ENTERPRISE OPTIMIZATION

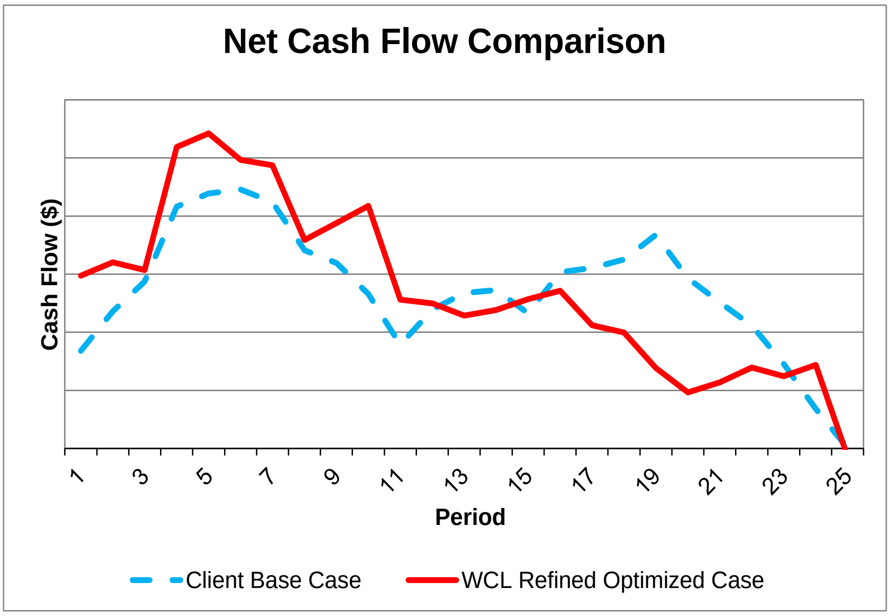
Case Study: ITM Coal Operations, Indonesia

INTRODUCTION

Whittle Consulting's (WCL) Enterprise Optimization (EO) solution is an integrated approach to maximizing the Net Present Value (NPV) of a mining business by simultaneously optimizing up to 10 different mechanisms across the mining value chain. The EO methodology which WCL has developed over the last 14 years draws from the manufacturing industry (*Theory of Constraints*) and cost accounting (*Activity Based Costing*) as well as incorporating advanced mining techniques such as cut-off grade optimization. The principles behind EO are to accelerate cash flow through the business by applying a holistic planning approach over the whole value chain rather than conventional 'silo' based decision making. The EO methodology and techniques are underpinned by sophisticated in-house proprietary software and has proven to be an excellent strategic planning tool for mining businesses having consistently identified significant value uplifts to projects and operations alike.

This paper presents the findings from the Enterprise Optimization Study for PT Indo TambangrayaMegahTbk (ITM) in Indonesia and demonstrates the applicability of the WCL EO methodology at the strategic level - across nine coal mining operations producing detailed life of mine plan requirements for each mine. The applicable modelling techniques and optimization mechanisms were successfully applied to nine open pit coal operations and produced an overall 14% increase in NPV above ITM's best business case (referred to as the "base case").Figure 1 below shows the result of EO on net cash flows, which brings forward cash flows that enables further business opportunities that are able to be funded sooner.

Figure 1: Net cash flow comparison



CASE STUDY BACKGROUND

ITM manages five mining companies with nine operating open pits situated on the island of Borneo in the provinces of East Kalimantan and South Kalimantan. These mining operations are generally divided into three groups (Bontang, Melak and Jorong) each with their own ports. The main export terminal is at Bontang Port with Bunyut and Embalut barge ports feeding coal to it from Trubaindo, Bharinto and

Embalut mines. Coal from Bunyut and Embalut barge ports can also be loaded at trans-shipment locations off-shore for export and does not have to be sent to Bontang Port for export trans-shipment. The Jorong mine and port, the only mine situated in South Kalimantan, supplies the domestic market of Indonesia. With nine operations and multiple ports, this makes for a complex network of potential logistics and blending to be modelled.

At the request of Banpu Public Company Limited, ITM's parent company, WCL conducted an EO Study and carried out a strategic life of mine optimization on the nine ITM coal mining operations in Indonesia. In addition, three marketing scenarios and two business improvement scenarios where produced in consultation with ITM.

WHITTLE CONSULTING ENTERPRISE OPTIMIZATION METHODOLOGY

Whittle Consulting has developed the EO methodology over the last 14 years that has been proven to be an excellent strategic planning tool for mining businesses. This methodology draws from the manufacturing industry and cost accounting, combined with specialised mining optimization techniques. It is focused on isolating the main value drivers in the business and understanding the ramifications that these have on all of the components of the business. Any element that can be quantified can be modelled and included in the EO – these can be economic drivers, physical constraints or licence to operate conditions.

Fundamental to the EO methodology is *activity-based costing (ABC)* and the *theory of constraints (ToC)*. Conventional cost modelling usually involves excessive averaging and allocation of costs only to production volume (tonnes), and simplistic, usually inadequate, distinction between fixed and variable costs. ABC involves a more detailed and responsive cost model which reflects more accurately the cause-and-effect relationship between activity costs and the cost drivers they are attributable to.

The ABC approach allocates variable costs to cost drivers that are truly variable, and can change or become a limitation to the rate at which a product can be produced. Typically in any business system there is a step or process that limits the rate of production and this constraint needs to be recognized and treated differently than the other non-constraining processes (Goldratt 1984, 2002). In the case of mining businesses, the constraint (aka bottleneck) is typically the processing plant and specifically the mill or grinding circuit, as this is the single largest capital outlay and also the most difficult to expand. This element also tends to have a high variable cost.

After determining the truly variable costs and isolating the constraint in the system, remaining elements of the variable costs are allocated to period, or fixed costs. These period costs tend to be much higher than the G&A figures generally quoted, as many costs are incurred by an operation that do not disappear if the operation is active, but not producing anything. WCL has seen that about 30% of variable costs are actually fixed costs that are related to "keeping the lights on".

The period costs are used to penalise the constraint in the system, which forces the optimizer software to consider the effect of running the operation for one more period. This, in effect, is quantifying opportunity cost. This usually has the result of flat lining the period costs as the constraint in the system should always be at capacity. If the system constraint is not planned to be kept consistently at capacity, then there is value being lost to poor utilisation of the constraining element. Should this be the case, then other parts of the system should be evaluated with a focus on de-constraining the non-bottleneck components.

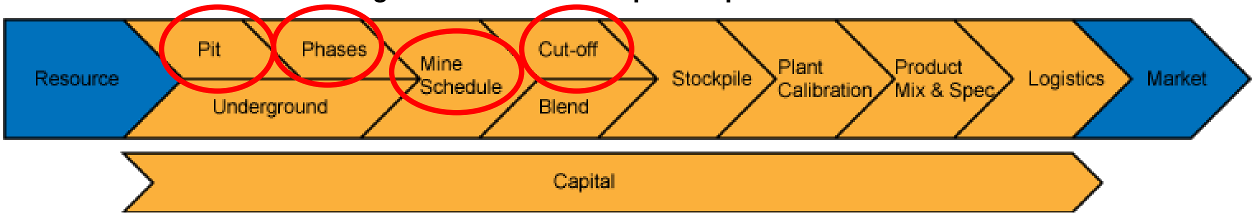
WCL builds a cash flow business model that contains the cost elements to be used in the optimization. These models can be relatively simple or very elaborate, but the goal is always the same - to isolate the critical cost drivers and maximize value through the mining system. Every block in the resource model is valued and assigned certain attributes to reflect cashflow, physical characteristics and contribution towards limits, which are then used for pit optimization (shape selection) and scheduling by Prober.

In consultation with the client, WCL carried out ABC on processing and mining costs. Each cost item was scrutinised line by line to determine if it was fixed or variable, or if it needed to be split into fixed and variable. Evaluation of fixed and variable cost was broadly based on:

- Type of cost
- Forecasted cost profile
- Cost driver
- Client consultation

For this work package, the four key areas that WCL focussed on for value contribution are shown below in Figure 2. The other elements were modelled but ITM is a bulk thermal coal producer with little downstream processing, so the focus was on the mining optimization in this component of the work. Additional scenarios were used to evaluate logistics and marketing strategic options, the results of which are not disclosed here.

Figure 2: Whittle Enterprise Optimization Value Drivers

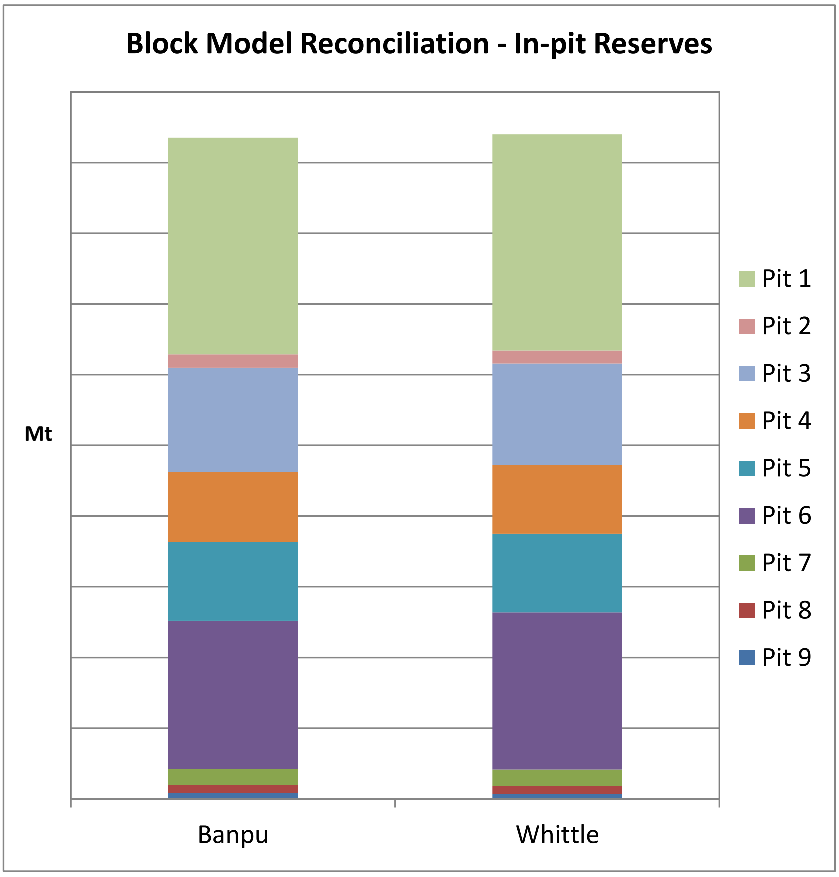


DEFINING THE BASE CASE

The first step in the EO methodology is to define a base case which is typically derived from an existing mine plan and financial model provided by the client. All key assumptions on price, cost and discount rates are aligned so the comparison and subsequent improvements are measured on a comparable basis. Based on this, WCL constructs a model and applies the same limits and constraints used in the client case to emulate this in our optimization software. Significant time is spent on this step, as it serves as an important validation and calibration step in the EO process.

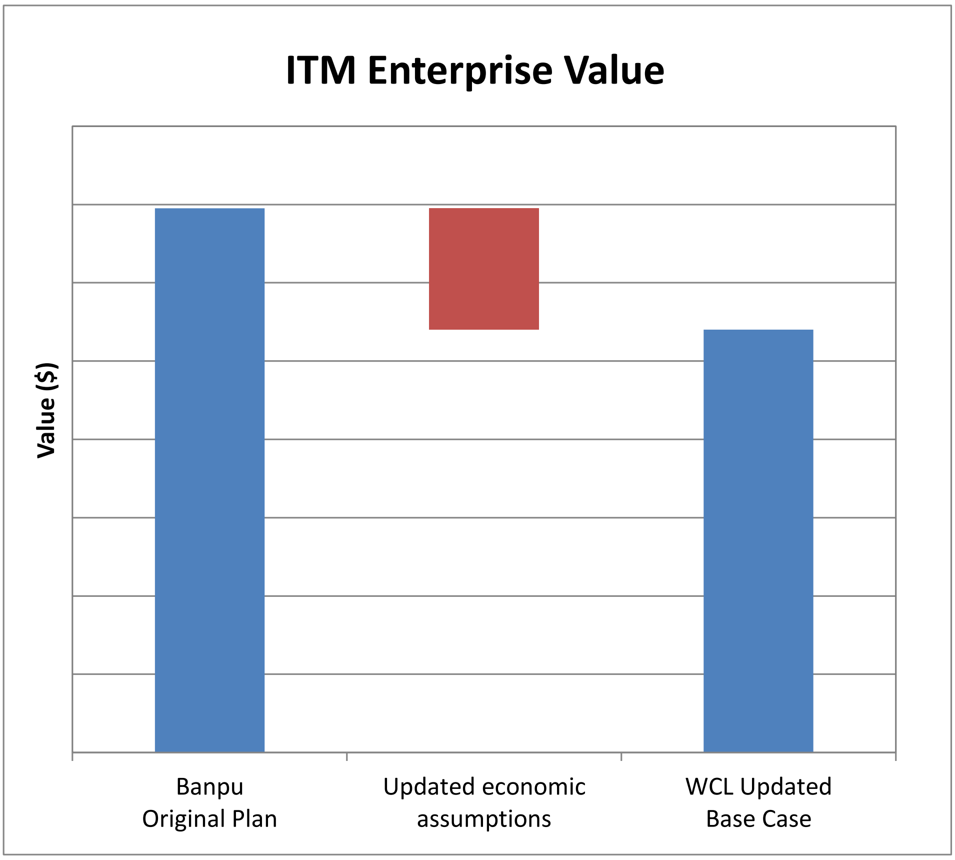
Using existing ITM designed pits and phasing, a non-optimized schedule was generated to emulate the original ITM plan. An important and detailed step was to reconcile the current Coal Resource model as summarised in Figure 3.

Figure 3: Original Plan



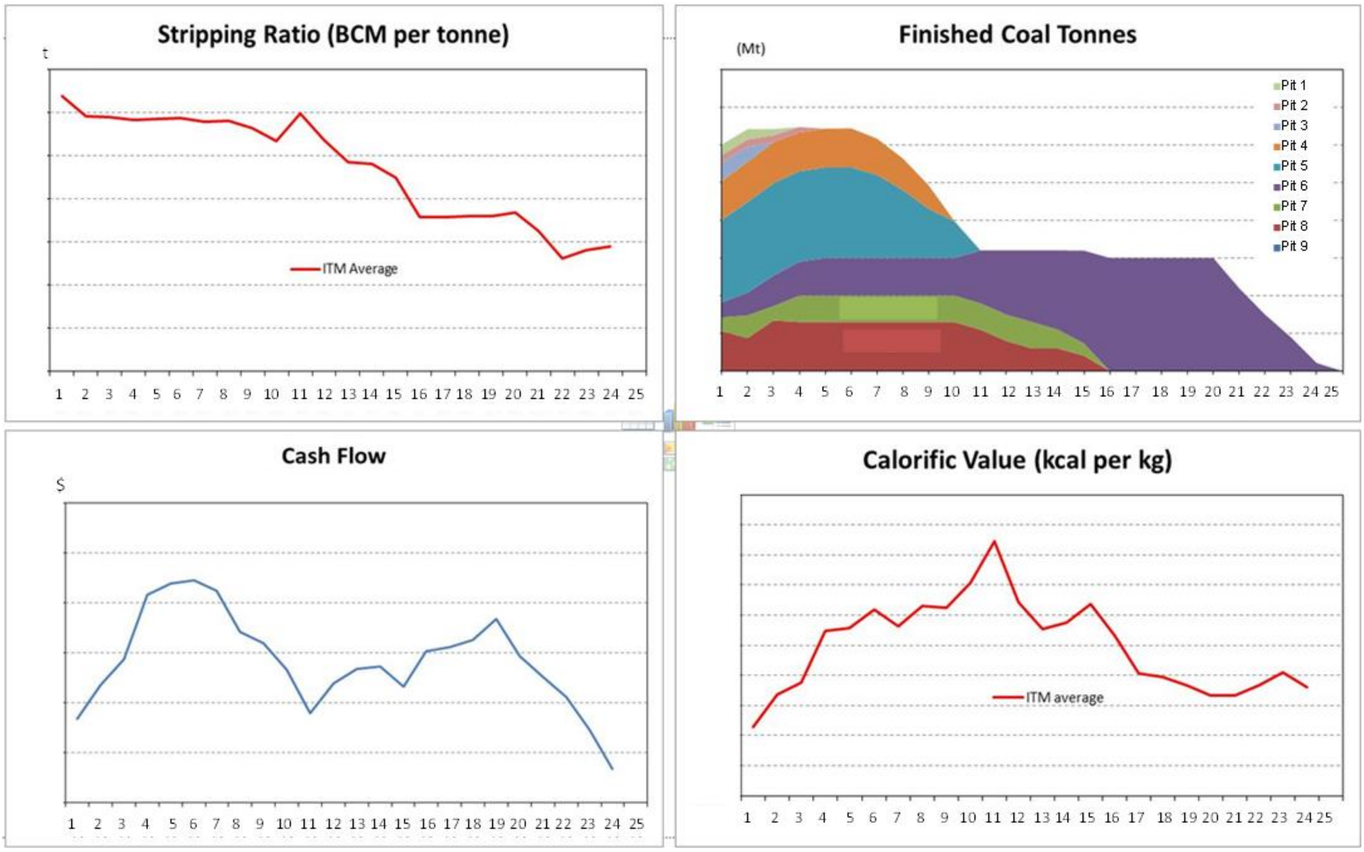
Following this, WCL generated a business model with updated economic assumptions to account for the time that had elapsed since the client's previous business case and to ensure the EO results were current with existing or forecast market conditions. Using current topography along with the resource model and ITM current pit designs, an updated Base Case was created. The WCL model was again reconciled and compared to the original plan as illustrated in Figure 4.

Figure 4: Original Plan versus Updated Base Case



In the reconciliation process, the Updated Base Case had a lower coal price and higher cost assumptions.

Figure 5:Banpu Base Case



A simplified dashboard for the updated Base Case is presented in Figure 5 above as the accepted benchmark for the EO study. The average ITM stripping ratio declines steadily over the LOM. Total finished coal production is sustainable until period 7 before declining until period 11. Total production is sustained at this level for another ten years. Average CV increases steadily until period 11 where it peaks significantly before declining towards the end of the life of mine. This fundamental step in the process set the Banpu Base Case benchmark for the EO study to proceed.

COAL PRICING MECHANISM

Coal product types and specifications were received as set values (eg. 5,000kcals) from the client, but it was observed during the early stages of the EO that this drove the behaviour of the optimization software to discard a lot of coal that would actually be sold in practice because it was obeying the limits as a fixed value, so if it could not blend to this value, it would be discarded. In order to mitigate this behaviour, the specifications for the different products were then adjusted to give the CV (calorific value) value a valid range (eg. 5,000-6,000kcals) so the optimizer could blend to different product standards to match marketing expectations.

Further into the EO process, this range of product specs was again adjusted in order to apply a penalty/reward pricing mechanism so that it influenced not only the optimization scheduler, but the mineable shape selection process as well. This then gave the coal in each pit/mine a price based on each CV unit (kcal) and whether or not it falls within the TS (total sulphur) upper limit. High TS material could be blended with low TS material if the CV value warranted it. This mechanism was applied for two different applications:

1. For the Shape selection phase:
    a. To generate the optimal pit shapes and phases, the enhanced block model was imported into the Gemcom Whittle software with a long-term price assumption used. The long-term price was chosen from the price profile provided by ITM. This mechanism helped to guide the shape of the pit during the optimized shell creation, by differentiating individual blocks and moving away from a generic pricing model of all blocks in a range having the same value. Furthermore, Total Sulphur is also priced in the same way by penalising TS outside of specification and rewarding low TS coal. This mechanism can be extrapolated to any mineral that has different specifications for payables and penalties for deleterious elements.

2. For the Schedule Optimization phase:
    When the schedule optimization is done (which simultaneously optimizes all 9 mines), a client supplied price profile (ie. can change over time – unlike shape selection which tends to use a long term average) is used and the CV adjustment ($/kcal) is calculated for each period and applied to the different periods.

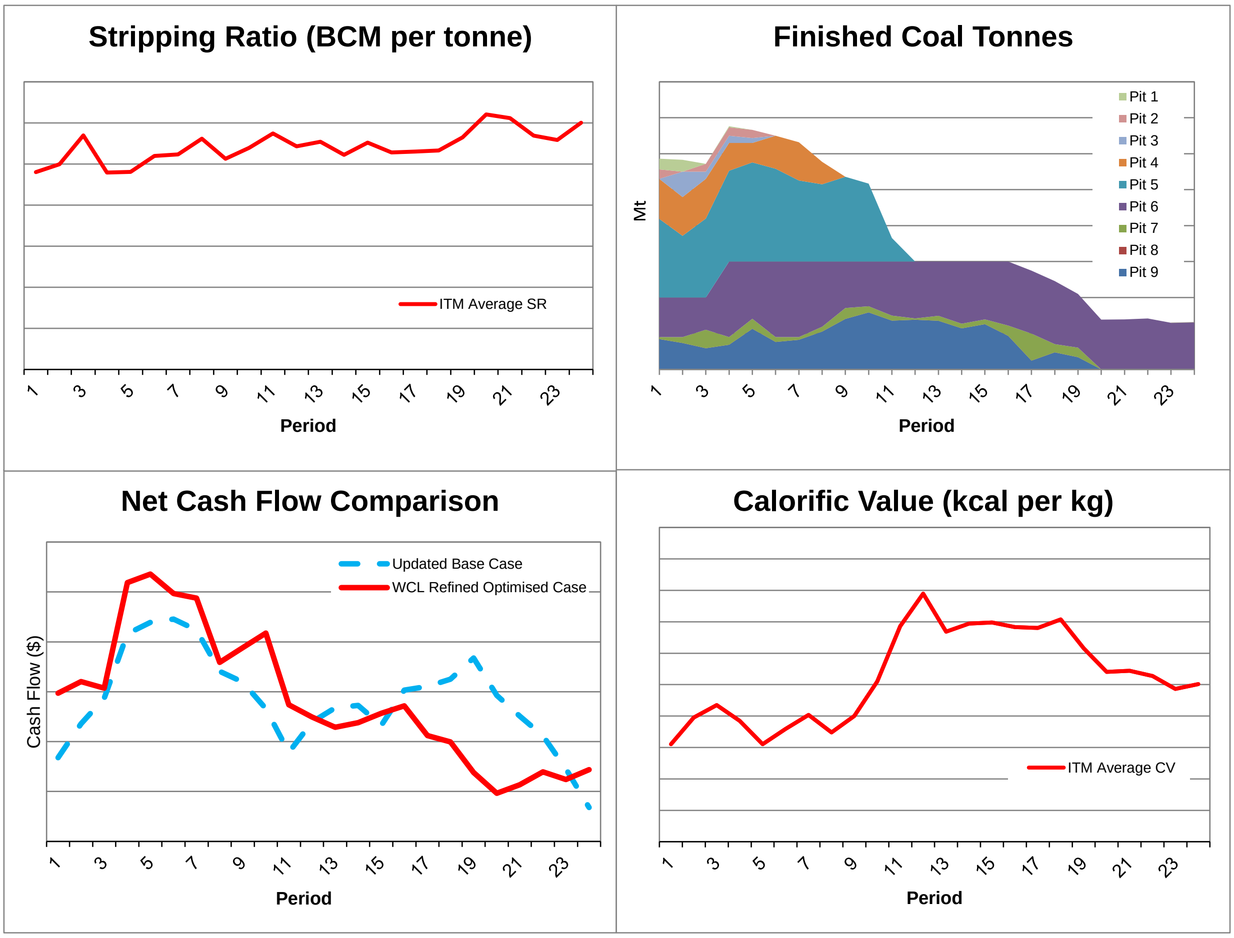
The mechanism described above was applied in the same manner for all 9 mines simultaneously during this EO study. The Optimizer was then able to blend material from all mines, within the permissible logistics limits, to achieve optimum product specifications and maximise net cash flow and NPV.

ENTERPISE OPTIMIZATION RESULTS

A result of the work was that the crushing plants and port capacities were identified as the bottleneck in the system, so the optimization process involved ensuring that both elements operated at capacity for as early and long as possible, in line with the *Theory of Constraints*. WCL also added mine scheduling constraints such as timing of permits, production smoothing and overburden removal across the entire lease areas to produce a practical mine plan that was both viable and economically superior.

An NPV-optimized case was produced by designing new pit shapes, phase selection, scheduling simultaneously across all nine mines and applying a cut-off to calorific value (CV). Application of the EO methodology was able to pull cash flow forward producing an initial net gain of 13% in NPV over the Base Case. Further refinement of the optimized case increased the NPV by another 1%, resulting in an overall 14% increase in NPV. This refined optimized case was selected for further scenario analyses and is summarised below:

Figure 6: WCL Refined Optimized Case Summary



SCENARIO ANALYSIS

At the conclusion of the EO study, three marketing and two business improvement scenarios were undertaken, which sought to quantify the potential value of several strategic ITM possibilities. A key benefit of this additional scenario analysis was being able to provide rapid turnaround of results which highlighted which scenarios should be the focus for internal resources for future planning cycles.

SKIN ANALYSIS

While the EO study up to this point was based on mining the already identified and reported ITM Coal Reserve, WCL applied an additional technique known as Skin Analysis. Skin Analysis tests to see whether a larger or smaller size pit might give better value. This is done by changing the Revenue Factor (RF).

- RF 1.0 pit = maximum size of the pit with the current price assumption where cash is maximised (mining to where blocks become cash neutral).
- RF 0.5 pit = if the price were half the current price assumption, the pit would be reduced to this size. Broadly speaking, this is the highest value material within the mineable resource.
- RF 2.0 pit = if the price assumption were doubled, the pit would be larger. This theoretical shape is often use for guiding sterilisation drilling and infrastructure placement as it creates an envelope around the ore body which is unlikely to be mined.

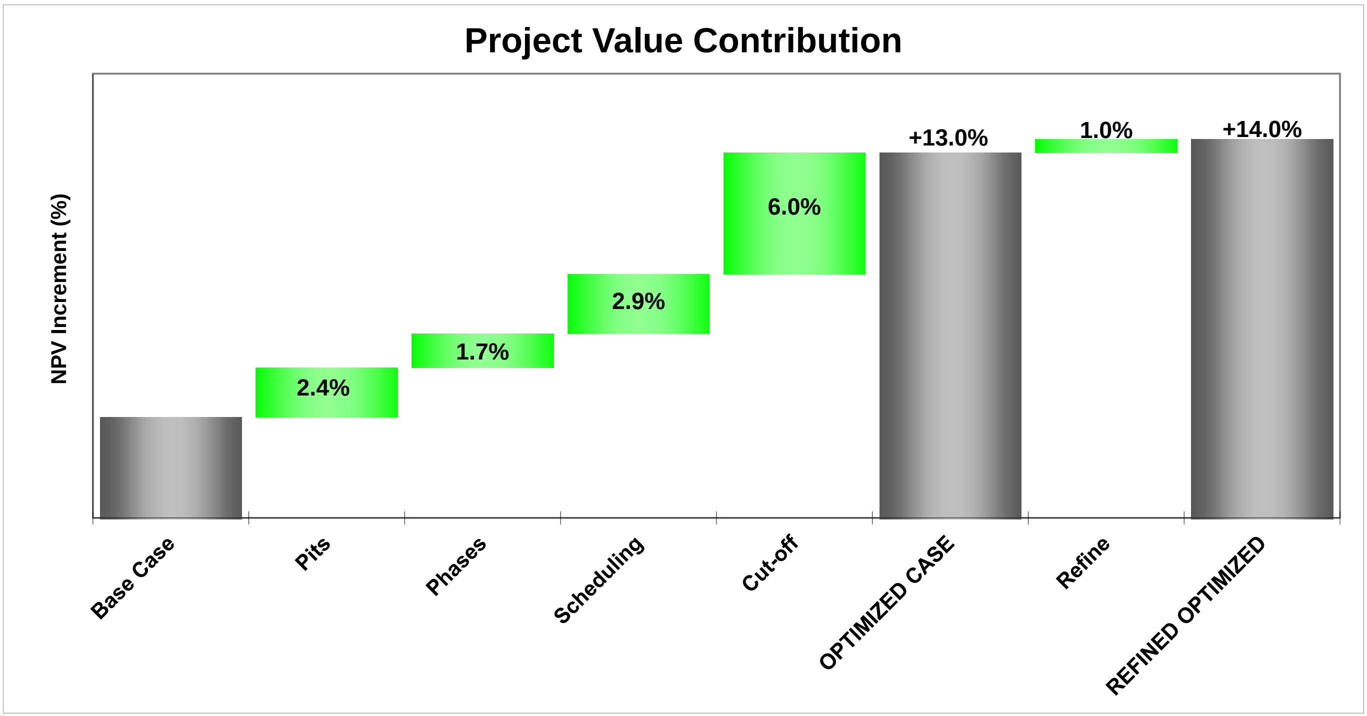
The analysis showed that a plus 10% RF (ie. RF = 1.1) improved the NPV of the Base Case by 20%. For this high level analysis, this was applied universally across all the pits and with further time and refinement could be applied differentially to each pit. This was indicative that current designs were potentially undervaluing the material in the pits. This was only undertaken at a desktop level and did not involve detail design, but it indicated where significant potential value could be unlocked in the client's next mine planning cycle by reviewing corporate assumptions.

CONCLUSION

A summary of the EO mechanisms used and the respective value contributions is shown in Figure 7. Application of the EO methodology was able to pull cash flow forward producing an initial net gain of 13% in NPV over the Base Case. Further refinement of the optimized case increased the NPV by another 1%, resulting in an overall 14% increase in NPV. The key outcomes from the EO were:

- Pits – selecting the right material to mine based on a scalable CV value and Total Sulphur.
- Phases – in the Banpu case it was possible to break the large pits up into smaller phases to enable the best value material to be brought forward as well as better blending.
- Scheduling – having more discrete mining units enabled better utilization of the bottlenecks (ports) by having smaller overburden requirements to uncover coal resources, as well as permitting finer control over blending parameters.
- Cut-off – being more selective on what makes the grade as product and not trying to sell everything that has a CV. This requires a preparedness to stockpile and even discard material.

Figure 7: Waterfall diagram of value contribution



The five additional scenarios undertaken provided valuable insights into the interactions and behaviours of the nine open pit operations and the shared logistics network, helping to guide ITM's future planning priorities. In addition, WCL applied an additional technique of Skin Analysis by changing the Revenue Factor (RF) to test whether a larger or smaller size pit might give better value. This indicated that a plus 10% RF (larger pits) improved the NPV of the Base Case by 20%.

This EO study has unified all the available information into a single strategic business model to identify value opportunities for ITM. The integration of nine coal operations into one overarching model provides a holistic view of the business, and is able to rapidly iterate through many scenarios in a short period of time.The resultant EO model is ideally suited to provide ongoing support for future strategic planning and evaluate the potential impact of changes in key assumptions such as market conditions. Updated inputs including operational pit and phases can easily be incorporated to generate new schedules and plans to maximise business value as circumstances change. Practical strategic limitations on mining and plant have been overlaid to ensure the results are technically robust. Through application of *Activity Based Costing* and the *Theory of Constraints*, combined with a focus on NPV and bringing cash flows forward, the WCL solution has identified unlocked hidden value and potentially increased the economic appeal of this business as displayed in Figure 7. The resultant schedule is an outcome based on WCL's philosophy, methodology and techniques that maximizes the flow of cash through the whole business.