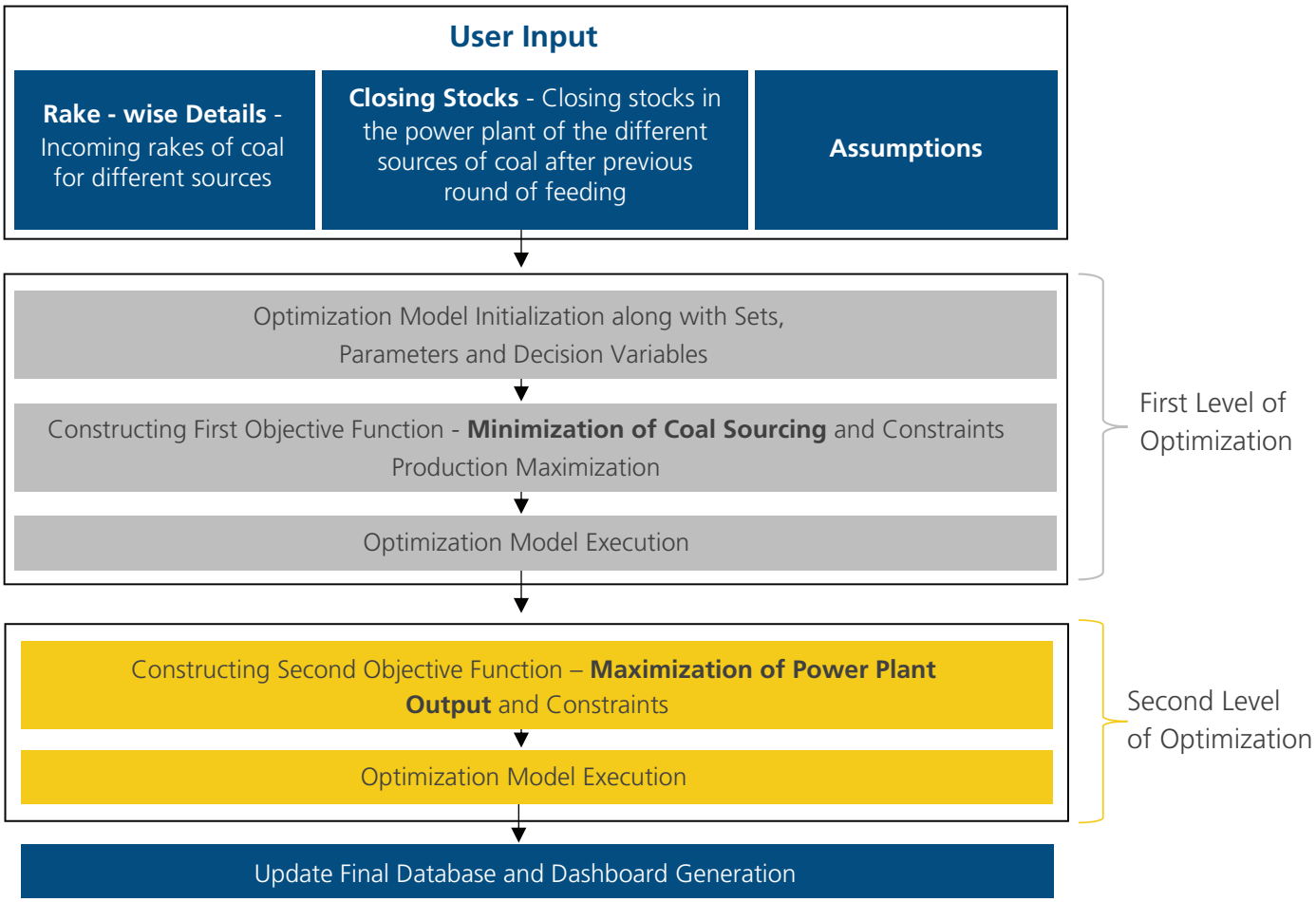
Table 1: Brief description of components

Technology Stack

Technology	Version	Usage
Python	3.8.10	Used to translate the excel model to Python.
Docker	20.10.7	Used to host the Nginx and SSV servers.
MS SQL Server	2019	Stores data from the application for historical reference.
Angular	13.0.4	Used to develop the user interface.
Nginx	1.19	Used for running the Python application.
SSV		Used for creating and hosting the dashboards.

Solution Approach

A non-linear modelling approach has been chosen, which has a multi-objective and multi-stage framework. It has a cascaded workflow where the output of one stage flows into the succeeding stages. The following diagram depicts the outline of a power plant optimization workflow.



The following is the summary of inputs required from the end user.

- Rake-wise Details
  It is an excel file containing all the incoming rakes of coal for different sources. It also contains the properties of the incoming coal (like ash percentage, weight, etc.) for proper utilization while feeding.

- Closing Stocks
  It is an excel file which contains the closing stocks of different sources of coal in the power plant after a previous round of feeding. This information helps in determining the opening stock for next round of feeding.

- Assumptions
  Entered by the user in the UI.

Business Benefits

This optimization solution aims at helping the end user plan their operations – sourcing, blending, and firing of coal - in an optimized manner so that the cost per unit of power generated is minimized.

The beneficial aspects of the solution can be listed as below:

- User-friendly application requiring minimum human intervention.
- High processing capabilities requiring minimum computational power.
- It is deployed in the cloud with 24x7 uptime.
- Highly intuitive and interactive dashboards, which publish optimized sourcing, blending, and feeding of coal for optimal plant operation.
- Feature to visit historical model results from past model runs.
- It has robust and secure data handling with Big Data storage and processing capabilities. It can store results from over five financial years for future reference and trend analysis.
- Customizable and scalable to handle more variables at any time.

Optimized sourcing can help in reducing costs for operations and optimized firing of coal will also reduce any chance of insufficient or surplus power generation issues. This may subsequently improve the station life cycle.

Conclusion

At Mindtree, we have an experienced pool of researchers and practitioners in the field of optimization. We have applied the principles of optimization to solve complex problems as articulated above. Our experience covers a diversified set of niche industries such as construction, power, and mining, to name a few. We would like to hear your business challenges and help you optimize the right levers to achieve the best business outcome as partners.

About the Authors

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Rounaq is an IT professional with 7+ years of experience in R&D in the field of Artificial Intelligence, Machine Learning, Deep Learning and Computer Vision. He completed Bachelor's in computer science and Engineering, with an interest in Computer Vision and Social Graph-based algorithms. He is currently developing solutions using various optimization and data science techniques.

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Abhishek is an effective Project Manager with 13+ years of experience in delivering digital transformations across multi-industry verticals. He has expertise in leading AI/ML-based projects oriented towards optimization and predictive analytics. Abhishek has a significant background in R&D and power plant operations. He holds an MBA from IIM Calcutta in manufacturing and supply chain and is also a technology enthusiast with a keen interest in AI/ML, IoT, Digital Manufacturing and Industry 4.0.

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Anindita is a dedicated researcher and IT professional with 20+ years of experience in the IT industry. She has 17+ publications in Scopus indexed journals and conferences. Anindita has submitted her PhD thesis on "Machine Learning and Analytics" from Department of Computer Science & Engineering, Jadavpur University. She is engaged in developing solutions for various Machine Learning and Optimization-based products and projects.

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