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Integrated mine planning system for a sustainability of mining business (Case study: X coal mine project)

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Abstract

Aim: Even though the project has been declared run based on the feasibility analysis results, this study assessed the mining company's operations as prices began to drop. The POAC approach will be used throughout observing the parameter mentioned above, from planning and organisation to actuation and control.
Method: Due to the positive results of the feasibility study, the project is now considered operational, and this study examined how the mining industry operates in the face of falling prices. Starting with scheduling and moving on to coordination, actuation, and management, the POAC method was used to keep the parameter under control.
Findings: The results predicted that although the project has been declared to be feasibly run, it is still possible and should to re-conduct a feasibility study or planning strategy due to the changes in parameters, both technical and economic parameters, which are assumed as the basis for making plans and its makes the plan remains relevant. To remain profitable, a mining company needs to adjust to new circumstances quickly and easily, no matter how dire they may get.
Implications/Novel Contribution: Comprehensive information about mine planning has been compiled as a result of this study. The findings may aid policymakers in better comprehending the system, which may lead to greater efficacy.

Keywords: Sustainability, Feasibility, Mine Planning, Integrated System

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INTRODUCTION

The coal industry in Indonesia has gone from obscurity to prominence over the past two decades, becoming the largest exporter of thermal coal (coal quality under 6100 kcal/kg) (Lucarelli, 2010; Yoshino & Alekhina, 2016). Based on the Mineral Exploration and Mining Report 2016 (MEMR), Indonesia has 120.5 billion tonnes of coal resources or 146 years of coal at current production rates (Tharakan, 2015). Increasing demand from China and India has helped Indonesia's coal exports grow steadily. Also, during this period, the Law on Mineral and Coal Mining was passed in 2009, giving the central government more authority over mining licences, signalling a period of significant regulatory change. This means that half of all steam coal imported into Asia comes from Indonesia, making the country's coal industry a major player in a very short amount of time. As a result, about 80% of Indonesia's coal production goes to overseas markets. This phenomenal expansion can be attributed to Indonesia's strategic location, which allows it to supply the coal demand centres of the last decade, China and India, at a low cost (Ayuningrat, Noermijati, & Hadiwidjojo, 2016; Cornot-Gandolphe, 2017; Khakimyanov & Khusainov, 2016; Kumtong, Saosaovaphak, & Chaiboonsri, 2017). Figures from the Ministry of Energy and Mineral Resources of Indonesia show that in 2016, the country produced 419 million tonnes of coal, making it the fifth-largest coal producer in the world (Ministry of Energy and Mineral Resources, 2016).

This ranks Indonesia behind India, Australia, the United States, and China. Like other nonrenewable resources, coal production is affected by a wide range of variables. Coal production is affected by several variables, including the number of reserves, the strength of the market, and the rate of technological advancement in the mining, processing, and transportation of raw materials. Physical factors are important, but economic, social, and environmental

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factors also play a role in determining coal output (Rosyid & Adachi, 2016). The Indonesian coal industry has been severely impacted by the persistent drop in international coal prices and lower import demand from China and India until June of this year. While still exceeding the government's goal, coal production fell from 485 Mt in 2013 to 469 Mt in 2015 (Ministry of Energy and Mineral Resources, 2016).

Table 1: World's coal producers in 2016

Country	Production Volume (Ton)
China	1685.7
US	364.8
Australia	299.3
India	288.5
Indonesia	255.7
Russia	192.8
South Africa	142.4

Many small companies suffered enormous losses despite the relatively low price of Indonesian coal and were forced to either slow down or cease operations altogether. Indonesia's largest companies, which run some of the country's cheapest mines, also saw their profits decline. But by cutting costs, they were able to keep production steady. Due to lower import demand from China and India, Indonesian steam coal exports dropped by 13 percent in two years, to 368 Mt in 2015 (International Energy Agency, 2016).

Table 2: HBA-Indonesian coal price index from Jan 2012 to Jun 2017 Ministry of Energy and Mineral Resources (2016)

Month	2012	2013	2014	2015	2016	2017
Jan	109.29	87.55	81.90	63.84	53.20	86.23
Feb	111.58	88.35	80.44	62.92	50.92	83.32
Mar	112.87	90.09	77.01	67.76	51.62	81.90
Apr	105.61	88.56	74.81	64.48	53.32	82.51
May	102.12	85.33	73.60	61.08	51.20	83.81
Jun	96.65	84.47	73.64	59.59	51.87	75.46
Jul	87.56	81.69	72.45	59.16	53.00	
Aug	84.65	76.70	70.29	59.14	58.37	
Sep	86.21	76.89	69.69	58.21	63.93	
Oct	86.04	76.61	67.26	57.39	69.07	
Nov	81.44	78.13	65.70	54.43	84.89	
Dec	81.75	80.31	69.23	53.51	101.69	

Before deciding whether or not to invest in a mine, a feasibility study should be conducted within the context of the coal business, as this is the first crucial step that will determine whether or not the mining venture will be profitable (Sontamino & Drebenstedt, 2013). According to the theoretical literature, a feasibility study investigates future projects to determine their viability (Suratman, 2003). In other contexts, the term "feasibility study" refers to evaluating the likelihood that a given project can be carried out successfully, taking into account relevant aspects such as cost, technological barriers, regulatory hurdles, and time constraints. When deciding whether or not to invest a large amount of time and money into a project, project managers conduct feasibility studies to weigh the pros and cons of the endeavour (Investopedia, 2017). Strategic decisions in the mining industry are made with the help of the feasibility study, conducted under a wide range of technical and market uncertainties. That's why to make the most informed choice possible, you need to factor in the unknowns associated with the input variables and the technical and financial risks associated with the project's merit measures (Abdel Sabour & Wood, 2009). However, in 2015, 125 legal Indonesian coal mining companies on the island of Borneo went bankrupt. The decline in coal prices is the primary factor threatening the industry's long-term sustainability; furthermore, the Indonesian coal industry is characterised by high operational risk, political and regulatory risk (including environmental risk), and an essential

capital requirement with a lengthy project timeline (Kompas, 2015). Many mining companies create short-term, medium-term, and long-term plans to handle mining operations. Integrating sustainable development principles into mine planning has recently brought attention to the need to consider these principles from the beginning of mine planning onwards to realise the best outcomes over life-of-mine and following closure (Guardian, 2012). A mining organisation that hopes to succeed over the long term must be flexible enough to adjust to the myriad of variables that can shift, even in the face of disaster. This study will evaluate the mining firm's operations by watching how it responds to a sudden drop in commodity prices after the feasibility study has declared the project viable. POAC methodology will be used to keep an eye on all the important details, beginning with the planning phase and continuing through the organising, enforcing, and monitoring phases.

CONTINUOUS MINE PLANNING CYCLE

"X Coal Mining Company" runs the business opportunities also based on feasibility study result. To make plans remain relevant due to the constantly changing parameters (coal prices, requirements of market quality, additional exploration, geotechnical issues, productivity, and incompliance in previous period and other affected parameters), x coal mining company applies a continuous planning cycle by describing the long-term mining strategies that has been designed into mid-term plan as well as short-term plan. Then, all the plans will be integrated into all functions so that each action plan and risk analysis of the plan can be designed. The Long-term planning strategies/Life of Mine (LOM) will be created with all technical risk and financial (Steven, 2017) and translated into mid-term plan and also short-term plan, then, it returns to the long-term planning again and becoming one cycle. This planning cycle is implemented to make the plan remains relevant.

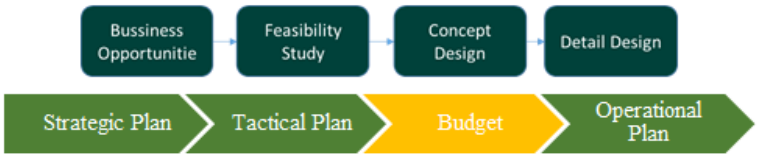

Figure 1. Mine planning cycle

Long-term Plan

According to the Mine Planning Cycle shown in Figure 1, the first hierarchy is designing the long-term plan. Long-term plan is a strategic planning whose objective is to:

1. Create the life of mine
2. Evaluate and make strategic options
3. Maximize the value of a project
4. Estimated value of the reserve
5. Determine the economical period of the project
6. Valuation (including asset) during the project
7. Guidelines for midterm planning cycle process

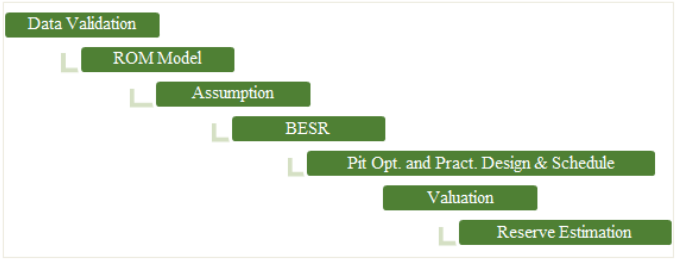

Figure 2. Life of mine plan process

Mid-term Plan

The second hierarchy is a 5 years plan or mid-term plan which is designed according the result of the long-term plan. Mid-term plan/5 years plan is the mid-point of the mine planning cycle at X Coal Mining Company. It is because 5 years plan considers both from long-term plan view especially financial result and an operational plan view or short-term plan view which is more specific.

The result of 5 years plan is assumed as the best estimation for the future that already considered some risks and uncertainties such as updated parameters and current situation related to technical condition in the mine operational and other non-technical condition (external issue and cost parameter).

Basically, 5 years mine plan which has been developed will be used as a reference to determine some activities, as follows:

1. Strategic decision making for five years business plan, including capital, manpower, infrastructure and other resources.
2. Identification of technical and non-technical problem and other issues which are predicted happen within the next 5 years.
3. Mining readiness and its action plan based on the identification of problem analysis.
4. Projection of quality and quantity in term of product marketing.
5. Key Performance Index for each function.
6. Preparation of annual plan (1 Year Planning).

In the scope of 5 years plan, pit optimization is still executed to get the boundary of economical pit in accordance with the predetermined value of EBITDA. In this case, the optimize pit remains restricted by the boundary of Pit Shell from the Expected Life of Mine Plan. Basic difference from the optimization process of the mid-term plan over the long-term plan is its result is not used to obtain the boundary of Pit to determine the NPV value. But, it is used to obtain an economical pit within the one year according to the EBITDA value, the capacity of units and also expected capacity of units in accordance with the performance analysis. In this case, it is important to consider the value of LOM stripping ratio is eroded based on the results of annual pit optimization, especially if the used of economic parameters such as fuel assumption and coal price are significantly different or moreover dropped. The process of designing 5 years plan is shown in Figure 3.

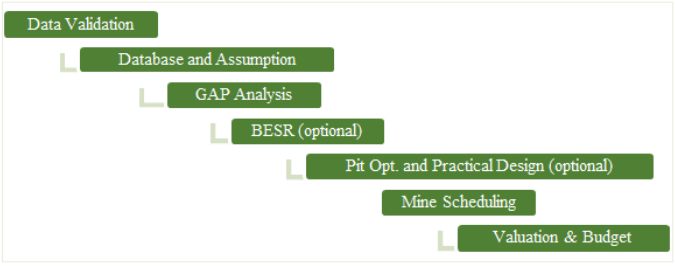

Figure 3. Mid-term mine plan cycle

Short-Term Plan

After 5 years plan and budget plan have been created, the next step is designing 1 year plan by providing detailed information and more operational. In this cycle, planning is designed by involving mine contractor in order to obtain an understanding related to detail sequences. It considers some parameters and assumptions that have been agreed by both parties such as production rate assumption, the number of used tools, effective working hours, support tools, mud removal, mine drainage, access for drills & blasting, access for excavators and haul trucks, disposal & ROM assumption, infrastructure, dewatering plan and others assumption. Then, after the agreement reach from all parties, it will be documented and signed or called "Agreed Parameter" and it will be used as reference for operational activities in the 1 year period. The "Agreed Parameter" will be review every month with the achievement of production and monthly mining plan, so that a clear and solution for corrective action can be produced. Figure 4 below describes the process of monthly plan and evaluation in X Coal Mining Company. In final, the annual target can be achieved.

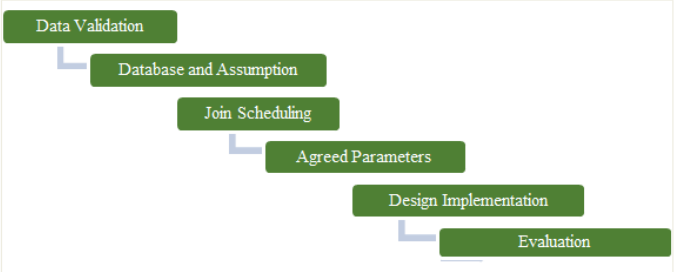

Figure 4. Operational plan and evaluation process

PARAMETER	UNIT	AGREED
Waste Volume (OB)	Bcm	
Coal Volume	Ton	
Stripping Ratio	Bcm/Ton	
Coal Inventory	Ton	
Overburden Distance	m	
Coal to Rom Distance	m	
Rom to Port Distance	m	
Hand Over Pit	Ha	
Hand Over Disposal	Ha	
Effective Working Hour	Hour	

Figure 5. Mine plan agreed parameters

INTEGRATED MINE PLANNING SYSTEM

All mine planning result including business objective, parameters and obstacle that will be faced, will be presented to all function in the business unit of 'X Coal Mining Company'. This program is applied to make the understanding to all functions related to the company's condition and how to reach the future company plans. Then, they can provide the action plans and the entire mine plans based on mine plan result. Figure 6 shows all the functions to support the successful of mine plan result.

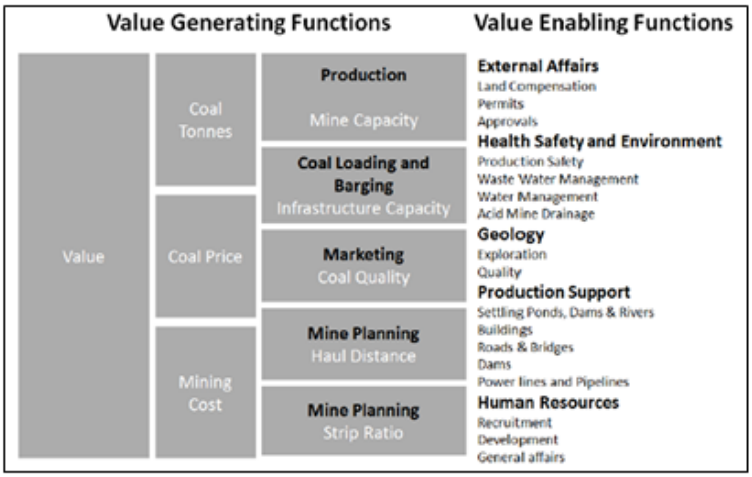

Figure 6. Mine plan function support

The action plan created by all functions used to be a corrective action from inadequacy performance of the previous years so that it won't be a gap for the next plan. The element which should be included in the integrated mine planning system are:

1. Historical performance & Gap analysis on performance of key value drivers: This element is not discussing

new actions to achieve new target. However, it discuss about the action should be implemented to overcome the previous target.

2. Determine targets: Target need to involve results from the gap analysis. Determine the target is not for the management's performance. Targets should be achievable and considered the deviations from previous targets.

3. Key initiative and Develop action plans.

4. Determine the resources and the required capabilities to support the business process.

5. Risk assessment and Contingency planning.

The results of mine planning including assumptions and action plans of all related functions are integrated, documented as a book, approved and signed by all the key stakeholders from each related function and will be distributed to all related functions and used as a guide of the company's business plan and objectives.

MINE PLANNING CONTROL

Mining Readiness

Mining readiness is one of mine planning control systems that is used to determine the percentage of readiness of mine operation according to the planning result against current actual condition. In addition, mining readiness will be used as, 1. Initial identification regarding some constraints and issues arising from the mining plan

2. Tools to analyze and identify the risk from the constraints and issues resulted by the plan

3. To follow up some concerned aspects, thus the plan can be prepared carefully

NO	ASPECT OF READINESS	WEIGHT	READINESS SCORE	TARGET	Hard	Medium	Easy
					1	2	3
A	PIT	33.3%	3.0	3.00	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have high Impact to Mine Operation (Cannot avoid)	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have minor Impact to Mine Operation (Can Avoid with additional cost)	1. No Asset & Property Need to be Release or Relocated 2. All Land needed already compensated
1	Pit A	16.7%	3.0	3.00			
2	Pit B	16.7%	3.0	3.00			
B	DISPOSAL	33.3%	3.0	3.00	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have high Impact to Mine Operation (Cannot avoid)	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have minor Impact to Mine Operation (Can Avoid with additional cost)	1. No Asset & Property Need to be Release or Relocated 2. All Land needed already compensated
1	Disposal A	16.7%	3.0	3.00			
2	Disposal B	16.7%	3.0	3.00			
C	INFRA	33.3%	3.0	3.00	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have high Impact to Mine Operation (Cannot avoid)	1. Government Asset, Property & Permit Need to be Release or Relocated 2. Uncompensated Land that have minor Impact to Mine Operation (Can Avoid with additional cost)	1. No Asset & Property Need to be Release or Relocated 2. All Land needed already compensated
1	S. Ponds	16.7%	3.0	3.00			
2	Haul Road	16.7%	3.0	3.00			
	Total Score		3.00	3.00			
	Average Score		100%				

NO	ASPECT OF READINESS	ISSUES	ACTION	ASK	PIC	WHEN	STATUS
A	PIT						
1							
2							
B	DISPOSAL						
1							
2							
C	INFRASTRUCTURE						
1							
2							

Note :
Outstanding : Belum dikerjakan
Outgoing : Sedang proses pekerjaan
Closed : Sudah selesai

Open : 0
Progress : 0
Closed : 0
% Progress : #DIV/0!

Figure 7. Mining readiness

All of aspects will be assessed including pits, disposals and all infrastructure that required to support the mining plans, where each area is prioritizes according to the level and target of coal and overburden which are produced in a period of mining operation. The assessment procedures can be seen in the following scoring matrix and shown in Figure 7.

1. Easy: there is no issue for the mining plan area and ready to be used

2. Medium: mining plan area has a minor issue. The issue has low to high impacts on mining operations or the arising risks can be overcame by addition of mining costs (additional cost)

3. Hard: the mining plan area has a major issue. The issue has high impact on mining operations and the arising

risks unable to be overcame by additional cost of mining (additional cost).

By using this scoring system, it is expected that the mining operation can be well prepared, the potential of additional cost can be avoided, and the awareness to overcome potential risk for all function can be increased so that the production target as well as successful of 1 year plan until 5 years plan can be achieved.

Mine Plan Accuracy

Mine Plan Accuracy is a mine control planning system to assess the level of success of the mining plan (pit and disposal) either on daily, weekly, monthly and yearly plan. It is also used to measure the monthly performance. In this system, the achievement of target volume against the progress of boundary and the actual decreasing elevation of the plan (out of Plan) are measured. There are two kinds of measurement:

4. Over-plan: if the actual progress of the pit elevation exceeds the plan
5. Over-strip: if the actual progress is outside the boundary of plan

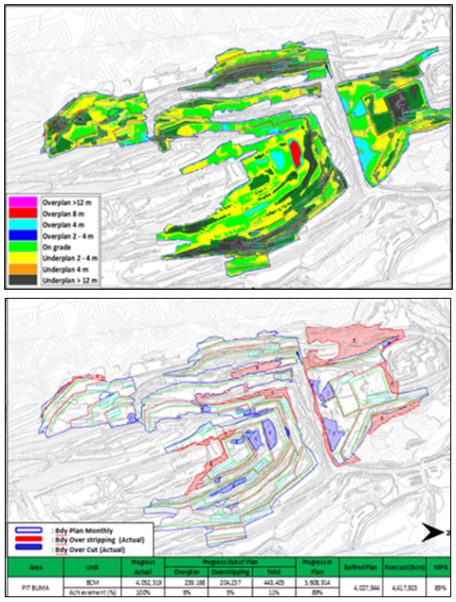

Figure 8. Mine planning accuracy august 2017

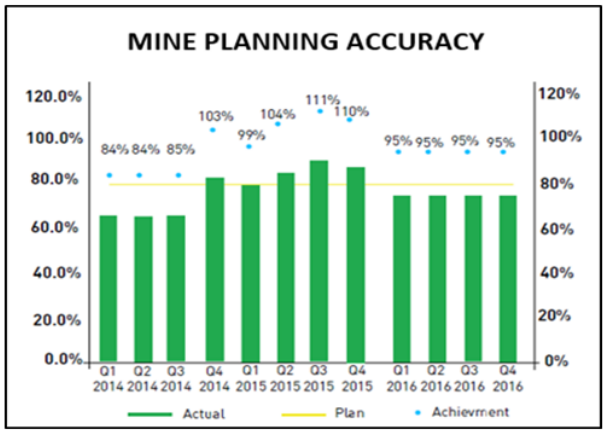

Figure 9. Actual mine plan accuracy (2014 - 2016)

Compliance on Mining Budget

In this system, the achievement of target stripping ratio and distance will be reported into cost variable. This control system can be use as data control of mining cost budget, to identify the problem of the production

achievement toward financial budget and its technical parameters, and also as a risk evaluation and strategy to increase the operational achievement and its risk.

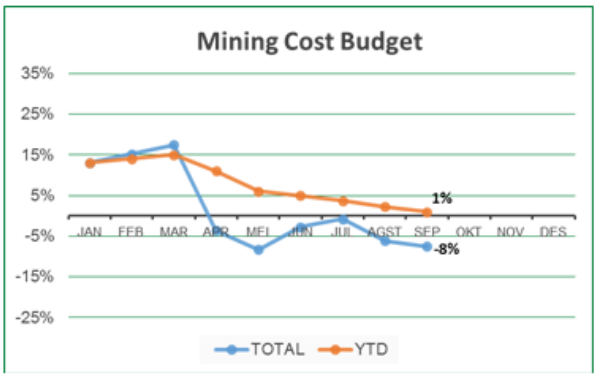

Figure 10. Mining cost budget report

Sensitivity Analysis

Mining Project and their evaluation are characterized by high risks and high uncertainties. One of the procedure for analyzing the effect of uncertainty is sensitivity analysis. This tools is also used as the mine plan control that all key parameters (volume, distance and fuel) are translated into financial budget. Main purpose is all operational result is meet the plan as financial budget.

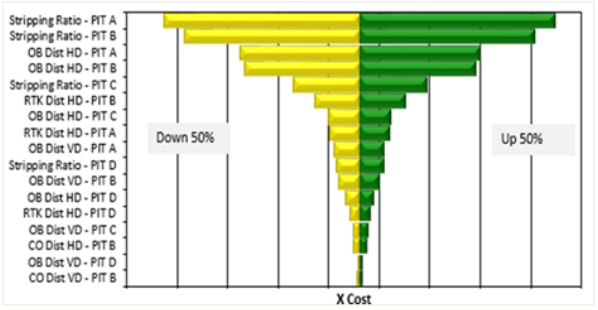

Figure 11. Mining cost budget report

CONCLUSION, RECOMMENDATIONS AND IMPLICATIONS

Although the project has been declared to be feasibly run, it is still possible and should to re-conduct a feasibility study or planning strategy due to the changes in parameters, both technical and economic parameters, which are assumed as the basic for making plans and its makes the plan remains relevant. A good mining entity must be able to adapt to the changes parameters which can occur even in the worst conditions in order to make a sustainable business. In carrying out its mining practices and to adapt the changes of parameters, X Coal Mining Company runs its mining business by applying an integrated mine planning system. The continuous mine planning cycle runs to make the plan remains relevant (P). All the mine plan result will be integrated into all functions (O) to create the detail of action plan and risk analysis (A). The assessment and control systems (C) are also used to ensure the successful of the plan. The achievement of coal production of Coal Mining Company from 2012 to 2017 can be seen in Figure 12 as follow.

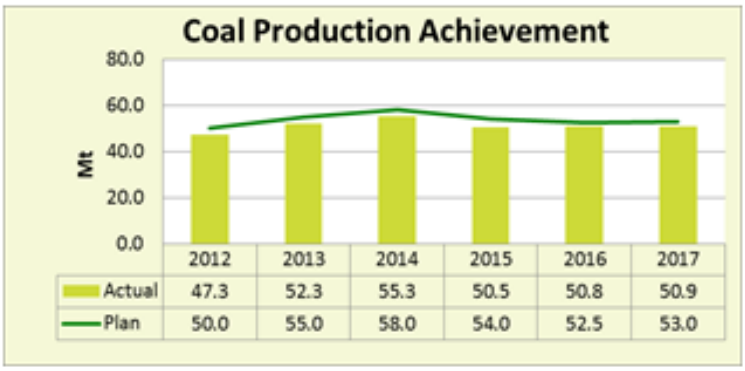

Figure 12. Coal achievement of X coal mining company

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