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

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Abstract

From 2012 - 2016 the coal price is dropped and affected to sustainability of mining business even the projects is closing. X coal mining company is one of the companies that are able to survive when coal price dropped. To overcome the problem, X coal mining company implemented a sophisticated planning to ensure its feasibility and implemented the integrated mine planning system. The mine planning process is divided into three cycle, starts from long-term, mid-term and short-term. All mine planning result including parameters and obstacle are explained to all function to make the understanding of the company’s condition, business objective and how to reach the future company plans. After that, all function create the action plans and risk analysis according to the mine plan result and the result is the integrated mining budget. Moreover, the assessment and control systems are also used to ensure the successful of the plan. As a result, the X coal mining company is successful to maintain about 95% of coal volume achievement in 2012-2017 when the price dropped and the integrated system gives a big influence for the achievement of X coal mining company. For further improvement, in order to get the better results X coal mining company should analyze the achievement of coal, based on quality and its influence on revenue based on long-term mine plan result.

Keywords: Sustainability, Feasibility, Mine Planning, Integrated System

INTRODUCTION

Over the past two decades, Indonesia’s coal industry has transformed itself from being an unknown, minor player in Asia's coal markets to the world’s largest exporter of thermal coal (coal quality under 6100 kcal/kg (Lucarelli, 2010; Yoshino & Alekhina, 2016). According to MEMR 2016, Indonesia has coal resources at around 120.5 billion tons with 146 years of coal at current production rates (Tharakan, 2015). Indonesia, step by step growth of coal exports driven by surging demand from China and India. It is also a period of major regulatory changes with the adoption of the Law on Mineral and Coal Mining in 2009, which gave the central government greater control over licenses in the mining sector. In a relatively short time, the Indonesian coal industry has therefore, become one of the largest influences in the seaborne steam coal market in Asia, accounting for half of Asian steam coal imports. Consequently, the Indonesian coal mining sector has become highly dependent on the export market with about 80 percent of coal production exported. The reason for this impressive growth is to be found in the availability of low-cost mines close to the ports as well as in Indonesia’s advantageous geographic location to serve the coal demand centers of the last ten years, namely China and India (Ayuningrat, Noermijati, & Hadiwidjojo, 2016; Cornot-Gandolphe, 2017; Khakimyanov & Khusainov, 2016; Kumtong, Saosaovaphak, & Chaiboonsri, 2017). As shown in Table 1, Indonesia produced 419 million tons of coal in 2016, thus listed as the world’s largest coal producer and placed at number 5 after India, Australia, the United States and China (Ministry of Energy and Mineral Resources, 2016).

Production of coal, like other non-renewable resources, is influenced by many factors. Factors affecting the production capacity of coal are the availability of reserves, the demand/market, and the development of technology on exploration, mining, and processing. In addition to the aforementioned physical factors, there are also...
considerations with respect to economic, social, and environmental aspects which influence the coal production (Rosyid & Adachi, 2016). Until June 2016, the continuous decline of international coal prices and lower import demand from China and India, have had a serious impact on Indonesia’s coal industry. In contrast with previous periods, coal production decreased to 485 Mt in 2014 and to 469 Mt in 2015 (yet above the government target) (Ministry of Energy and Mineral Resources, 2016).

Table 1: Worlds coal producers in 2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Production Volume (Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1685.7</td>
</tr>
<tr>
<td>US</td>
<td>364.8</td>
</tr>
<tr>
<td>Australia</td>
<td>299.3</td>
</tr>
<tr>
<td>India</td>
<td>288.5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>255.7</td>
</tr>
<tr>
<td>Russia</td>
<td>192.8</td>
</tr>
<tr>
<td>South Africa</td>
<td>142.4</td>
</tr>
</tbody>
</table>

Despite the low cost of Indonesian coal, many small companies experienced huge losses and were forced to suspend or stop production. Even the largest Indonesian companies that operate some of the countries least expensive mines, saw their margins squeezed. They were nevertheless able to maintain their output thanks to cost reductions. Lower import demand by China and India significantly reduced Indonesian steam coal exports which fell by 13 per cent 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

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

A mining project is a field of risks, a mine feasibility study should be conducted within the coal business concept before making decision whether the mine project will be run or not and this decision on investment in mining is the first important step of profit or loss the money in the mining business (Sontamino & Drebenstedt, 2013). From the theory said that the feasibility study is a study to assess projects that will be carried out in the future (Suratman, 2003). In other literature, a feasibility study is an analysis of how successfully a project can be completed, accounting for factors that affect such as economic, technology, legal and scheduling factors. Project managers use feasibility studies to determine potential positive and negative outcomes of project before investing a considerable amount of time and money into it (Investopedia, 2017). The feasibility study is a strategic decisions in the mining industry are made by the under multiple of technical and market uncertainties. Therefore, to reach the best possible decision, based on information available, it is necessary to integrate uncertainty about the input variables, all technical risk and model financial risk of the projects merit measures (Abdel Sabour & Wood, 2009). But in fact, 125 Indonesian legal coal mining companies in Borneo Indonesia was Bankrupt in year 2015. Price dropped is the main root cause that effect the sustainability of coal mining business, more over the characteristic
of Indonesian coal industry have high risk of operational risk, political and regulation including environment and also have an essential capital requirement with long duration project (Kompas, 2015). According the situation, many mining companies develop short, medium and longer-term plans to manage operational mining activities. Recently, the integration of mine planning with sustainable development principles has brought attention to the need to consider these principles from the start of mine planning onwards, in order to realize best outcomes over life-of-mine and following closure (Guardian, 2012). 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. This research will be asses with the observation how the mining company run the business while the prices drop start even though the project has been declared run based on the results of the feasibility study. The parameter that will be observe use POAC methodology, begin from how the plan is made, how to organizing, the actuating and controlling.

**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.

**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 1. Mine planning cycle](image1.png)

![Figure 2. Life of mine plan process](image2.png)
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.
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](image)

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 5. Mine plan agreed parameters](image)

![Figure 6. Mine plan function support](image)
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 managements 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

![Figure 7. Mining readiness](image)

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](image)

![Figure 9. Actual mine plan accuracy (2014 - 2016)](image)
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 used 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.

![Mining Cost Budget](image)

Figure 10. Mining cost budget report

Sensitivity Analysis

Mining Project and their evaluation are characterized by high risks and high uncertainties. One of the procedures for analyzing the effect of uncertainty is sensitivity analysis. This tool 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.

![Sensitivity Analysis](image)

Figure 11. Mining cost budget report

CONCLUSION

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 success of the plan. The achievement of coal production of Coal Mining Company from 2012 to 2017 can be seen in Figure 12 as follow.
REFERENCES