Optimising pathways for decarbonisation in mining

Strategic approaches and best practices

Part two

Original research: Stocktake, barriers and complexities, opportunities, and a way forward

dss+

Protect. Transform. Sustain.

Introduction

The mining industry stands at an inflexion point. As global demand for critical minerals rises to support the energy transition, mining companies face mounting pressure to reduce their carbon footprint. The industry accounts for 4-7% of direct global greenhouse gas (GHG) emissions, but when scope 3 downstream emissions are included, this figure surges to 28%, making mining the second-largest contributor to global emissions after agriculture.

Despite growing commitments to net-zero targets, progress remains slow – current decarbonisation rates hover around 2% annually, far short of the 4.5% required to meet Science-Based Targets and the goals of the Paris Agreement.

While many mining companies recognise the urgency of decarbonisation, translating ambition into tangible impact remains a challenge. A lack of consistent and accurate emissions data, misalignment between corporate targets and operational execution, and financial constraints often result in fragmented efforts that fail to deliver meaningful progress. Additionally, organisational silos and a lack of integration between sustainability, operations, and procurement teams hinder the ability to execute initiatives at scale. **Part 1 of this series explored these barriers in detail, highlighting that without a structured and integrated approach, decarbonisation efforts tend to remain reactive or incremental rather than transformative. A summary of Part 1 of this series can be seen on the following page.**

The complexity of scope 3 emissions reporting, the absence of standardised data frameworks, and the difficulty of aligning decarbonisation investments with core business strategies all contribute to the slow pace of change. Without addressing these systemic issues, mining companies risk stalling their decarbonisation journeys—exposing themselves to increased investor scrutiny, regulatory pressure, and operational inefficiencies.

To bridge this gap, mining companies must shift from high-level commitments to a more systematic, data-driven approach that embeds decarbonisation into business strategy and operations. We have developed six recommendations for how companies can achieve this, and move beyond fragmented or reactive efforts towards a more strategic, data-driven approach to emissions reduction that can deliver measurable progress, strengthen business endurance and position them for long-term success in a low-carbon future.

While many mining companies have committed to net-zero, the complexity of executing decarbonisation plans remains a challenge

Lack of operationalisation and centralisation

Decarbonisation efforts are currently fragmented and lacking a centralised approach. Decisions are made at site-level hindering the effectiveness of company-wide decarbonisation

Inadequate capital management frameworks

Capital allocation not making provision for environmental attributes (requires redesign with focus on core values - decarbonisation MUST be seen as a corporate responsibility like safety)

Organisational structures that prohibit improvement

Sustainability leaders are accountable for emissions reductions, but they often have little to no operational authority, and thus little ability to deliver meaningful reductions

Resources and skills shortage/constraints

Difficult to attract talent and create a more diversified workforce. It is perceived as dangerous, physically demanding and environmentally harmful and requires a more positive image

Upfront costs are often extensive

Inherent mine design for economies of scale makes decarbonisation CAPEX intensive

Shortage of affordable funding

Marginal abatement cost curves (MACC's) suggest that several decarbonisation projects are NPV positive with significant potential to abate emissions. However, many of these projects are CAPEX intensive and access to "green" capital is expensive

Insufficient data and monitoring frameworks

Companies are only measuring emissions on an annual basis, rather than using real-time data and a mix of leading and lagging indicators that can give more meaningful insights on carbon intensity across operations

No financial incentives

No incentives (small carbon tax liability) - consumers still demand certain products and lifestyles i.e., convenience of ICEs, cheap electricity from coal, etc.

Lack of conducive policy frameworks

Inadequate policy frameworks in certain geographies can inhibit financing, delay CAPEX or remove incentives to decarbonise such as delayed permitting for RE grid connection of prohibitive wheeling charges

Lack of felt leadership and a compliance mindset

Despite very ambitious decarbonisation targets, the behaviours and practices of the mines does not extend past the minimum compliance requirements

dss+ recommendations to optimise decarbonisation pathways:

1. **Develop a detailed view of the company's footprint** to identify priority focus areas and generate the data and insights necessary to size and scope decarbonisation initiatives.

2. **Assess the organisation's decarbonisation maturity** to refine initiatives that align with the company's current capabilities and risk appetite.

3. **Explore future scenarios** to identify risks and opportunities, guiding the development of well-informed marginal abatement cost curves (MACCs).

4. **Systematically assess and prioritise initiatives** using MACCs, ensuring objective decision-making and identifying initiatives that could be feasible with further refinement or financial support.

5. **Incorporate qualifying initiatives into a structured decarbonisation pathway**, enhance the MACCs through a value creation frame and considering constraints such as capital availability, operational capacity, and the required emissions reduction trajectory.

6. **Develop a comprehensive decarbonisation strategy** that integrates both technical solutions and cultural and operational transformation levers necessary for successful implementation.

Step 1:

Assess current state

As we established in part 1 of this series, accurately assessing the current state of decarbonisation efforts remains a significant challenge for mining companies due to the complexity of their operations, the breadth of their value chains, and the evolving regulatory landscape. Most mining companies struggle with incomplete or inaccurate emissions data, particularly in Scope 3 emissions, leading to an overreliance on estimates that obscure the true carbon footprint. Additionally, unrealistic assumptions about the feasibility and cost of reducing emissions can result in commitments that are difficult to achieve. Without a clear and accurate understanding of their emissions baseline and reduction potential, companies risk making misinformed decisions that undermine both credibility and long-term sustainability goals. Strengthening the assessment of decarbonisation progress will allow companies to set realistic targets, prioritising impactful initiatives, and ensuring alignment with industry best practices and stakeholder expectations.

The most common issues we observe are 1) overreliance on estimates which result in an incomplete view of the company's true carbon footprint, 2) under (or over) estimating the company's ability to reduce these emissions, 3) not incorporating pragmatic estimations of what a net-zero commitment would cost before publicly committing to targets such as the Science Based Targets initiative (SBTi).

The first step in addressing these issues is to enhance the company's understanding the current state of its emissions baseline.

Some suggested actions include:

- **Consider aligning with industry-specific reporting guidelines but remain pragmatic:** Reporting frameworks like the SBTi, IFRS and CSRD are becoming more explicit in the level of detail that is required and guidelines developed by industry bodies like the ICMM (International Council on Mining and Metals), can help entities to consistently quantify emissions in line with industry best practices. Initial focus should be on emissions activities under operational control (scope 1 and 2) before advancing to value chain emissions (scope 3).

- **Stakeholder collaboration:** It is essential to engage stakeholders on decarbonisation ambitions and plans, fostering an ecosystem of collaboration can significantly streamline the process of collecting value chain emissions data. Mining companies rely on a complex ecosystem of suppliers, customers, regulators, investors, and local communities—all of whom play a role in emissions reduction. Effective engagement helps secure buy-in for sustainability initiatives, facilitates the collection of accurate emissions data (especially for Scope 3), and supports the development of feasible, industry-aligned solutions.

- **Increasing the frequency of monitoring and internal reporting:** Many companies only assess their emissions annually. This low frequency hinders a deeper understanding of the related activities and limits the ability to proactively manage the performance of decarbonisation initiatives.

- **Increasing the resolution of monitoring and internal reporting:** Ensure adequate metering and sub-metering of primary (e.g., electricity, gas, coal) and secondary (e.g., compressed air, steam, warm water) energy carriers with up-to-date calibration certificates. This increases the ability to assess and track the emissions-related performance of specific systems, equipment, or products. Precious metals might end up in a luxury goods product with the end-user more concerned about the product's performance (Life Cycle Assessment) than the organisation's performance. Detailed measurements ensure the accurate reporting of product performance.

- **Incorporating emissions as performance KPIs:** Expand the purview of data monitoring of energy management systems to provide carbon data by incorporating applicable emission factors into operational Key Performance Indicators (KPIs) and decision-making steps. This is crucial for sites with fuel-switching capabilities, but it is also important to be able to effectively communicate the emissions impact of operational decisions to various stakeholders within the business (e.g. energy-, operations-, financial- and general mangers).

- **Bridging data monitoring and reporting gaps:** Comprehensive baseline assessments and product-specific LCAs should be used to highlight monitoring and reporting gaps (especially in Scope 3 emission sources).

- **Enhancing emission quantification methodologies:** As emissions reporting matures from Tier 1 to Tier 3, track carbon mass balances in real-time, especially when product carbon performance is linked to carbon pricing mechanisms and benchmarks.

- **Scope 3 and Life Cycle Emissions:** Emissions intensity of raw materials and purchased goods and services should be a critical factor in supplier selection. For example, 80% of the life cycle emissions for aluminium automotive sheets come from sourcing primary aluminium ingots. Purchasing primary aluminium from Canada, where it's predominantly smelted with hydroelectricity (2kgCO2/kgAl compared to the global average of 15), can reduce emissions by up to 70%. Conduct Life Cycle Assessments (LCAs) to evaluate product performance and identify emission-intensive products for elimination. Certain aluminium alloys like 5849 contain high-emission elements such as chrome, magnesium, and titanium, which handicap the overall emissions performance of the alloy.

Anticipating stricter compliance demands, efficient reporting frameworks and automated data workflows can save resources and provide a single point of audit. Additionally, utilising digital twins, machine learning, and AI can aid in testing and developing decarbonisation roadmaps.

Key Takeaways:

- **Accurate emissions assessment is crucial:** Mining companies often struggle with incomplete emissions data, particularly Scope 3, leading to overreliance on estimates and unrealistic decarbonisation commitments.

- **Stronger monitoring and reporting drive better decisions:** Increasing the frequency, resolution, and integration of emissions data into performance KPIs enhances proactive management and operational efficiency.

- **Stakeholder collaboration and industry alignment accelerate progress:** Engaging suppliers, regulators, and industry bodies ensures better emissions data collection, supports compliance, and unlocks opportunities for impactful carbon reduction initiatives.

Step 2:

Evaluate decarbonisation maturity

An interesting observation from Part 1 of our series is that no executives cited technical or technological barriers as reasons for missing emissions reduction targets. However, a major barrier to effective decarbonisation was the organisation's ability to effectively execute its decarbonisation roadmap and associated strategies. A successful net-zero pathway cannot be developed and implemented in isolation from other business activities and requires alignment and transformation across all business functions with clear objectives and allocated resources.

Achieving such alignment and transformation requires the right cultural context—one that embeds sustainability into decision-making at all levels of the organisation. Leadership commitment, cross-functional collaboration, and a culture that prioritises continuous improvement, accountability and pro-active decision-making are essential to embedding decarbonisation into daily operations. Developing organisational maturity in these areas enables mining companies to move beyond isolated initiatives and drive sustained, measurable progress.

To classify an organisation's decarbonisation maturity and identify the cultural and operational shifts that are required, we make use of the dss+ Bradley Curve™ - a model that proves the correlation between operational performance and cultural maturity. The dss+ Bradley Curve™ defines the four stages of cultural maturity as follows:

1. Reactive

Focus is purely on meeting compliance requirements (e.g. TCFD/ CSRD/IFRS reporting, carbon tax, CBAM etc.).

2. Dependent

Reactive to regulatory and compliance pressure, making gradual shifts to incorporate decarbonisation and sustainability considerations into enterprise risk management processes. Work is consultant-driven with minimal management involvement.

3. Independent

Focus on integrating sustainability into business operations. Developing strong technical capabilities, but the approach to decarbonisation and sustainability actions remains conservative (e.g. waiting for proven approaches before initiating major shifts, assessing the feasibility of initiatives on the same NPV/ROI requirements as all other projects in the business).

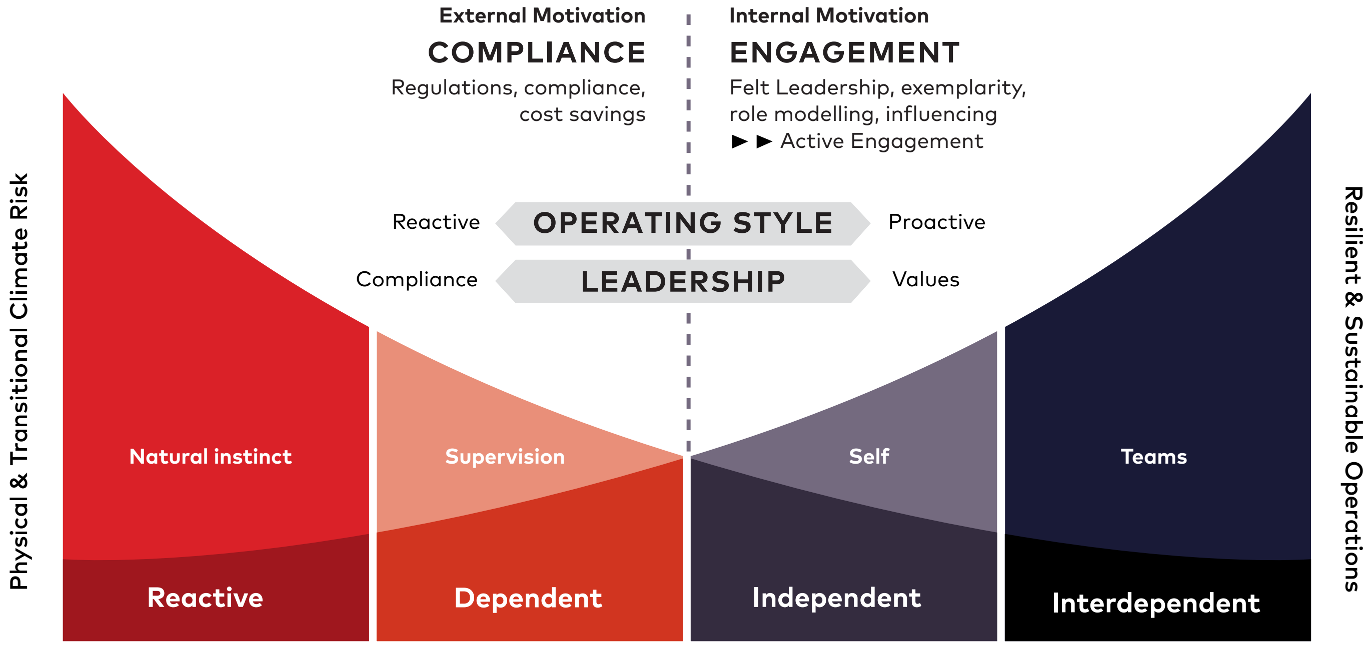
4. Interdependent

Embraces comprehensive decarbonisation and sustainability commitments (e.g. carbon neutrality, net-zero), proactively driving action and pioneering sustainable technologies & business models through a value-driven strategy (i.e. holistically considering the impact of initiatives considering factors such as cost, risk, brand equity and revenue)

As organisations move up the maturity curve, from dependence on external enforcement to an interdependent culture where sustainability is ingrained in everyday actions, they achieve better emissions reductions through innovation, collaboration, and ownership at all levels. By fostering this cultural evolution, mining companies can accelerate decarbonisation, ensuring long-term resilience and competitive advantage.

Companies could deliberately decide that they don't want to be a global leader in decarbonisation but rather an agile follower. If this is the chosen strategy, then aiming for independence should be the objective. Regardless of the level of ambition, it is important to map the existing cultural maturity early on to ensure adequate cultural enhancement for the specific ambition.

How mature is your organisation with managing the risks and opportunities associated with decarbonisation and climate change?



Physical	Unmitigated exposure to climate events across value chain Limited supplier redundancy Decisions based on history	Situational and risk awareness by management Climate hotspots identified and integrated into ERM	Climate response strategy derived from TCFD aligned assessment Detailed asset vulnerability assessment based on flood and climate models	Risk mitigation is operationalised across business functions Continues investment in R&D and climate-resilient products & services
Transitional	Compliance with local/national regulations is the goal Delegated to HSE manager Lack of management involvement	Minimum training to ensure compliance and reporting Strong and frequent monitoring of both emissions and processes in place Impact of carbon pricing/ tax well understood	Emissions are projected and deviations are analysed Strong team with technical knowledge but limited integration into business functions (operate in silos) Operations solve for efficiency but not decarbonisation based on NPV	Emissions are projected and deviations are analysed Strong team with technical knowledge but limited integration into business functions (operate in silos) Operations solve for efficiency but not decarbonisation based on NPV

Key Takeaways:

- Successful decarbonisation requires organisational alignment and strategic execution beyond just compliance.
- Greater cultural maturity around decarbonisation will allow mining companies to activate decarbonisation roadmap effectively.
- Leadership commitment, cross-functional collaboration, and a culture that prioritises continuous improvement, accountability and proactive decision-making are essential to embedding decarbonisation into daily operations.

Step 3:

Explore future scenarios

Several reporting frameworks such as the Taskforce for Climate-related Financial Disclosure (TCFD), Corporate Sustainability Reporting Directive (CSRD), and the International Financial Reporting Standards Sustainability disclosure (IFRS S1, S2) require the disclosure of risks and opportunities associated with climate change under different future scenarios. These risks and opportunities are typically projected over the short-, medium-, and long-term horizons (e.g. 2030, 2040, 2050) through scenario analysis of physical risks (e.g., droughts, flooding, heatwaves etc.) and transition risks (e.g., carbon pricing, brand reputation, regulatory requirements etc.).

The nature of these risks tends to change depending on the selected scenario, for example:

Scenario 1: Climate policies do not impose significant costs on emissions so the associated transition risks will remain relatively low, leading to significant climate change (e.g. a +3°C global warming scenario). This in turn results in significant physical risks due to extreme weather events.

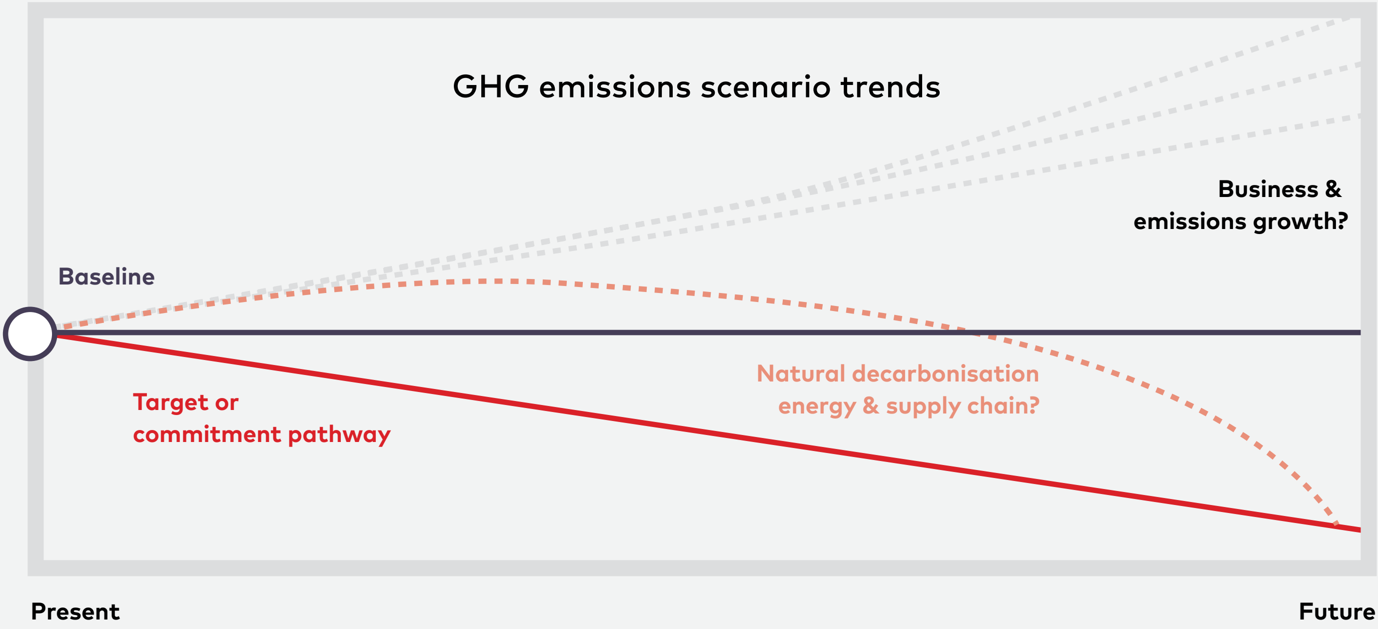
Scenario 2: Emissions are driven down aggressively by leveraging various policies & regulatory mechanisms. This presents an increased transitional risk by increasing the cost of business through emissions taxes, need-to-adopt new technologies, impact on energy/supply chain costs, product demand etc. However, the reduction in emissions also limits the rate & subsequent impact of climate change (e.g. <+1.5°C scenario) and therefore reduces the associated physical risks.

Selecting the appropriate scenario and understanding its context will prevent the under- or over-estimation of climate-related risks.

When developing a climate transition plan most companies establish baseline emissions (typically scope 1 and 2) and project future emissions solely based on their expected growth and the estimated impact of their pipeline projects. This approach often fails to include scope 3 emissions and does not objectively account for external factors associated with different future scenarios. This means that transitional or physical risks may be either over- or under-stated. For example: under the USA's Inflation Reduction Act (IRA) grid emission factors are expected to reduce by 80% by 2050 (but with a potential increase in energy cost), while if the USA departs from this approach, emissions may not reduce (but energy costs may). These two scenarios will result in vastly different risks and will also have significant impacts on the feasibility of different decarbonisation initiatives.

Several organisations, such as the International Energy Agency (IEA), Network for Greening the Financial System (NGFS), and the Intergovernmental Panel on Climate Change (IPCC), have developed future scenarios that include transitional data such as future energy costs, grid emission factors, market shifts etc. These scenarios and their parameters should be explicitly incorporated into the development of business scenarios so that the underlying assumptions are well understood and clearly articulated. It is also advisable to consider multiple scenarios (as per reporting framework guidance) to better understand how transitional & physical risks shift under different circumstances.

Example emissions scenario trends that can be used to determine the shortfall between BAU and targets



Key Takeaways:

- Most companies only consider the impact of their own growth on scope 1 and 2 emissions when projecting future emissions. The companies often overlook the impact of scope 3 emissions, and the impact different scenarios will have on external factors like changing grid emission factors.
- There is an interplay between different future scenarios and associated climate transitional and physical risks. Selecting the appropriate scenario and understanding its context will prevent the under- or over-estimation of climate-related risks.
- Utilising scenarios from organisations such as the IEA, NGFS, and IPCC can help companies develop robust scenarios to identify transitional risks and inform decarbonisation strategy development.

Step 4:

Effectively compare decarbonisation options through more accurate MACCs

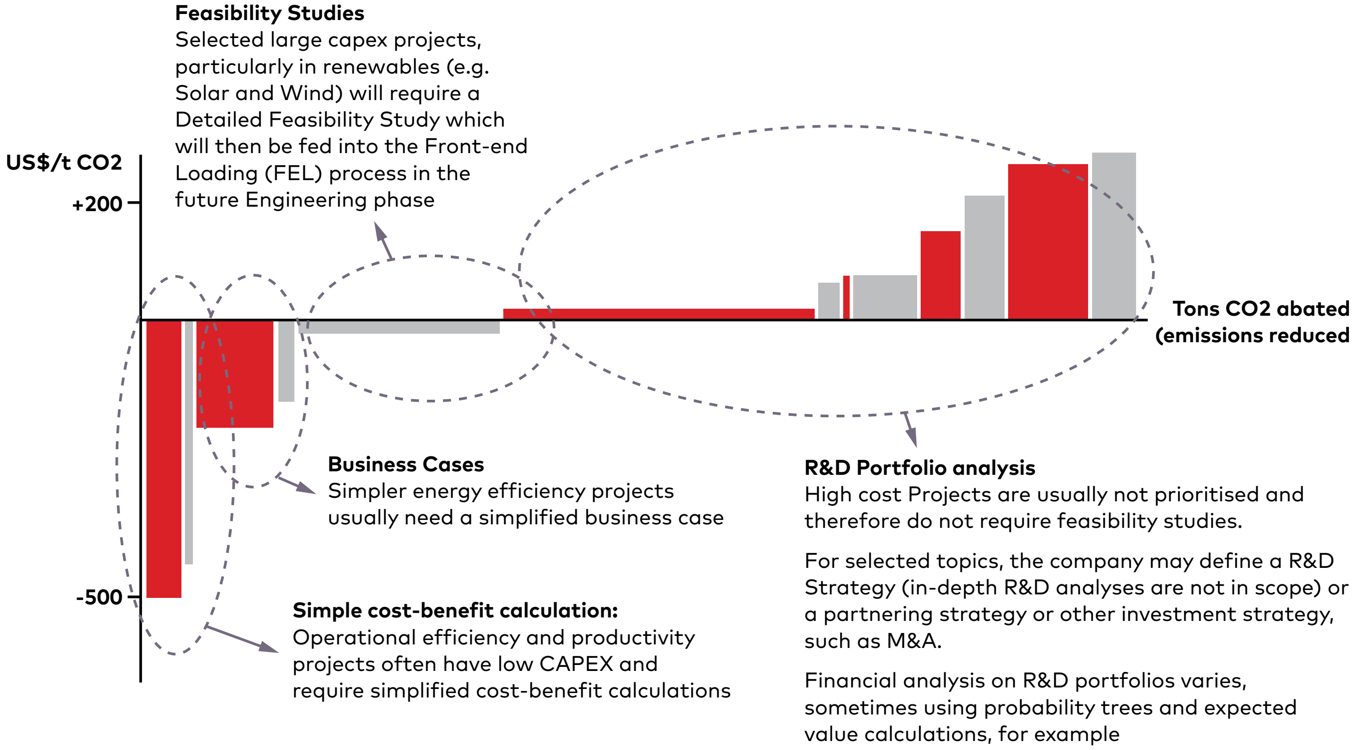
Since the introduction of **Marginal Abatement Cost Curves (MACCs)** in 2007, they have become integral to developing decarbonisation roadmaps by prioritising cost-effective abatement projects. However, accurate metrics (e.g. costs, emissions impacts and relevant scenario planning as noted in step 3) are essential for constructing MACCs that are realistic representations of the initiatives they seek to characterise and compare.

Though building accurate MACCs can be complex, they are essential for informed decision-making. Projects with marginal returns may require a detailed assessment to ensure well-informed decisions. Inaccuracies could lead to non-commitment due to unfavourable financial outcomes or incorrect initiative prioritisation and selection which in time can lead to underperforming decarbonisation strategies.

Below is an illustrative example of a MACC adopting these principles.

Project Ideation and MACC Development

Not all projects require detailed feasibility studies



A quick full potential diagnostic, designed to identify bottlenecks, asset integrity and availability issues and general inefficient resource allocation will identify several decarbonisation projects. Even though such operational excellence diagnostics are not designed in the first instance to identify decarbonisation projects they have the ability to significantly improve short-term decarbonisation performance at little to no cost. Increasing tonnes crushed and milled with 10% by improving maintenance and reliability has the unintentional side effect of decreasing emission intensity without even retrofitting expensive low-carbon technologies. Safe and stable operations often has the biggest decarbonisation impact and there is no excuse for not implementing these.

Refining assessment of abatement & cost curves:
Common retrofit technologies utilised by mining companies within their decarbonisation plans like LEDs, VSDs, and renewable energy solutions such as solar and wind have readily quantifiable abatement impacts, often provided by OEMs or detailed engineering studies. However, initiatives such as process-, control-, product-, or supply chain optimisation require a more holistic analyses as they often involve systemic interactions across multiple processes, operational constraints, and value chain dependencies. A narrow MACC analysis may underestimate or overlook secondary benefits such as increased efficiency, reduced waste, or enhanced product quality, as well as hidden costs like implementation complexity or workforce adaptation. Additionally, these initiatives can have cascading effects across emissions scopes, influencing Scope 1, 2, and 3 reductions in interconnected ways.

Important considerations include:

- **Grid emission factors:**
  Incorporate changing grid emission factors over time, as this will impact overall company emissions while potentially being detrimental to specific projects.

- **Product emissions:**
  Conduct critical reviews of product emissions relative to revenue contributions. Discontinuing low-value, high-emission products can substantially reduce portfolio emissions. Life Cycle Assessments (LCAs), in line with ISO14044, can guide such decisions, attributing foregone revenue to abatement costs.

- **Energy & emissions costs:**
  Under certain scenarios, there may be an impact to the availability of specific energy streams and additional costs/penalties could be levied on emissions. So, just as the emissions associated with different energy streams can change over time, so can the potential costs associated with these streams.

- **Technology costs:**
  Many of the technologies required to achieve a truly net-zero society are still in development so the expected emissions impact and associated costs are expected to change over time as these technologies develop and mature. Placing an initiative on the MACC based on a static technology cost brings the risk that it may be overlooked during the strategy development (e.g. consider green fuels, -chemicals, carbon capture etc.)

- **Supplier emissions:**
  Represent emissions from the supply chain in MACCs. While initiatives considering emissions reduction through supply chain changes are typically positioned higher on the MACC, this still provides a complete picture, encompassing the effort required to reduce scope 3 emissions.

It is also advisable to link the metrics used in the development of MACCs to specific scenarios (or to develop multiple assessments of the same initiative under different scenarios) to gain a holistic overview of the decarbonisation portfolio and pathway can be optimised.

A final consideration that can also be incorporated into the development of the MACCs is the possibility of improving the financial viability of selected initiatives by making use of green financing mechanisms.

Improving financial feasibility through green financing:

- **Reducing CAPEX requirements:** Making use of available grants and incentives or alternative business models such as leasing or offtake agreements.
- **Reducing cost of capital:** Utilise financial instruments such as green- or sustainability-linked bonds to obtain lower interest rates compared to conventional bonds.
- **Quantifying revenue opportunities:** Engage in voluntary carbon markets to generate short-term revenue through mechanisms such as carbon offsets or renewable energy certificates (RECs). (Note that selling these can provide additional revenue for decarbonisation initiatives but will forfeit the associated carbon reduction claim).

By refining MACC methodologies and leveraging green financing mechanisms, mining companies can effectively prioritise key decarbonisation initiatives. Accurate and comprehensive Marginal Abatement Cost Curves (MACCs) are necessary but its inherent limitation to only assess the reduction in cost makes it insufficient and requires further enhancement to also capture more strategic and value-enhancing attributes of decarbonisation initiatives. The next section covers this in more detail.

Key Takeaways:

- Accurate metrics and holistic analysis are crucial for effective construction and performance validation of Marginal Abatement Cost Curves (MACCs).
- Incorporate comprehensive abatement opportunities, including scope 1, 2, and 3 emissions, to ensure that the full value of the optimisation opportunities are captured, thus contributing to better decision making.
- Maximise financial feasibility through mechanisms that can reduce CAPEX or the cost of capital, incorporate cost savings and revenue opportunities, leverage grants, incentives, and other green financial instruments.

Step 5:

Develop decarbonisation pathways

The results from Steps 1 – 4 will generate the building blocks required to develop or refine decarbonisation pathways. In step 5, the qualifying initiatives must be incorporated into a decarbonisation pathway considering various constraints including the required reduction trajectory, available capital, personnel & operational capacity, and practical constraints of the priority initiatives identified on the MACCs (e.g. safety hazards, technology maturity, regulatory uncertainty, design & construction requirements, rate of change in costs & penalties etc.).

The process of constructing a decarbonisation pathway should not be done in isolation by a few individuals but should incorporate various stakeholders throughout the business. A proven approach to achieve this is to start with the refined candidate initiatives and developed MACCs and then go through a second iterative process with the various stakeholders:

- **Start with the technical teams**
  Re-evaluate the refined list of candidate initiatives, agree on the practical aspects of these initiatives (e.g. sizing, implementation timing, emissions impact) and update/reiterate the MACCs if needed to produce a pathway of projects that are deemed to be technically achievable by the relevant stakeholders.

- **Translate the project pathway into financial terms**
  Take the draft pathway and work with the financial teams to determine the cash flow (i.e. CAPEX, OPEX, savings) and financing requirements for the pathway, updating/reiterating the MACCs if needed, and ultimately refining the draft pathway so that it is deemed to be financially achievable by the relevant stakeholders.

Despite this rigorous approach, it is expected that there will be a shortfall between the impact of initiatives that are deemed practical based on typical business requirements and the target reduction pathway. This means that some projects necessary to meet decarbonisation targets will neither reduce operational costs nor have positive NPVs. These projects will therefore have to be assessed based on none technical and financial parameters such as risk reduction or brand equity.

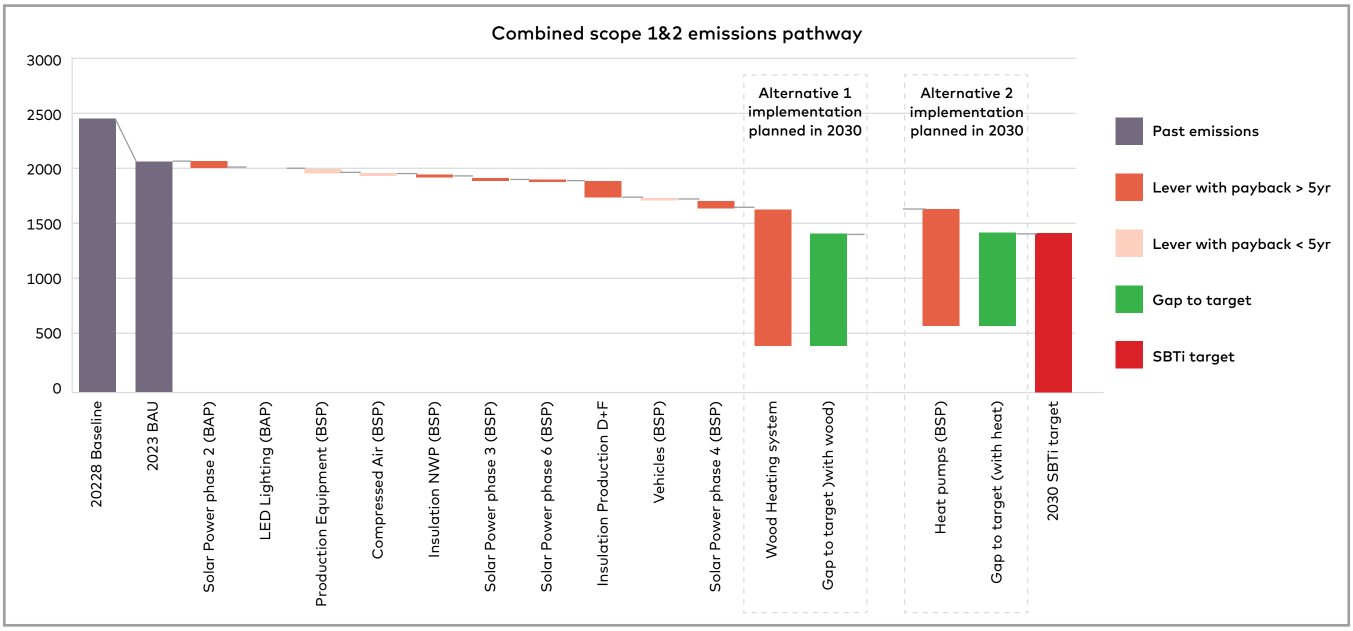
To this end also consult the following stakeholders:

- **Consider safety hazards and technological maturity** – Introducing battery electric haulage trucks could increase fire hazards, reliability and maintenance challenges but could improve air quality and overall worker health. Any such trade-offs should be well investigated and incorporated into a risk adjustment factor that reduces cost savings or increases the cost of capital i.e. risk-adjusted ROI.

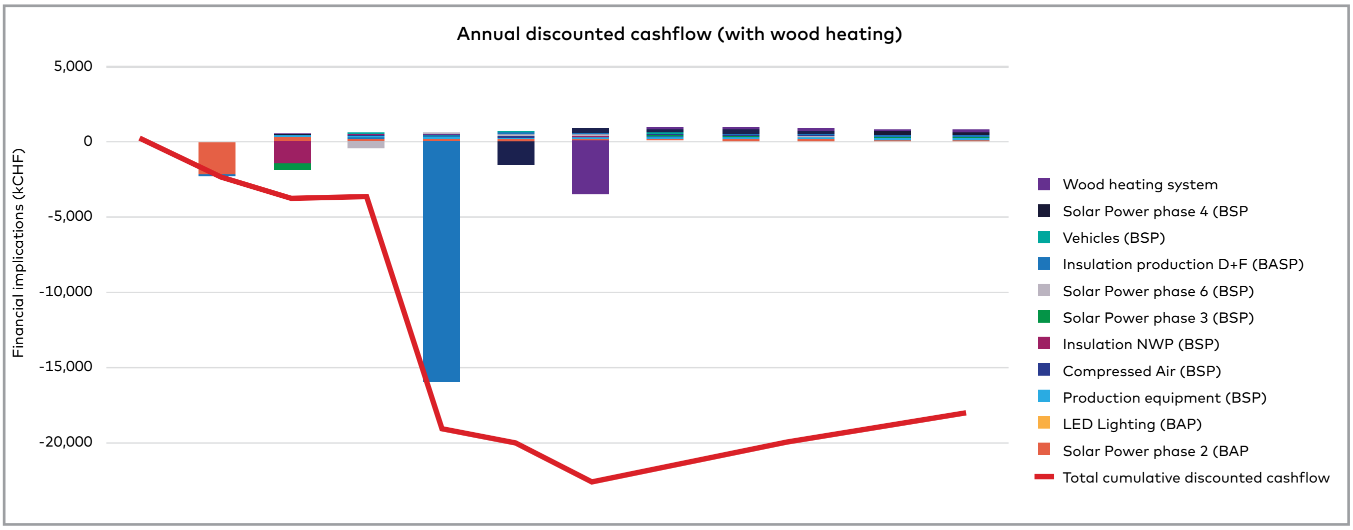
- **Involve marketing** – Adopting first of its kind or state-of-the-art decarbonisation technologies can appeal to the market and enhance brand equity. Even in commoditised markets one can anticipate a price premium for example green steel, recycled and lower carbon aluminium or even zero-carbon lab-grown diamonds.

From the above, it is clear that an opportunity exists to enhance a MACC to also reflect decarbonisation project attributes beyond the techno-economic analysis.

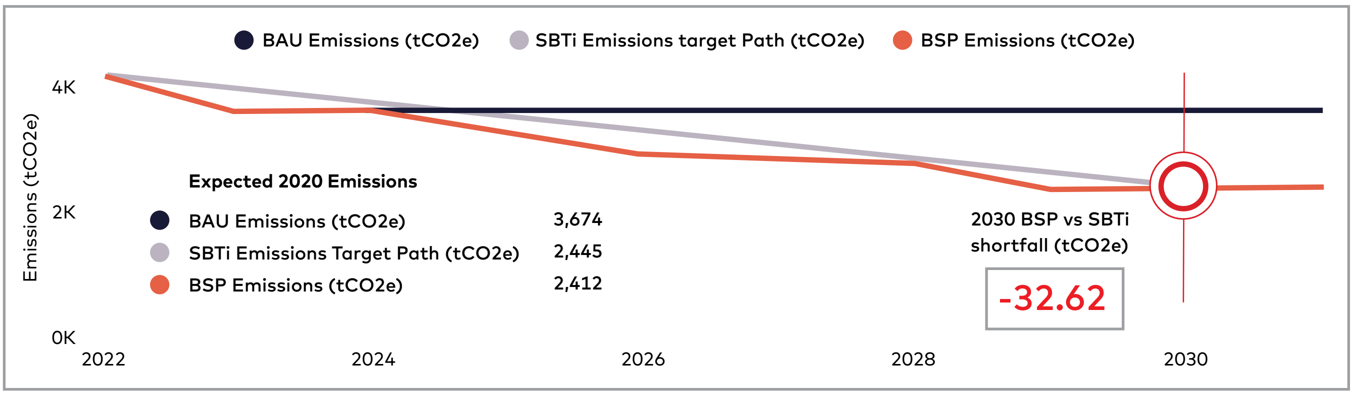
Site-specific decarbonisation initiatives waterfall with detail metrics and characteristics



The expected annual & cumulative cashflow implications of the selected initiatives



The expected emissions reduction associated with the strategic selection against SBTi targets compared to a BAU scenario



* BAU: Business As Usual (i.e. continuing with the present state of affairs)
BAP: Business As Planned (i.e. incorporating existing future plans)
BSP: Business Strategic Plan (i.e. interventions & actions considered for the decarbonisation strategy)

To this end, we recommend considering the impact of an intervention based on its timeline and its potential to decrease downside or increase upside of the following:

- **Reduced costs:** Typically considered as part of the MACC assessment and general project assessment procedures.

- **Increased Revenue:** Innovation to reduce emissions can potentially unlock new business models and revenue streams, these innovations can also make businesses more resilient to other climate change risks (whether transitional or physical) and as a result can increase market share where competitors are less resilient.

- **Reduced Risk:** Long-term considerations beyond the direct cost impact includes risks that could impact the value of the business, its ability to perform its activities without disruption, or pushback from stakeholders, shareholders, suppliers, clients & regulators.

- **Brand Equity:** Effectively achieving decarbonisation ambitions can enhance brand equity, especially as climate change remains a top concern for customers, investors and employees.

Assessing carbon abatement options through this dss+ value creation dimensions allows for updating the MACC to reflect risk adjustments for specific risks like safety hazards or technological maturity. The risk (probability x impact) is simply factored in by reducing or increasing the revenue of a new technology with this risk factor. Similarly, any enhancement in brand equity can reduce the weighted average cost of capital. This creates a more comprehensive assessment of decarbonisation options for management to select a decarbonisation pathway.

Developing effective decarbonisation pathways involves a complex, iterative process that requires comprehensive stakeholder engagement and a blend of cost-reducing and value-driven initiatives that will enable the management team to make the critical decisions required to align achievable decarbonisation pathways with overall business strategies while mitigating associated risks.

Key Takeaways:

- The development of decarbonisation pathways is an iterative optimisation process that incorporates identified & prioritised initiatives within various constraints. It is therefore critically important to systematically include various stakeholders throughout the business (e.g. technical-, financial-, and management-teams) to ultimately deliver a pathway that is practically achievable and supported throughout the business.

- It is possible that the company will not be able to achieve its decarbonisation ambitions by only making use of initiatives that reduce costs and have positive NPVs. It is therefore necessary to also evaluate candidate initiatives under a values-based framework to identify the ones that best align with the overall business strategy (whether that is that is reducing risk, improving brand equity, or increasing revenue).

- Failure to act on decarbonisation poses risks to the business, however, failure to achieve publicly stated decarbonisation ambitions also holds significant risk (including shareholder activism, loss of certifications, brand equity, market share etc.).

Step 6:

Factor in cultural transformation

Effective decarbonisation in the mining sector is not just a technical challenge – it is a transformation that requires agility, adaptability, and organisational commitment. Too often, mining companies focus heavily on technological solutions while underestimating the cultural and leadership shifts needed to drive lasting change. Successful large-scale transitions depend on an organisation's ability to align people, processes, and mindsets with new ways of working. Without a strong cultural foundation, even the most advanced decarbonisation strategies risk falling short of their potential.

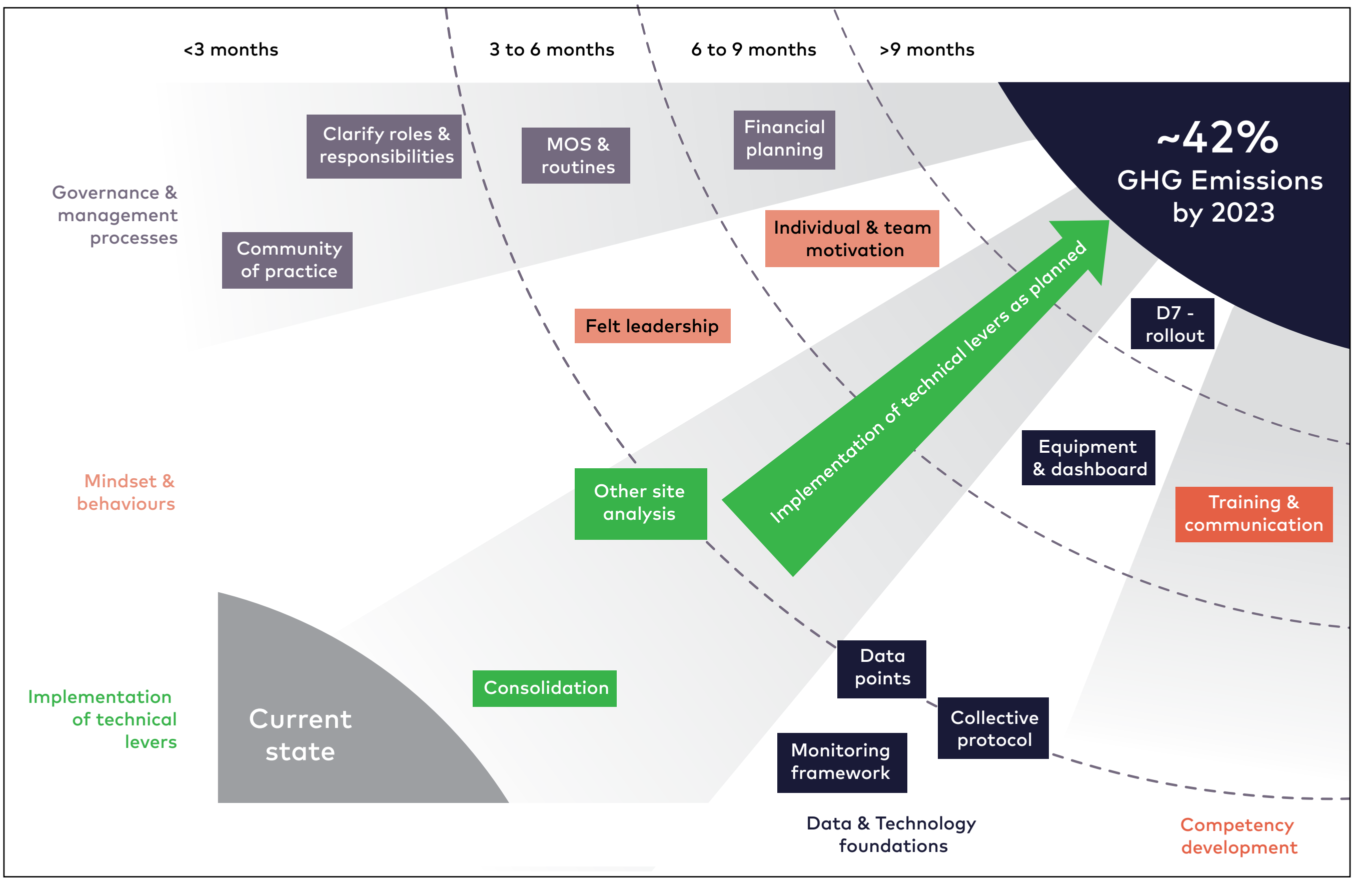
The dss+ integrated model combined the cultural elements that mining companies should prioritise:

- **Mindset and behaviours of leaders:**
  Establishing a decarbonisation strategy requires a fundamental shift in the mindset and behaviours of leadership. Leaders must embrace sustainability as a core value and drive a culture of environmental responsibility. This entails prioritising climate actions and steering the organisation towards green initiatives. They need to set ambitious goals, inspire by example, and foster a shared vision aligned with carbon reduction targets. The strategy might not be perfect but focus on rapid iterations of investment and innovation to break the status quo of inaction. Leadership commitment and visible actions are vital in galvanising the entire organisation towards a decarbonised future.

- **Governance and management process:**
  Robust governance and management processes are critical for the execution of a decarbonisation strategy. This involves establishing clear roles and accountability frameworks to ensure all levels of the organisation are aligned with sustainability objectives. Key activities include integrating carbon reduction targets into corporate governance, regularly monitoring progress, and reporting transparently. A strong governance structure enables the organisation to adapt and respond effectively to evolving regulatory requirements and stakeholder expectations.

- **Capabilities and competencies:**
  Building the necessary capabilities and competencies within the organisation is essential for a successful decarbonisation strategy. This encompasses both technical skills related to innovative technologies and systems, as well as soft skills such as change management and collaboration. Investing in training and development ensures that employees at all levels are equipped to drive and support decarbonisation efforts. Innovation and continuous learning should be encouraged to keep pace with advancements in sustainable practices and technologies.

- **Design and implementation of systems, processes, and technologies:**
  A well-designed and implemented infrastructure of systems, processes, and technologies form the backbone of a decarbonisation strategy. This includes adopting energy-efficient technologies, optimising resource use, and integrating renewable energy sources. Effective systems and processes should be in place to track and manage emissions, identify opportunities for improvement, and ensure compliance with environmental standards. Continuous improvement through regular audits and updates to systems ensures long-term success in achieving decarbonisation goals.



dss⁺ integrated model to align all business functions with technical objective

By embedding sustainability into decision-making, fostering a workforce equipped for change, and implementing systems that drive accountability and continuous improvement, mining companies can create a resilient, agile organisation capable of meeting decarbonisation goals. Prioritising cultural transformation alongside technical solutions will not only accelerate emissions reductions but also position companies for long-term success in an evolving industry landscape.

Key takeaways:

- A complete decarbonisation strategy requires that both technical & cultural transformation needs are effectively addressed.
- Critical levers necessary for the effective implementation of a decarbonisation strategy include:
  1) Mindsets and behaviours of leader;
  2) Governance and management process;
  3) Capabilities and competencies;
  4) Design and implementation of systems, processes, and technologies.

Conclusion

Mining companies face significant barriers to decarbonisation, from data accuracy challenges and misaligned targets to the complexity of assessing and implementing initiatives. The structured approach we propose provides a practical roadmap to overcome these challenges by ensuring companies develop a clear emissions baseline, assess their decarbonisation maturity, anticipate future risks and opportunities, and systematically evaluate potential initiatives.

By integrating the following steps, mining organisations can move beyond fragmented or reactive efforts, instead taking a proactive, data-driven, and strategic approach to emissions reduction.

1. **Develop a detailed view of the company's footprint** to identify priority focus areas and provide the data and insights necessary to size and scope candidate decarbonisation initiatives.

2. **Understand the present level of decarbonisation maturity** to refine candidate initiatives so that they objectively match the company's capabilities and appetite for decarbonisation.

3. **Explore different future scenarios** to enable the objective identification of potential risks and opportunities, which in turn inform the development of well-informed marginal abatement cost curves (MACCs).

4. **Systematically assess and prioritise potential initiatives using MACCs**, enabling objective decision-making and identifying initiatives that could become feasible with additional refinement or financial support.

5. **Incorporate qualifying initiatives into a decarbonisation pathway,** considering constraints such as the required reduction trajectory, available capital, operational capacity, and the practical limitations of the identified initiatives.

6. **Develop a comprehensive decarbonisation strategy** that includes both the technical and cultural transformation levers required for successful implementation.

Beyond compliance, effective decarbonisation delivers tangible business value. It enhances operational efficiency, mitigates regulatory and financial risks, and strengthens stakeholder trust – including from investors, customers, and communities increasingly demanding responsible mining practices.

Companies that embrace decarbonisation not only future-proof their operations but also unlock new opportunities, such as access to green financing, preferential supplier status, and improved workforce attraction and retention.

dss+

At dss+, we help mining companies navigate this transformation by combining deep industry expertise with a comprehensive understanding of both technical and cultural levers for change. Our experience shows that lasting impact comes from embedding sustainability into core business strategy – aligning leadership, governance, workforce capabilities, and decision-making processes to drive real results.

By partnering with dss+, mining companies can turn decarbonisation ambition into action, ensuring a more sustainable and resilient future for their operations and the industry as a whole.

Authors

Gerhard Bolt
Principal, Sustainability & Mining, dss+
gerhard.bolt@consultdss.com

Walter Booysen
Senior Manager, dss+
walter.booysen@consultdss.com

About dss+
dss+ is the operational transformation partner for complex and high-hazard industries. We help organisations achieve breakthroughs in safety, performance and sustainability that drive lasting success.

Combining deep technical expertise and decades of hands-on experience with cutting-edge methodologies and data-driven insights, we empower teams to shift mindsets, shape cultures and build the capabilities needed at every level.

www.consultdss.com

Contact us

dss+
Protect. Transform. Sustain.

linkedin.com/company/consultdss
twitter.com/consultdss
youtube.com/consultdss
instagram.com/consultdss
www.consultdss.com