Teach yourself how to build a Business Case → Mine Planning

1s Hands On Modelling – doing Mine Planning properly

Contrary to some peoples' teaching, optimising is much more than selecting the mine plan with the highest NPV!

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NPV is nothing more than the mathematical treatment of a collection of expert opinions.

Spend only a few minutes on each page

This website may contain errors so always check your own work and have it audited by a competent person.

This module has personal opinions!!!

← These two opinions are key to mine planning →

NPV is just one of a basket of metrics by which you can assess your business/project.

Where does mine planning fit with economic evaluation?

In any business the economic evaluation must sit above mine planning. Just as it must sit above the metallurgy, the production plan, the marketing, the capex, the opex and the various taxes.

Each of these feed into the economic evaluation, which is the only activity that brings in each and every one of these items in precise amounts at exactly the correct time to compute an overall business assessment.

- Working alone the mining engineers and geologists can create a mine schedule that "maximises NPV".
- The metallurgists can create a processing plan that "maximises NPV".
- The marketing specialists can create a sales plan that "maximises NPV".
- The engineers and operators can devise a plant configuration and operating plan that "maximises NPV".
- But assembling each of these into one overall plan is likely to produce inconsistencies and most probably will not yield "maximum NPV" for the business.

But as is discussed throughout this website: -

There is a lot more to selecting the best production schedule than the narrow and obsessive search for 'maximum NPV'.

Tell that to any mine planner who is absolutely confident about their software being the ideal solution!

Mine Planning …

Around the world there is a vast array of excellent mine planning software and a huge amount of high quality professional expertise investigating, understanding and optimizing mining.

A huge amount of intellectual interaction and progress has been made in the arena of mine planning: from drilling, to ore-body modelling, through cut-off-grade theory to mine scheduling. This has been through advances in geology, geo-statistics, geo-mechanics, hydrology, geo-metallurgy, mining engineering, metallurgy, computer programming, logic and economic evaluation. One of the key building blocks has been the Whittle shell software.

Mine planning is in an advanced state and the momentum is likely to keep it improving. Unfortunately the power of all this expertise makes some mining engineers, and the occasional project leader,believe that mine planning software on its own will generate the optimum business plan. They incorrectly think that selecting the mine schedule with say, "the maximum NPV", is the end of the game. As we know it is only a start. It is only one of several alternative mine schedules that need to be assessed to characterize the possible business profiles.

Firstly, when it is inputted to the economic evaluation model it may not be the scenario/case with the highest NPV,
and
Secondly there is a lot more than NPV to selecting the best business profile!!! ← so important

As demonstrated in other modules on this website, a mine schedule that produces a lower final NPV but achieves one of the following profiles may be judged to be a wiser selection for a particular company: -

- Low upfront capex in a company where cash/debt is limited, or
- A more stable future with lower long term risk for a company with a sole business, or
- Fast payback for a company considering investing in a country or market with high risks, or
- Ability to survive market downturns by having lowest quartile opex and higher margins on sales.

End of Module

Mine Planning versus Economic Evaluation

There is not a competition between mine planning and economic evaluation, but the following characteristics demonstrate how the two differ in broad terms.

1. **Mine schedules:** Mine planning can generate sophisticated, high quality mine schedules. Its various software packages have been developed over decades. Some can be used generally whilst other software is better for specific types of deposits. Usually each software package can generate different mine schedules depending on the criteria being specified. By contrast the economic evaluation model does not generate its own mine schedule but accepts the data from the mine planning software. (Do not waste your efforts and others time by having a pseudo mine schedule in your economic model. It is futile to start with the mining inventory and try to mimic a mine schedule by deducting the year's ore mined then recalculating a new mining inventory at the end of each year. Instead take the mine schedule generated by the mining engineers.)
2. **NPV:** Much mine planning software computes an indicative NPV before income taxes and possibly without inputting upfront capex and major growth capex as it occurs over the life of mine. It allocates revenue, opex and sustaining capex to each block of ore/waste in a sophisticated way and computes a sequence of alternative mine schedules. But usually this is not a proper, year-by-year, after-tax, discounted cash flow and so is not a precise NPV. By contrast, economic models can compute proper NPV's with precise mine schedule, production, sales, capex, opex and taxes for each year over the life of mine. An NPV generated by mine planning software is a good start but may not be the highest once construction schedules, major capex spending, metallurgical interactions, production limits, exact pricing mechanisms, changing prices, precise variable/fixed costs and taxes are applied. 3.
3. **Selection criteria:** As outlined above, NPV is very useful but is just one of the basket of criteria by which the best mine schedule may be selected. NPV is a start but far from adequate.
4. **Annual variations:** I understand that most mine planning software cannot yet change the following inputs on a precise year-by-year basis as the mine schedule is being generated: price forecasts, concentrate pricing mechanisms, throughput constrictions, real opex cost increases, step changes in fixed costs, variable sustaining capex, royalty rates and income tax payments. By contrast, economic evaluations are set up to make any number of year-to-year changes precisely as they occur in time.
5. **Transparency:** In general it would be impractical to try to step through the millions of computations in mine planning software. It is not visible, transparent and readily followed by a lay person. By contrast an economic evaluation model is a failure unless it is transparent, intuitive, readily followed in small steps and so auditable by a lay person.

Mine planning and economic evaluation are not competitors but have complementary roles.

Your responsibility is …

As an evaluation practitioner you must understand the inputs and the assumptions upon which the mine plan in you model was generated. Otherwise, you are just blindly accepting someone else's set of assumptions into your evaluation model. You cannot sit back and say that is not my expertise and I have to take what I am given. Are those inputs and assumptions the same as is now being adopted by the business for the economic evaluation?

Instead you must live and breathe your evaluation, getting inside the logic and work of those experts providing you with data, challenging their inputs in a creative way when you have doubts, noting when you have worries about inputs, testing the impact of troubling assumptions, ... *All the time being positive, productive, reasonable, honest and open.*

Different cut-off-grades for different purposes

Cut-off-grade is a most important element of mine planning. Basically it is the grade of mineralisation above which processing is economic so is classified as 'ore' and below which it is classified as 'waste'.

- Its theory and practice is well covered elsewhere and the following is briefly about how it interacts with economic evaluation
- It uses many of same data inputs as are in the economic evaluation model for revenue, opex and possibly sustaining capex. The most important of these inputs is the forecast of price, as it must pay for all the costs. But many mining projects forget this and focus entirely on technical issues.

It is common for there to be more than one cut-off-grade for an 'ore deposit'.

- To define the **broad size of the mineralisation**, a higher price may be used. This gives a larger sized, three dimensional model with tonnages and grades – part or even all of this mineralisation may be uneconomic.
- To define the mineralisation/ore body for **public reporting** the price forecast needs to comply with the government/stock exchange/professional association guidelines. This is likely to be lower so the three dimensional size will be smaller and the reported tonnes fewer, but the head grade may be higher as a consequence. Within, there may be a smaller core that has been studied and shown to be economic.
- To define the ore body for the **company's own economic evaluation** and internal management decision making, the company's internal forecast of price can be used. This may be lower or higher than for public reporting depending on the company's own view of the industry.

It is common for companies to have guidelines or perhaps rules on how much 'proven' economic ore is needed, and so how many years it would last - whether it covers pay back. The proportion of 'proven' ore that is well defined by the geologists, etc, etc. This is a consequence of bad experiences in other companies where the ore exhausted prematurely. (Some people become overawed by these guidelines and do not think beyond their arbitrary limits.)

These guidelines/rules should be considered when the company is making its major decisions on projects. Prior to this, however, the company should investigate cases where these rules/guidelines are broken; so as to fully understand the business opportunity. Economic assessments can be made of these cases so the company knows the potential, the risks and rewards of each.

Putting cut-off-grade into perspective: -

Some technical/operational people get very concerned about cut-off-grade: -

- They see cut-off-grade as a hugely important decision that will define the mine's future.
- They get into lots of healthy debate about the absolute value of the various elements of operating costs and about metallurgy. Sometimes they dive into highly detailed technical and cost analysis where they perceive lots of uncertainties.
- But too often they fail to recognise that some person(s) in corporate office who recommends price forecasts to the Board/Management can swamp their finessing with a new market study.

I have become relaxed and flexible about cut-off-grade: -

- I believe there is no absolute and true cut-off-grade. Like NPV it is only an opinion of the future which will change over the months and years ahead. If a different team of experts were working on this ore body then a different cut-off-grade could well be computed. Of course, someone's forecast of price will have the biggest impact.
- Instead the ore body should be investigated and understood from a range of perspectives.
- Essential: Those working on cut off grade should always be asked to produce a grade-tonnage curve as a very simple and visual output of the range of possible cut off grade outcomes for an orebody. This is industry standard practice.
- The mine scheduling process should be run with a range of cut-off-grades to see how the mining inventory changes in ore tonnes, grades and waste. Is cut-off-grade of low importance because the ore body has sharp natural boundaries from higher grade ore to host rock or is cut-off-grade highly important because the ore body fades in grade across to host rock?
- If the ore-body does fade gradually from ore to waste so that a change in cut-off grade significantly increases the mining inventory, then these extra tonnes are liable to be of low cash margin and so contribute little to NPV.
- Armed with this knowledge, a comprehensive range of mine schedules should be generated.

Each of these schedules should be run through the economic model, with adjustments to capital and operating costs, so its business profile can be revealed. Each case can be assessed for NPV, payback, sales margins, cost of production compared with competitors, capex outlay, life, flexibility, risk, etc - much more than "highest NPV".

Declining head grade strategy:-

It is standard practice for companies to assess a 'declining head grade strategy' when considering various alternative mine plans → Where feasible, the mining engineers will try to get higher grades early in mine life and suffer lower grades later in mine life. This brings revenue forward in mine life so this revenue incurs less discounting. The downside is that the lower head grades suffered in the later years will make the mine more vulnerable to market downturns. Of course this strategy is motivated by NPV which encourages managers to maximise the near term at the expense of the long term. *It was brought to prominence by a man named Ken Laine a few decades ago, who published a landmark book, I think while or after he worked for Rio Tinto.* The strategy has been successfully employed on many mines over the decades.

Whether declining head grade strategy works and is the correct course depends on many factors, including:

- Ore body geometry must be appropriate so that higher grade ore can be accessed early with reasonable waste to ore ratio. Having high grade ore very deep may make this strategy difficult except if block caving.
- Mining conditions such as mining dilution, geotech and hydrology must not be far worse in the high grade zones.
- Metallurgy of the higher grade ore cannot be significantly lower in recoveries nor more deleterious in product quality, such as trace elements.
- The market must be able to handle the extra production in the earlier years and reduced production in the later years. This could be important where the mine supplies a local or dedicated market.
- Production facilities: I worked on one project where having higher head grades early was of little advantage because the production facilities were limited in output of final product. No extra sales could be made early so the only benefit was a slight reduction in operating costs early at the expense of higher costs later.

Declining head grade strategy definitely should be assessed.

Summary: -

Mine planning has reached a high level of sophistication and capability.

- It uses much of the data that is used for the economic evaluation.
- It has a different purpose to economic evaluation, that is complementary.
- It is just one of the many business activities and not a stand-alone technical activity.

Like NPV, mine schedules and mining inventories are nothing more than a best opinion. They are not absolute truths.

- Best to explore and understand the business with a range of cut-off-grades and resulting range of mine schedules
- Assess each case with the full basket of criteria: not just with the inadequate criteria of “maximum NPV”.
- Understand the different business profiles that could be developed for the mine.

Most important: The economic evaluation specialist needs to develop a close and productive working relationship with the geologists and mining engineers so everyone understands what is required for a proper evaluation