CSYM ITERATION-1

GMR Kamalanga Energy Ltd

Abstract

Proposal to implement Coal Stock Yard Management (CSYM) for Iteration 1 as part of multi generation plan to improvise coal management

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Context

The Coal Stockyard Management (CSYM) digital dashboard will provide a real-time, data-driven approach to manage coal stockpiling, blending, and quality control at the GMR Kamalanga Energy Ltd coal yard. The company plans to implement the entire CSYM in 3 iterations – in a Multi Generation Plan (MGP). In iteration 1 - The system will enable operators to effectively monitor coal quality, make informed decisions regarding blending or direct feeding, and maintain operational efficiency, while reducing aging and intermixing issues in the stockyard.

The application will leverage Python as the intelligence engine, MySQL/PostgreSQL for database management, and Python Dash for the frontend, all designed to support future scalability and integration needs (including Machine Learning and potential SAP integration).

Objectives of Iteration 1

1. Optimization of Coal Quality: Achieve and maintain the desired GCV for feeding coal.

2. Proportional Blending and Stocking: Manage coal GCV proportions effectively to reduce aging and intermixing of coal.

3. Real-Time Monitoring: Provide a comprehensive view of coal yard operations with visual indicators for GCV, pile quantities, and blending recommendations.

4. Scalable and Extensible: Build the application with an eye towards integrating future Machine Learning models for forecasting, predictive analytics, running advanced optimization algorithms and enabling integration with SAP if needed.

Components

Key Components of the CSYM System:

1. Coal Yard Overview with Pile and Sub-pile GCV and Quantity:

- Display data for 16 piles (top and bottom quantities and GCV).
- Visualize GCV data with 4 colour bands for easier interpretation.
- Include max Aging and average Aging for piles

2. Pile Coal Quality Proportion:

- Summary of pile composition across different coal GCV ranges and quantities.
- Prioritize immediate-use pile compositions based on real-time data.

3. Blending, Direct Feeding, and Stacking Decisions:

- Forecast incoming coal GCV based on historical data and recent trends.
- Provide automated decisions for direct feeding (with or without blending) or stacking.
    - CYSM will analyze and take the above decisions of either stalking or feeding (with or without blending) based on the following parameters
        - What is incoming coal GCV
        - What is the required GCV for bunkering
        - What coal is available at site for blending
        - Aging of pile
        - GCV value difference in Top and Bottom of prioritized piles

Technology Stack:

Backend:

- Python
- MySQL/PostgreSQL, SQL Alchemy, Psycho PGT2

Frontend:

- Python Dash and Plotly for interactive dashboards and data visualizations.

Python Packages :

- Scikit-learn, pandas, numpy, openpyxl, dash, plotly

Deployment:

- AWS/Azure for cloud hosting.
- Docker for containerization if needed

Security & Monitoring:

- OAuth for authentication.

Development Phases and Activities:

Phase 1:

Requirements Analysis

- Activities:
  - Detailed requirements analysis with stakeholders to understand user needs and preferences.
  - Finalize system functionalities, workflows, and define user roles (operators, admins).
  - Create project timeline, define key milestones, and allocate resources.
- **Deliverables**
  - User requirements documents on all data inputs for pile dashboard, cell computation and logic pseudo code for computation of all decision points

Phase 2:

Design and creation of DB

- Activities:
  - Design initial system architecture (backend, frontend, database, integration points).
  - Database Design: Design MySQL/PostgreSQL database schema to store coal data (e.g., pile info, coal quality, quantity, GCV).
    - Create tables for pile and sub-pile details, coal quality metrics, aging data, and blending history.
  - Data Processing Logic: Implement algorithms for calculating coal quality and GCV for individual piles and sub-piles.
    - Create functions for determining the top/bottom GCV values and proportions.
  - Backend APIs: Develop RESTful APIs for accessing and manipulating coal yard data (e.g., fetching pile details, updating GCV values).

Phase 3:

Decision Engine for Blending, Feeding, and Stacking (Weeks 5-8)

- Activities:
  - Decision Logic Development: Implement decision-making algorithms based on:
    - Incoming coal GCV.
    - Required GCV for bunkering.
    - Available coal for blending.
    - Aging of pile.
    - GCV difference in top and bottom layers of the prioritized piles.
  - Decision Outputs: The system should provide recommendations for:

        - Direct Feeding (without blending).
        - Direct Feeding (with blending).
        - Stocking/stacking decision.
    - Forecasting Algorithm: Implement a basic forecasting model for incoming coal GCV based on historical trends
    - Blending Prioritization: Ensure the system provides optimal blending ratios for achieving the required GCV.
- **Deliverables**
    - All python class designs from phase 3 including the ER diagrams from phase 2

Phase 4:

Frontend Development

- Activities:
    - Dashboard Design: Design interactive, user-friendly dashboards using Python Dash.
        - Coal Yard Overview Dashboard: Visualize GCV and quantity for each pile with color-coded GCV bands.
        - Pile Composition Dashboard: Show coal quality proportions in 4 different GCV ranges
        - Blending Decision Dashboard: Display blending options and automatic decision-making for feeding or stacking based on available data.
    - Visualization: Use `Dash` components (graphs, charts, sliders) to represent coal data interactively.
        - GCV trends over time, pile aging, coal composition proportions, and blending decisions.
- **Deliverables**
    - Front-end screen validation sign-off from users

Phase 5

Creation of Admin module

- Activities
    - Creation of the admin module with different access levels and screens
    - The admin modules will have options to change the values of the different thresholds on real-time basis for computation of decision points
    - All the python modules will be designed with the variables features that will interact with the decision intelligence module and the admin module
    - All front-screens will also be designed for the Admin module in this phase

Phase 6:

Integration and Testing

- Activities:
  - Frontend and Backend Integration: Complete integration of all frontend dashboards with backend data sources and APIs.
  - System Integration Testing: Test end-to-end workflows such as data retrieval, dashboard updates, and decision-making for blending and stacking.
  - User Testing: Gather feedback from stakeholders (operators, managers) to validate dashboard functionality and usability.
  - Optimization and changes: Fine-tuning feature correction, threshold adjustments ensure scalability, and user interface layout and components
- **Deliverables**
  - Test cases sign-off from users

Phase 7

Deployment and Documentation

- Activities
  - Conduct user training sessions on how to use the CSYM system.
  - Provide comprehensive documentation (user manuals and technical documentation).

Scalability and Future Integration:

- Machine Learning Integration (Future Work): Design the system architecture to support future integration of ML models for predictive analytics (e.g., forecasting coal GCV, blending optimization, and aging prediction).
- SAP Integration (Optional): Plan for the potential integration with SAP for seamless flow of data, especially for inventory management and real-time tracking of coal stock and blending operations.

Project Timeline:

Phase Activities	Duration	Start week	End week
Requirements analysis	1 week	1st week	End of 1st week
Design and creation of DB	1 week	2nd week	End of 2nd week
Building Intelligence engine in Python	3 weeks	3rd week	End of 5th week
Building front-end with Python Dash with user reviews	3 weeks	6th week	End of 8th week
Creation of Admin module	1 week	9th week	End of 9th week
Integration, testing (UAT) and finetuning	2 weeks	10th Week	End of 11th week
Deployment & Documentation	2 weeks	11th week	End of 13th week

Future Scope

There is a plan to follow up with iteration 2 and 3 after completing the iteration 1.

Iteration 2

Optimize coal yard stock piling – The plan is to have an intelligence system to decide how to stack coal from incoming rakes and trucks into the stockyard in different piles including deciding Top or Bottom stalking. This will depend on the proximity of sub-piles with the GCV and Spur of incoming coal and also on aging and quantity of those already in the sub-piles.

Iteration 3

Industry 4.0 enablement – Implement IIoT for required sensors and devices so that most data entry is automated as much as possible and decision points are more real-time and accurate.

Conclusion:

The CSYM Application in iteration 1 will provide GMR Kamalanga Energy Ltd with an intuitive, data-driven system for GCV monitoring, blending decision support, and effective pile management. The application is designed to be scalable, enabling future integration with Machine Learning models and other enterprise systems like SAP.

With a structured development approach, the project will be delivered within a 12-week timeframe, ensuring timely and high-quality delivery. The system will not only optimize current operations but also lay the foundation for advanced analytics and decision-making in the future.

Appendix (Illustrations)

High level illustration of Coal Stockyard layout

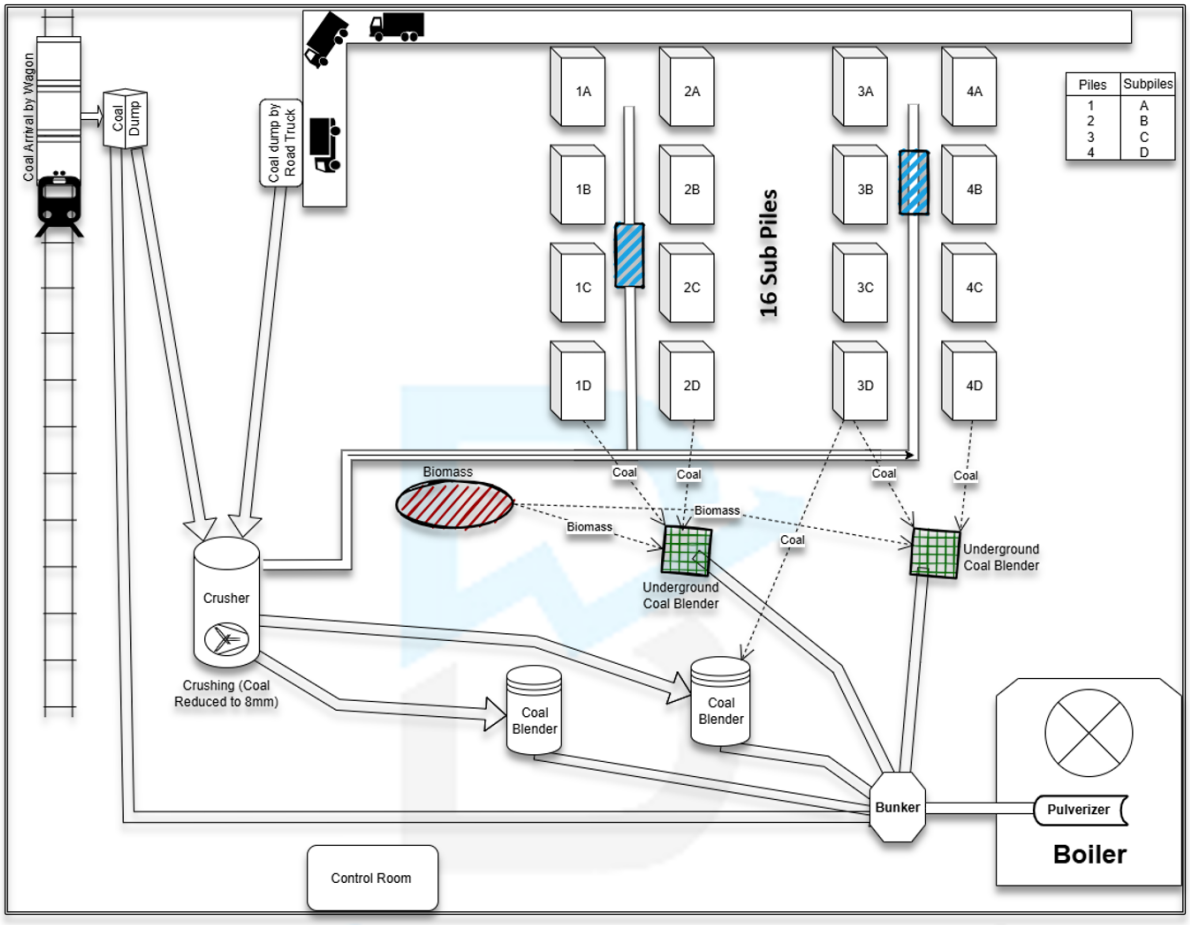

Illustration dashboard of Pile – GCV along with Quantity

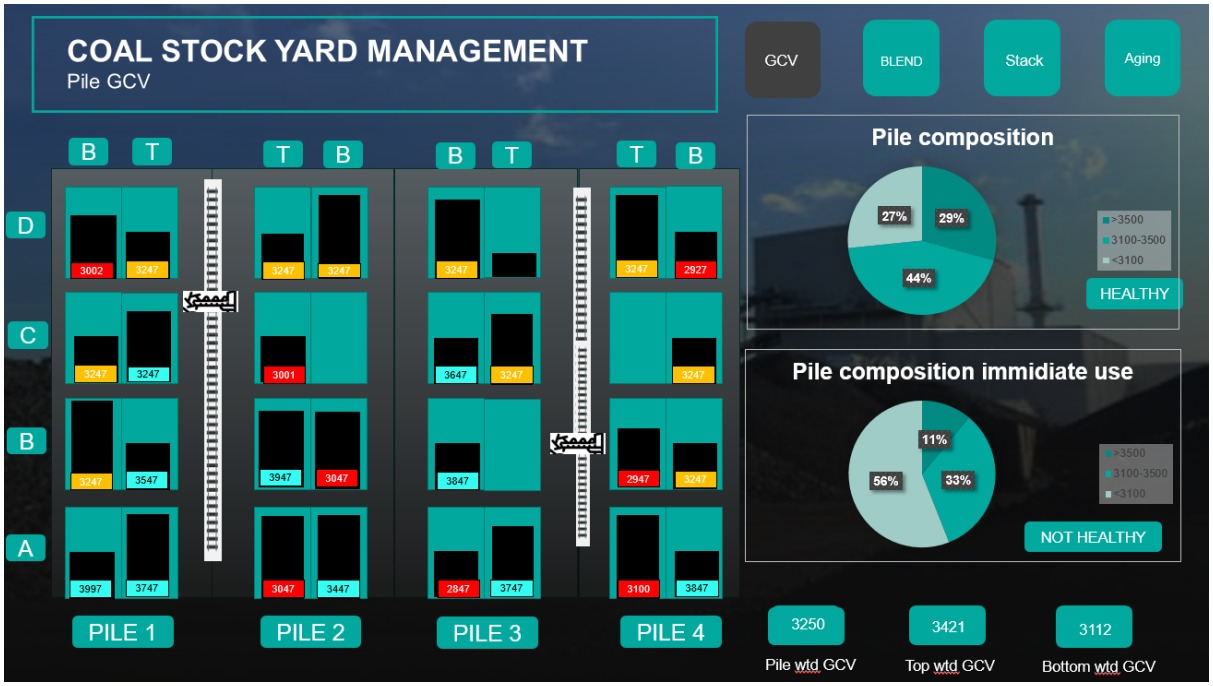

Illustration dashboard of blending decision

	Quantity top	GCV top	GCV BTM	Aging	Blending possibility @ 20%	Blending possibility @ 15%	Blending possibility @ 10%	PRIORITY
PILE 1A	10140	3410	3148	40	3082	0	0	2
PILE 1B	21723	3043	2773	41	0	0	0	0
PILE 1C	10680	3502	3552	40	3100	3075	0	2
PILE 1D	14369	3529	3383	36	3106	3079	0	2
PILE 2A	7950	2655	2655	8	0	0	0	0
PILE 2B	8405	3318	3318	7	0	0	0	0
PILE 2C	8800	3324	3129	38	0	0	0	0
PILE 2D	7506	3637	3637	6	3127	3096	0	1
PILE 3A	10277	3091	3091	57	0	0	0	0
PILE 3B	3032	3173	3022	77	0	0	0	0
PILE 3C	3348	3153	3083	10	0	0	0	0
PILE 3D	10173	3301	3204	13	0	0	0	0
PILE 4A	12261	3079	3235	29	0	0	0	0
PILE 4B	9297	3545	3322	46	3109	3082	0	2
PILE 4C	5202	3338	3566	43	0	0	0	0
PILE 4D	2237	3248	3371	38	0	0	0	0
WT	4000	3200	3200	0	0	0	0	0