Dynamic Influences of Optimisation on Emissions

PJ Bangerter[1] *B.Min.Tech(Hons), FAusIMM and J Pan*[2] *BSc, BCom*

1.Principal Consultant, Orchardman Pty Ltd, Forest Lake Qld 4078. Email: Philip@Bangerter.net.au
2.Consultant, Whittle Consulting Pty Ltd, Surrey Hills Vic 3127. Email: Jason@whittleconsulting.com.au

Keywords: Methodology, Carbon, Scope 3, Optimisation,

INTRODUCTION - THE STATE OF PLAY

Optimising for Net Present Value (NPV) with a strategic optimiser such as COMET, Prober-E, Blaser or Minemax has hitherto lacked a dynamic method for analysing the so-called 3rd-order outcomes (such as Carbon emissions) of optimisation within life-of-mine planning.

Optimisation, per se, has natural effects on carbon emissions in a life-of-mine plan. Contemporary strategic planning employs a mathematical optimiser to make sense of non-linear data (i.e., a block model) and produces a best-NPV optimised mining schedule, within a set of constraints. The very act of optimisation influences emissions, and in a dynamic way.

FIRST, SECOND AND THIRD ORDER

Strategic Planning can be applied at the first, second and third-order (Bangerter, 2022).

First-order effects concern assembling capital and operating costs and calculating a net-present-cost for these. Financial impacts can be compared across options or scenarios, as required.

Second-order effects concern the orebody as an integrated whole and its optimisation.

Pit or Stope designs can be optimised using appropriately directed Lerchs-Grossman algorithms (Lerchs & Grossmann, 1965). Lerchs-Grossman is effective at determining the economic three-dimensional shapes considering block grades, open pit slopes or underground design characteristics, costs, recoveries, and metal prices. Such an optimised schedule utilising these designs should raise early cut-off where physically possible, to increase early metal production, even if positive margin material is discarded and the mine life shortened (Lane, 1988). Introducing appropriate activity-based costing allows the optimisation to account for real world cost differences between bringing different ore types to product such as haul distances and ore hardness, directing designs and schedules to account for maximising margin rather than just grade and revenue. (Whittle, 2023).

A re-optimisation will thus change the mining schedule, have a dynamic cut-off policy and even modify the mining design shapes. Such changes become strongly reflected in the emissions.

In the general case, optimising for NPV with such a strategic optimiser and methodology, will naturally favour the inclusion of shallower, higher-grade, softer material and in consequence reduce emissions per tonne of output (i.e., improve carbon intensity compared to a poorly optimised schedule).

Additionally, there are further consequences for any cost and price variations tested in the planning and subsequently adopted as the plan. These include:

- For mining assets with processing-dominated energy (such as base metals open pit) lowering costs or a predicting a more elevated commodity price naturally increases carbon intensity. It favours expanded exploitation of existing pit-shells which brings marginal material (lower-grade, harder and more distant) to plant rather than waste; whereas,
- In mining-dominated energy assets (such as iron ore) cut-offs are lowered, life-of-asset increased, and pit-shapes expanded. Marginal material is thus brought into the schedule, increasing the carbon intensity as well; and,
- By contrast, when planning introduces process efficiencies (technology improvements, efficiency drives), higher throughputs are possible for the same energy – this will reduce emissions intensity.

Finally, third-order effects are concerned with environmental and community value or impact and an evolving full assessment of sustainability impacts of each choice between options. These are best illustrated in case studies.

CASE STUDIES

Decision-making in this space can look at emissions reductions/increases as a total and as an intensity; all judged against NPV or other financial indicators. Recent case studies can be used to illustrate the decision-support of such an analysis, including technology comparisons and decarbonisation strategies.

Recently, Nordic Iron Ore (NIO) revisited their pre-feasibility level 2019 strategic planning which now includes both a new carbon model and a decarbonisation strategy that includes fleet electrification for their project Blötberget (Hamerslag, 2022). Figure 1 below compares the total estimated emissions for the originally planned diesel-powered fleet and the substantial reductions afforded by electrification in a low-carbon grid (Sweden).

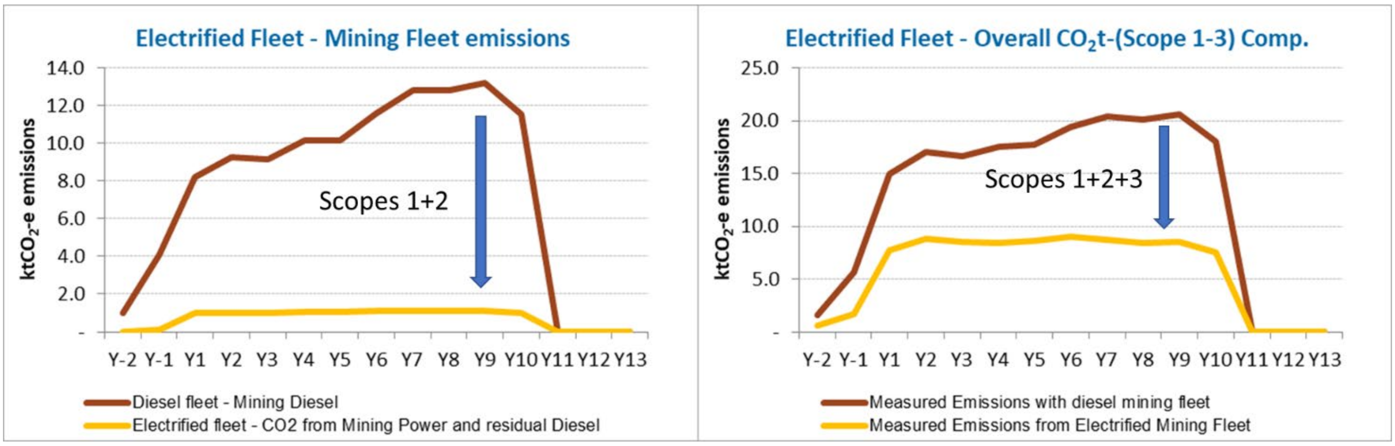

Figure 1 Nordic Iron Ore Electrification Implications

Scope 3 emissions include estimates of the material upstream components (such as grinding media, explosives, cement / concrete and transport in the supply chain) as well as downstream transport emissions to the customer's gate. The importance of scope-3 emissions in several analyses has become apparent and can be further illustrated by the example in Figure 2.

*Carbon emmissions **Scope 1 & 2 only** vs. NPV*

*Carbon emmissions **Scope 1, 2 & 3** vs. NPV*

Figure 2 DPM Emissions guiding strategy decisions.

Here, Dundee Precious Metals (DPM) have used their integrated strategic planning study at Chelopech, judging improvements to long-range forecasts (LRF) and hence integrating climate decision-making into capital allocation decisions and transport of concentrates (Nolte, 2022). Assessing the carbon footprint vs. the net present value of the operation became a key feature of the study. It found that:

- Scope 1 and 2 emissions are insensitive to LOM scenarios meaning maximisation of NPV does not increase absolute carbon emissions (left graph); but that,
- Incorporating scope 3 emissions into the modelling presented some decision challenges in terms of 'up-stream' and 'down-stream' transport and processing assumptions because Scope 3 emissions are sensitive to the LOM scenario selected – mostly because of the downstream transportation (to alternative destinations other than DPM's Tsumeb operations (DPMT)) and processing of concentrate (right graph).

This reveals a strategic question to be answered: does the choice of customer expose concentrate producers to decarbonisation pressures? In a regional context, this can be yes. A more distant (Asia vs Africa in this case) and more carbon-intensive transport mode will show up in a scope 3 inventory.

Other examples from recent studies have been:

- Fleet electrification with trolley assist
- In-pit crush and convey vs truck haulage
- Renewables penetration vs traditional diesel at remote sites
- Dry-stack tailings vs conventional tailings storage

WIDER IMPLICATIONS

Of course, 3rd-order effects are not limited to carbon emissions and any sustainability-related issue can be included. The authors are seeing the positive implications for decision-making of widening this type of dynamic analysis to tailings and water, for example. The trade-off analysis between NPV and tailings volumes can now be routine in strategic planning and is expected to be extended to analyse grind size against not only water recovery, but also water-use intensity and ultimate tailings density. Moreover, it would not be surprising if coarse particle flotation and the emerging Hydraulic Dewatered Stacking methodology (Newman, 2023) would prove to be an interesting 3rd-order analysis in the very near future.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Whittle Consulting for the support afforded to us during the writing of this extended abstract and accompanying presentation material. Moreover, we greatly appreciate the kind permission to use examples from studies conducted for Whittle clients; namely by Mirco Nolte of Dundee Precious Metals and Ronne Hamerslag of Nordic Iron Ore.

REFERENCES

Bangerter, P. J. (2022). Implications of ESG on Mine Planning and Equipment Selection. *Webinar Presentation.* Jakarta: Djakarta Mining Club .

Hamerslag, R. (2022). Nordic Iron Ore AB. *Liam Forum.* Toronto: Brock University.

Lane, K. F. (1988). *The Economic Definition of Ore.* London: Mining Journal Books Limited.

Lerchs, H., & Grossmann, L. (1965). Optimum Design of Open-Pit Mines. *Transactions CIM, LXVII*, 17-24.

Newman, P. (2023). *Progress on Hydraulic Dewatered Stacking (HDS)*. Retrieved from Anglo American: https://www.angloamerican.com/our-stories/innovation-and-technology/progress-on-hydraulic-dewatered-stacking-hds-el-soldado-chile

Nolte, M. (2022). Holistic Approaches, Integrated Strategic Planning & Sustainable Resource Development. *Liam Forum.* Toronto: Brock University.

Whittle, G. (2023). *Activity Based Costing (ABC) and Theory of Constraints (TOC)*. Retrieved from Whittle Consulting: https://www.whittleconsulting.com.au/integrated-strategic-planning/#activity