Strategic Scenario Planning for Mining-Fleet Investment Decisions Under Energy-Cost and Carbon Uncertainty

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ABSTRACT

Purpose– *This study examines an operations decision faced by a mining contractor: which powertrain to choose when replacing a diesel haul fleet, given that each option's merit depends on futures the firm cannot control, namely the diesel price, the cost of electric trucks, and the carbon intensity of the charging grid.*

Design/methodology– *The study is a single embedded case study of a 28-truck haul fleet at a coal concession in Central Kalimantan, Indonesia. It applies a four-phase intuitive-logics scenario-planning cycle: identifying driving forces, isolating two critical uncertainties, energy-cost pressure and electric-vehicle accessibility, building four scenarios from their two-by-two, and comparing five powertrain pathways within each future on cost, carbon, operational risk, and disclosure readiness.*

Findings– *Solar-powered electrification remains a reliable pathway across all four future scenarios, while diesel is only sustainable when diesel prices are low. Grid-powered electrification is the lowest-cost option but a misstep for carbon-emissions reduction, as a coal-dominated grid increases fleet emissions by 46 to 56 percent. The same energy cost factors determine the future scenarios and drive the economics of each pathway, so the right choice changes with future assumptions.* The paper contributes a replicable decision architecture that couples scenario planning with real-options reasoning, giving managers of capital-intensive fleets a way to stage an irreversible electrification commitment under deep energy-cost and carbon uncertainty rather than treating it as a one-off comparison.

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A. INTRODUCTION

For mining contractors, choosing a haul truck drivetrain is a strategic investment decision. Companies purchase trucks in fleets, use them for many years, and pay for them with capital that could otherwise be allocated elsewhere. Therefore, today's drivetrain choice determines the company's cost structure, its exposure to fuel and carbon shocks, and, in part, its competitive position well beyond the next budget cycle. Research strategy considers these kinds of decisions, large, long-term, and difficult to reverse, most important precisely because they are made before the future that determines them is known (Furr & Eisenhardt, 2021). The contractor studied here faced exactly such a decision. They operate 28 heavy-haul trucks in a fixed coal corridor within a concession in Central Kalimantan, and they had to decide whether to keep purchasing diesel units or

transition part or all of the fleet to hybrid or electric drivetrains.

The decision carries strategic weight because of its scale and irreversibility, and because it ties the firm to outcomes that clients, regulators, and investors now watch. A fleet that is cheaper to run under a fuel-price shock, and that produces auditable low-carbon operating data, dampens cost-per-tonne volatility and builds the sustainability record that increasingly shapes competitive standing and access to capital. In the Indonesian market, financing and capital-structure decisions behind that standing have also been linked to firm value (Pradnyani & Widhiastuti, 2024). That record is about to become a formal obligation. The contractor is preparing a 2028 listing, at which point it will be bound by mandatory sustainability and climate disclosure under Indonesia's PSPK 1 and 2 standards (effective from 2027 and aligned with IFRS S1 and S2) and by the financial regulator's reporting rules for listed firms. For a contractor whose direct emissions come mainly from diesel transport, the powertrain choice sets the numbers that will enter the public record and be weighed by investors, making it a matter not only of fuel but of disclosure risk, investor confidence, and competitive position.

The difficulty is that the decision depends on conditions the contractor cannot determine, and no forecast can resolve them. Diesel prices reached around Rp 28,000 per liter at the site in early 2026 under supply pressure from disruptions in the Strait of Hormuz; the price of electric haul trucks has fallen but remains unaffordable for the contractor; and the electricity grid that will power the trucks, the Barito System, draws about 70 percent of its power from coal, so electrification does not automatically reduce emissions. Each of these factors can change over the life of the investment, and each changes the ranking of options. Deciding based on a single point forecast means betting the fleet on one future. With such profound uncertainty, more accurate predictions offer little advantage. What is needed for decision-making is foresight: the ability to sense how the environment might evolve and to shape investments that are sustainable across multiple plausible futures (Schoemaker, 1995; Haarhaus & Liening, 2020).

This is where the firm's usual decision tools fall short. A total cost of ownership calculation ranks the powertrain options crisply, but only under one set of assumed prices; it says nothing about how that ranking survives if diesel falls back or the grid cleans faster or slower than expected. Scenario planning, by contrast, maps the futures a firm may face, yet on its own it stops at description and does not choose. A contractor making an irreversible capital commitment needs both at once: to picture the futures and to test each option against them. Framed this way, the choice becomes staged rather than a single irreversible bet, in the logic of real options, where a firm keeps its options open and defers a large commitment until uncertainty resolves enough to justify it (Trigeorgis & Reuer, 2017), while scenario planning supplies the futures against which those options are weighed (Marinković et al., 2022). This study builds that combination on the contractor's own data.

Two bodies of work address this decision, but each stops short. Scenario-based studies of energy-transition choices have focused on developed economies whose grids are already clean or cleaning quickly, so electrification improves the carbon score under almost any future, narrowing the analysis to cost and timing (Kügemann & Polatidis, 2020). The techno-economic literature, for its part, ranks powertrains by discounted lifetime cost under one assumed price path, tying the answer to a forecast the firm cannot control and saying little about how the ranking holds when that forecast moves. Neither line has been brought to an irreversible fleet-capital commitment made on a coal-heavy grid in a developing economy, where the cheapest electric pathway can be the dirtiest and the firm is about to be held to its disclosed carbon under a listing mandate. This study addresses that gap. It asks how a mining contractor should select and stage a powertrain pathway to build a credible ESG record by its 2028 listing, under uncertainty about energy costs and electric-vehicle accessibility, in a setting where electrification and decarbonization are not the same move.

The contribution here is applied. The paper runs through the full scenario planning cycle, from the driving forces in the contractor's environment, through two critical uncertainties and the four possible futures they define, to the strategic options each future opens up. Within each future, five drive system pathways are compared based on cost, carbon, operational risk, and disclosure readiness, and the analysis identifies which pathway best fits which future, which remains valid across all four, and how companies should sequence their steps. The paper estimates the cost and carbon figures from the operator's operational records and published national emission factors. It

emphasizes the foresight cycle and the strategic investment decisions it informs.

B. LITERATURE REVIEW

Strategic Investment Decisions Under Uncertainty

The powertrain selection decisions studied here fall into a class that strategic management research treats as distinct: wide, long-term, resource-committing choices whose payoffs depend on conditions the firm cannot control or predict with certainty. The dominant analytical convention for such choices, discounting a single stream of projected cash flows, assumes that the future is sufficiently known to be priced. Furr and Eisenhardt (2021) argue that this resource and forecasting logic works in stable, low-uncertainty markets but weakens as uncertainty increases, where a commitment's value depends less on the accuracy of a single forecast and more on its ability to adapt as the environment changes. For mining contractors weighing irrevocable fleet investments against fluctuating fuel prices, uncertain technology costs, and a changing power grid, such decisions fall squarely in the realm of high uncertainty.

One branch of the strategy literature answers that territory with real options. Rather than treat an investment as a now-or-never bet, real options reasoning treats it as a set of rights to defer, stage, expand, or switch that a firm can exercise as uncertainty resolves, so that the timing of commitment becomes a strategic variable in its own right (Trigeorgis & Reuer, 2017). The logic fits a fleet transition well: a contractor need not electrify all at once; it can hold a bridging position, keep the option to move open, and commit the larger capital once price and policy signals governing the payoff have clarified. What real options do not supply is the picture of the futures against which those options are judged, which is the work of strategic foresight.

Strategic foresight provides that picture. A systematic review of corporate foresight positions it as an organized practice for anticipating and preparing for alternative futures, linked to stronger strategic decision-making and adaptive performance (Marinković et al., 2022), and firm-level evidence associates foresight with greater strategic flexibility and decision rationality, the more so as environmental uncertainty rises (Haarhaus & Liening, 2020). One force now reshaping those futures for capital-intensive firms is sustainability. Environmental, social, and governance performance has moved from a reporting afterthought to a strategic variable that shapes competitive position and access to capital; in Indonesia specifically, ESG disclosure has been found to raise firm value by building competitive advantage (Rohendi et al., 2024). In the same Indonesian setting, a firm's capacity for sustainable growth has been tied to the strength of its operating fundamentals (Meiliani et al., 2024), which for a haul contractor runs largely through the cost and carbon profile of its fleet. For a contractor preparing to list under mandatory sustainability disclosure, the carbon profile of its fleet is therefore a core part of the strategic calculus this study sets out to inform.

Scenario planning developed as a way for capital-intensive firms to prepare for futures they could not predict. Wack (1985), writing from Royal Dutch Shell's planning group, described scenarios as a discipline for changing managers' mental maps rather than for producing a single forecast, after the approach helped Shell read the 1973 oil shock better than its competitors. Schoemaker (1995) later formalized the method for wider use. He argued that its purpose is to explore several plausible futures so a strategy can be stress-tested against each, not tuned to one. That framing fits an irreversible fleet-capital decision taken under volatile energy prices. What threatens such a firm is a plan that holds up in one future and fails in another. The technique has since grown into a broad family of methods with a documented lineage of more than four decades in corporate planning, which is part of why it travels well to a capital-intensive fleet decision (Bradfield et al., 2005).

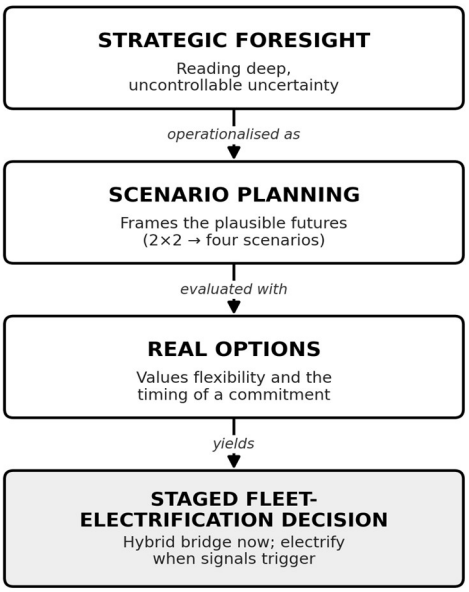
The method has a recognized procedural form: the intuitive-logics tradition that grew out of Shell's Global Business Network practice. Amer, Daim and Jetter (2013), in the most widely cited review of the field, set out its core sequence: state the focal decision, scan the environment for driving forces, sort those forces into predetermined elements and genuine uncertainties, rank the uncertainties by impact and unpredictability, pick the two most decision-relevant as the axes of a matrix, and build the scenarios from there. Schoemaker (1995) offers a compatible sequence, and stresses one separation above the rest, between what is broadly knowable and what is deeply uncertain. Van der Heijden (1996) frames the scan itself as reading driving forces across a layered environment that runs from contextual forces a firm cannot influence to the transactional forces of its own industry. Practitioners condense these accounts into four working phases: driving

forces, critical uncertainties, plausible scenarios, and implications and paths. This study follows that structure. Ramirez and Wilkinson (2014) examine the two-by-two matrix the fourth phase produces and defend its deductive logic, in which the analyst commits in advance to the two most decision-relevant uncertainties and reads the four quadrants as distinct strategic worlds.

Scenario planning frames futures but does not, by itself, say which option to choose, so one strand of work pairs it with a structured comparison of options across scenarios. Stewart, French and Rios (2013) treat scenarios as states of the world across which one set of options is compared for robustness rather than optimized for a single expected case, and Ram, Montibeller and Morton (2011) show how re-examining strategic options across scenarios exposes which choices stay strong and which lean on a favorable future. Montibeller, Gummer and Tumidei (2006) give a practical account of doing this in real decision workshops. This study applies the design principle without a formal scoring model: compare the pathways within each future, then look for the one that remains sound across all of them.

Most published applications of scenario-based decision analysis to energy-transition choices sit in developed economies with clean or fast-cleaning grids. There, electrification improves the carbon score under almost any scenario, and the decision narrows to cost and timing. The contractor here sits in a different world. Its charging grid is coal-heavy and cleans slowly, so grid-charged electrification can raise fleet carbon rather than lower it; this study quantifies that effect for the case fleet and one open-pit mining study reported elsewhere for dirty charging grids (Tokac et al., 2025). The carbon question therefore does real work here: it separates grid-charged from solar-charged electrification instead of treating both as equally clean. A framework built for a clean grid would miss this, because it treats electrification as uniformly good for carbon. This study examines the fleet-electrification decision on a coal-dominant grid in a developing economy, where carbon and cost pull in different directions and the firm must choose under a disclosure mandate that holds it to the outcome.

Figure 1 draws these three strands together: strategic foresight frames the decision, scenario planning maps the plausible futures, and real-options reasoning values the flexibility to time an irreversible commitment within them.



Source: Authors' elaboration,2026

Figure 1. Conceptual framework linking strategic foresight, scenario planning, and real options.

C. RESEARCH METHODOLOGY

This is a single embedded case study (Yin, 2018) of one mining contractor's powertrain-pathway decision. The single case is deliberate, not a convenience sample. It is a critical case in Flyvbjerg's (2006) sense: a coal-dominant grid and a live energy-price shock are exactly the conditions under which the standard prescription to electrify is most likely to fail. A framework that resolves the decision here should therefore travel to the wider class of coal-heavy developing-country operations. Within the single case, five powertrain pathways form the embedded sub-units of analysis.

Five pathways make up the decision set: the diesel incumbent (business as usual, ICE), a diesel-electric hybrid bridge, a full electric fleet charged from the PLN grid (EV-PLN), a full electric fleet charged half from on-site solar and half from the grid (EV-Solar 50/50), and a full electric fleet charged almost entirely from on-site solar with battery storage (EV-Solar 100%). The contractor is considering these options; they examined a solar-plus-genset configuration as a contingency and dropped it once grid connection was judged feasible.

The decision inputs come from three streams. The primary stream is the contractor's

2025 operating records for all 28 trucks over 12 months, which fix the empirical fuel intensity at 22.92 liters per hour, along with the fleet's tonnage and utilization. A second stream is a techno-economic and carbon model built on those records, which yields the five-year cost of ownership, the grid emission factor, and the greenhouse-gas intensity for each pathway from published national emission factors and current market prices for fuel, electricity, trucks, and solar plants.

Third is expert validation. The analyst, not the managers, generated the candidate driving forces through the layered environmental scan set out below, so the force list rests on documented evidence rather than recollection. Three senior managers of the contractor, the Deputy Director Plant, the Manager Maintenance Strategic and Development, and the Area Manager of the site, were then consulted to confirm the inputs the archival record does not capture: the current market and contract prices for hybrid and electric trucks, the maintenance and availability parameters behind the cost model, and the executive priority ordering that sets how much weight cost, carbon, and disclosure readiness carry against one another. The consultation was a structured discussion around the assembled evidence rather than a formal elicitation, and it served a confirmatory role. It did not originate the forces or fix their ranking; both follow the impact-and-uncertainty procedure described below. The model provides the cost, carbon, and emission-factor figures, and the analysis reports them only as far as the pathway comparison requires, keeping its focus on the scenario-planning cycle.

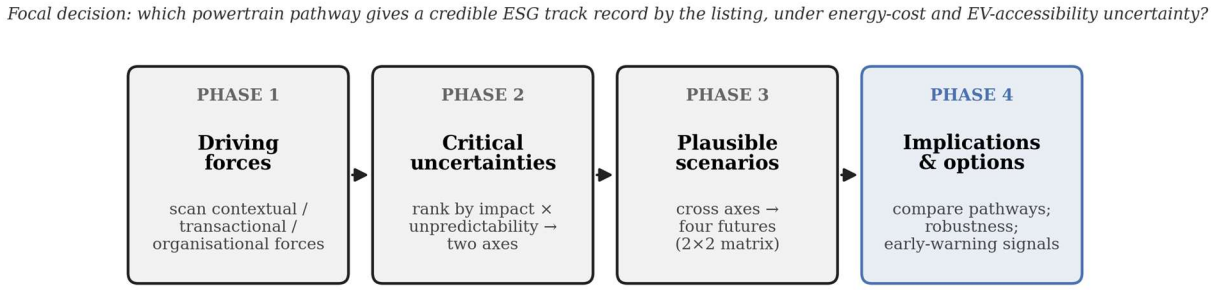
Scenario analysis here follows the intuitive-logics process in four phases: identifying driving forces, isolating the critical uncertainties, developing plausible scenarios, and drawing out implications and paths (Amer et al., 2013; Schoemaker, 1995). This condenses fuller step-by-step accounts, such as Garvin and Levesque's (2006) eight steps, into the phases a working analysis actually moves through. It keeps the decision legible to a management readership without dropping a stage. One question anchors all four phases: how should the contractor select a powertrain pathway that gives it a credible ESG track record by its 2028 listing, under uncertainty about energy cost and electric-vehicle accessibility.

The first phase identifies and sorts the driving forces. Candidate forces come from a layered scan of the contractor's environment in the sense of Van der Heijden (1996), reading across the contextual forces the firm cannot influence, such as the crude price and the grid's generation mix, the transactional forces of its own industry, such as truck availability and the PLN tariff, and its own operating baseline. The scan draws on sector literature and 2025 operating records, not unaided judgment, which keeps the list auditable. Each force is then sorted into predetermined elements, settled or slow enough to hold constant across every future, and genuine uncertainties that could break either way over the 2026 to 2028 window. A high-impact force that is effectively fixed belongs in the backdrop shared by all four scenarios, not on an axis.

Ranking follows, and it is where the two axes are earned rather than assumed. Each uncertain force is scored on how far it would move the powertrain decision if it broke one way rather than the other, and on how unpredictable it is over the planning window. The scale is qualitative: high, moderate, or low, informed by operating records and confirmed in expert consultation. Two forces rank high on both counts: the site diesel price and the acquisition price of electric haul trucks, which become the axes. The method uses exactly two because the deductive two-by-two treats the four quadrants formed by two high-impact uncertainties as distinct strategic worlds (Ramirez & Wilkinson, 2014), and a third axis would multiply the futures beyond what a management team can reason about at once. Forces that rank lower, or that affect revenue rather than the powertrain cost of ownership, are carried into the scenarios as narrative context or tracked as early-warning signals—Table 2 records where each was placed and why.

Each quadrant is then developed into a plausible future and tested against the three checks the scenario-planning literature treats as the marks of a sound set: that the future could realistically arrive from where the firm stands today, that its elements do not contradict one another, and that it would change what the contractor should do (Schoemaker, 1995; Wright et al., 2013). All four quadrants are checked against all three. Each is also mapped onto an archetype from Shell's Energy Security Scenarios (Shell, 2025), which anchors the local case in a published framework. One quadrant provides additional validation that was not planned. The Hybrid Bridge world describes the posture the contractor had already adopted on operational grounds before this analysis was run, so the matrix reproduces a decision the firm reached independently.

The fourth phase asks what each future implies, compares the pathways within each, and names the early-warning signals that tell the firm which future it is entering. Figure 2 sets out the four phases.



Source: Authors' elaboration, 2026

Figure 2. The four-phase intuitive-logics scenario-planning cycle.

The analysis moves through the pathways in two passes. The first pass reads each quadrant on its own terms and asks which pathway best fits the conditions the future presents, yielding a preferred pathway for each future. The second pass reads across the quadrants and asks a different question: which pathway holds up across the whole set of futures, since the contractor has to commit before knowing which one arrives. A pathway is treated as robust when it stays at or near the best choice in the largest number of futures and fails outright in none that are likely, following the logic that compares options across states of the world instead of optimizing one for a single expected case (Stewart et al., 2013; Ram et al., 2011). A pathway that wins in only one quadrant is marked fragile, and one that stays strong across several is marked robust. This two-pass procedure, per-quadrant fit followed by cross-quadrant robustness, separates the pathway worth committing to from the pathway that merely happens to suit today, and it runs without numerical weighting because the weighting itself shifts between futures.

Within each future, the five pathways are compared on the dimensions that matter to the contractor: cost of ownership, carbon intensity per tonne, operational risk and workforce safety, and readiness for both the 2027 disclosure mandate and the 2028 listing. The comparison is directional rather than scored, drawing on operating records, cost and carbon estimates, and managers' validation to ask one question in each quadrant: which pathway best fits the conditions the future presents. No fixed weighting is imposed across the dimensions because the balance among them shifts from one future to the next, and the scenario structure is built to capture that shifting balance (Stewart et al., 2013).

D. RESULTS AND DISCUSSION

The forces that drive the contractor's powertrain decision sit at three depths of its environment, following Van der Heijden's (1996) layered scan. The contextual layer includes macro forces the contractor cannot influence: global crude prices that set diesel prices at the site, the battery-cost learning curve that sets the price of electric trucks, the Barito grid's generation mix and carbon intensity, and national carbon-pricing policy. The transactional layer holds the industry forces the contractor deals with directly: the price and availability of hybrid and electric haul trucks from validated manufacturers, the PLN industrial tariff and grid-connection timeline, and the decarbonization requirements its mining clients pass down. Closest in sits the organizational layer: the contractor's operating baseline, its measured 22.92 liters per hour, its maintenance profile, and its fleet availability, all known rather than uncertain and entering the analysis as fixed inputs.

Table 1 lists the forces that survived the scan and marks each as predetermined or uncertain. This sorting reflects the discipline the intuitive-logics method insists on: a high-impact force that is effectively settled belongs in the constant backdrop of every scenario, not on an axis. Four forces are predetermined for the 2026 to 2028 window. The 2027 disclosure mandate and the 2028 listing target are fixed dates the contractor is planning around. The grid stays coal-heavy through the window, and on the committed build schedule it becomes more coal-intensive before it cleans, so its dirty state is constant over the horizon rather than variable. The hybrid and diesel cost parameters are

validated and stable. These sit in the backdrop. The remaining forces are genuinely uncertain, and the second phase ranks them.

Table 1. Driving forces and their disposition over the 2026–2028 decision window

Driving force	Environmental layer	Impact	Uncertainty	Disposition
Site diesel price (crude, Hormuz)	Contextual	High	High	Uncertain — axis candidate
Electric-truck acquisition price (battery learning curve)	Contextual	High	High	Uncertain — axis candidate
Electric-truck availability at fleet scale	Transactional	High	High	Feeds the accessibility axis
Barito grid emission factor	Contextual	High	Low (coal-heavy through 2028)	Predetermined; monitored
National carbon-pricing enforcement	Contextual	Moderate	Moderate	Early-warning signal
Coal price (contractor revenue side)	Contextual	Moderate	High	Narrative context
PLN industrial tariff and connection timeline	Transactional	Moderate	Low (regulated, slow)	Predetermined; monitored
Hybrid truck availability and price	Transactional	Moderate	Low (validated)	Predetermined
Client decarbonization requirements	Transactional	Moderate	Moderate	Narrative context
Fleet fuel intensity, maintenance, availability	Organisational	High	Low (measured)	Fixed input
PSPK 2027 disclosure mandate	Contextual	High	Low (fixed date)	Predetermined
2028 listing target	Organisational	High	Low (firm commitment)	Predetermined

Source: Authors' elaboration, 2026

The second phase takes the forces marked uncertain in Table 1 and ranks them on two questions: how much each would change the powertrain decision and how unpredictable it is over the planning window. Table 2 sets out that ranking. Two forces score high on both and become the axes. The site diesel price is the largest single term in the diesel and hybrid cost of ownership, and it swings with global crude and the Hormuz disruption, so it is both high impact and genuinely uncertain. The acquisition price of electric haul trucks, driven by the battery-cost learning curve and the scaling of Chinese manufacturers, determines whether full electrification is procurement-viable at the contractor's scale, and it is also high on both counts. These become the horizontal axis (energy-cost pressure) and the vertical axis (electric-vehicle economic accessibility).

The other uncertain forces remain but are placed differently, which is where the ranking earns its keep. Coal prices are uncertain and matter to the contractor. Still, it affects revenue and capital appetite rather than powertrain cost of ownership, so it enters as narrative context, not as an axis. National carbon-pricing

enforcement and the tightening of client decarbonization requirements are real but slower and lower in immediate impact, so they are carried as early-warning signals rather than axes. The PLN tariff, though it feeds electric-vehicle economics, is regulated, slow-moving, and correlated with the diesel axis, so a separate axis for it would add little and blur the picture. Reducing a long list of forces to two axes is the method's deliberate simplification, and explaining why we relegated each force keeps the two-by-two defensible rather than arbitrary.

Table 2. Ranking the uncertain driving forces by impact and unpredictability

Uncertain force	Impact on the decision	Unpredictability	Outcome
Site diesel price	High	High	**Axis X — energy-cost pressure**
Electric-truck acquisition price and availability	High	High	**Axis Y — EV economic accessibility**
Coal price (revenue side)	Moderate	High	Narrative context, not an axis
National carbon-pricing enforcement	Moderate	Moderate	Early-warning signal
Client decarbonization requirements	Moderate	Moderate	Narrative context
PLN industrial tariff	Moderate	Low (regulated; diesel-correlated)	Monitored, folded into economics

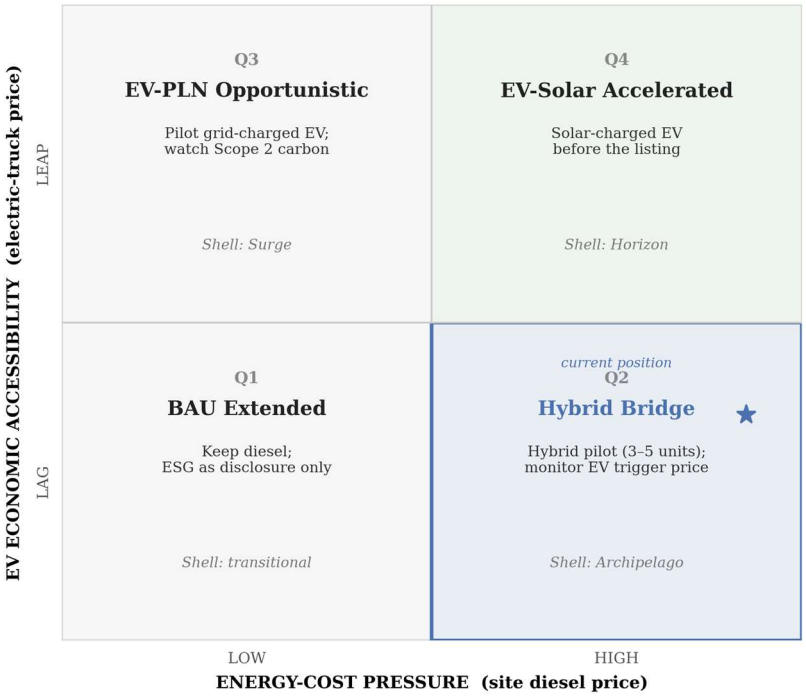
Source: Authors' elaboration. 2026.

Crossing the two axes gives the four futures shown in Table 3 and mapped in Figure 3. Each quadrant is a coherent strategic world with a different implied posture for the contractor, and each maps onto a recognized archetype from Shell's Energy Security Scenarios (Shell, 2025), which anchors the local case in an external reference that examiners and investors recognize.

Table 3. Scenario matrix: energy-cost pressure against electric-vehicle accessibility

Quadrant	Energy cost	EV accessibility	Scenario	Implied near-term posture	Shell ESS 2025 archetype
Q1	Low	Lag	BAU Extended	Keep diesel; minimal ESG spend	(transitional)
Q2	High	Lag	Hybrid Bridge	Hybrid pilot of 3 to 5 units, monitor EV trigger price	Archipelago
Q3	Low	Leap	EV-PLN Opportunistic	Pilot grid-charged EV, watch Scope 2 carbon	Surge
Q4	High	Leap	EV-Solar Accelerated	Move to solar-charged EV before the 2028 listing	Horizon

Source: Authors' elaboration, 2026



Source: Authors' elaboration, 2026

Figure 3. Scenario matrix: energy-cost pressure against electric-vehicle accessibility.

Q1, BAU Extended, is the benign world in which diesel falls back to a comfortable price and electric trucks stay expensive. Here the incumbent is defensible, the fuel bill is bearable, and the pressure to spend on transition is weak, so the contractor does little beyond the compliance minimum. This is the world in which inaction is rational, and it is the only one in which it is.

Q2, Hybrid Bridge, is where the contractor sits in early 2026. Diesel is expensive under the Hormuz disruption, but electric trucks are not yet cheap or fully deployable at the contractor's scale. Hence, the sensible move is a hybrid pilot of a few units that cuts the fuel exposure without committing to charging infrastructure, while the electric-vehicle trigger price is watched. The quadrant maps to Shell's Archipelago archetype, in which energy-security pressure meets constrained technology diffusion and firms reach for bridging strategies. The contractor had already reached this posture operationally before the analysis, and external evidence shows the two axes capture the decision it actually faces.

Q3, EV-PLN Opportunistic, is the world of cheap electric trucks under stable energy prices. Here, the falling truck price invites an opportunistic grid-charged pilot. Still, the coal-heavy grid means the carbon consequence must be monitored rather than assumed favorable, because charging from the Barito grid can raise fleet emissions even as it cuts fuel cost. The quadrant maps to Shell's Surge archetype, technology-led and fast-moving, and its risk for this contractor is that an economically attractive move quietly worsens the disclosure position.

Q4, EV-Solar Accelerated, is the world in which the transition accelerates, because expensive diesel and affordable electric trucks together make solar-charged electrification both the cheapest and the cleanest option ahead of the listing. It maps to Shell's Horizon archetype, where crisis and technology push decarbonization forward together, and it is the best-case scenario for the contractor's 2028 ESG narrative. The quadrants are not equally likely, and the exercise does not try to predict which one arrives. It aims to choose a pathway that holds up across all four.

Phase four: implications and paths

The fourth phase asks what each future implies and which pathway the contractor should favor, and it answers by comparing the pathways inside each future. Two features of that comparison set up everything else. On five-year cost of ownership, grid-charged electric is the cheapest pathway and the diesel incumbent the most expensive, with the hybrid and the two solar configurations in between. On carbon, the ranking almost inverts: grid-charged electric is the worst, raising fleet emissions by 46 to 56 percent because charging draws on a coal-heavy grid, while solar-charged electrification cuts

intensity by up to 94 percent against the diesel baseline. The cheapest pathway is therefore the dirtiest. That tension is why the right pathway depends on the future, because different futures weigh cost against carbon differently.

The contractor's decision, though, is which pathway to commit to without knowing which future arrives. That calls for the pathway that stays sound across the futures rather than the one that wins in a single quadrant, and solar-charged electrification is that pathway. Its cost advantage holds across both halves of the matrix: it stays cheaper than the diesel incumbent as long as diesel holds above about Rp 9,700 per liter, and cheaper than the hybrid above about Rp 5,300 per liter, both far below any realistic forward price. A fall in electric-truck prices, the move along the accessibility axis, only widens that advantage. Solar-charged electrification is therefore strong in Q2, Q3, and Q4, and weak only in Q1, the benign world where doing little is defensible. The incumbent is the mirror image: sound only in Q1 and collapsing once energy costs rise, because fuel is the overwhelming share of its lifetime cost. The hybrid bridge is a Q2 instrument, valuable when diesel is expensive but electric deployment is not yet feasible, and its value fades as soon as the accessibility axis moves. Pathways that look reasonable in only one quadrant are fragile; the robust choice is the solar-charged fleet.

The final step in the fourth phase names the signals that tell the contractor which quadrant it is drifting toward, so it can commit to the pathway at the right moment rather than too early or too late. Table 4 lists them, and mid-2026 readings already provide useful information. After the Strait of Hormuz reopened in April 2026, Brent crude fell back from a wartime peak above USD 120 per barrel to around USD 72 by July, easing the acute energy-cost pressure, while lithium-ion battery pack prices reached a record low of about USD 108 per kilowatt-hour in 2025 and continued to fall (BloombergNEF, 2025), a decline that peer-reviewed analysis attributes to sustained technology improvement rather than to temporary metal-price swings (Ziegler & Trancik, 2021). The first signal points to the low-energy-cost half of the matrix; the second points to the electric-vehicle-accessible half. These observable proxies capture the two axes, and the slower forces held out of the matrix, turning a static recommendation into a monitored one.

Table 4. Early-warning signals and the future each points toward

Signal to monitor	What it indicates	Toward which quadrant
Site diesel sustained above or below about Rp 28,000/L	Direction of the energy-cost axis	Q2/Q4 if high, Q1/Q3 if low
PLN industrial tariff rising more than 10% year on year	Energy-cost pressure rising	Q2/Q4
Battery pack or lithium price falling more than 20%	EV accessibility leaping	Q3/Q4
Chinese OEM electric haul-truck orders into Southeast Asia rising	EV trigger price approaching	Q3/Q4
Carbon-pricing enforcement above about Rp 100/kgCO_2e	Pathway economics shift; EV-PLN penalty grows	all
PLTA Muara Juloi hydro commissioning confirmed	Grid begins to clean; EV-PLN worth re-evaluating	post-2028
Strait of Hormuz disruption duration	Diesel supply-shock persistence	Q2/Q4

Source: Authors' elaboration, 2026.

The energy-cost axis is not only the backdrop to the futures; it is also the largest single driver of each pathway's own economics, so the force the contractor cannot control appears twice, as the axis that defines the four futures and as the fuel or electricity bill that decides which pathway is cheap in each. This is why a cost comparison run at a single diesel price misleads: the ranking depends on a price the firm does not set, so the diesel incumbent looks affordable in a cheap-diesel reading and ruinous in an expensive one. The scenario structure is the corrective. A solar-charged fleet barely feels the diesel axis, while the incumbent feels it fully, and that difference separates the robust pathways from the fragile ones.

How the result compares with earlier findings

The sequenced answer this study reaches, hybrid now and full electrification later, is not

new, and its recurrence in earlier work is a form of external validation. Tzeng et al. (2005), scoring alternative-fuel buses in Taiwan, concluded that the hybrid-electric bus was the better short-to-medium-term choice and that battery-electric buses would take over as the technology matured. Two decades later, a different method applied to mine haul trucks rather than city buses reaches the same shape of answer. That two studies so far apart in method, setting, and vehicle converge on one trajectory suggests the decision, not either analysis, drives the result.

This study departs from that literature by attaching a condition to the second step. Those earlier studies mostly sit on grids clean enough that electrification improves the carbon outcome under almost any assumption, so the electric option is rewarded and the debate is only about cost and timing (Kügemann & Polatidis, 2020). On the coal-heavy grid studied here, grid-charged electrification runs the other way for carbon: it raises emissions instead of cutting them. That splits grid-charged from solar-charged electrification, two options that a single headline number would otherwise lump together. The contribution is therefore the grid condition on the trajectory, not the trajectory itself, which is confirmed: on a coal-dominant grid the electric step has to be solar-charged, or it fails the carbon test that motivated the transition.

Both answers the analysis produces, the pathway that fits the present world and the one most robust across futures, point to solar-charged electrification, but neither means buying 28 solar-charged trucks tomorrow: allowing for infrastructure lead time, the destination and the next step are different decisions. The sensible reading is a sequence. In the Q2 world it currently occupies, the near-term move is a pilot-scale hybrid bridge that cuts fuel exposure and buys time without committing to charging infrastructure that depends on a grid feasibility study. Once feasibility is confirmed, the near-term Pareto move is EV-Solar 50/50, close to the cheapest pathway available while also cutting carbon. The end-state, positioned for the 2028 listing, is the higher solar fraction that cuts fleet carbon by 94 percent and gives the investor narrative its strongest form.

This sequencing is what the scenario cycle adds to a one-off comparison. A single read would name the best pathway and stop; the scenario matrix instead locates the contractor in a specific quadrant and pairs it with the early-warning signals that would move it to another, turning a static recommendation into a staged one, with the hybrid as the hedge for the current quadrant and solar-charged electrification as the committed direction. For a firm making an irreversible commitment under a listing deadline and a disclosure mandate, a staged pathway with defined triggers beats a single point recommendation: it says where to go and when to move.

Theoretical contribution

The study makes three contributions to how strategic investment decisions are theorized under uncertainty. The first is a boundary condition. The transport-electrification decision literature, built largely on clean or fast-cleaning grids, treats electrification as carbon-improving under almost any future, so its guidance reduces to cost and timing (Tzeng et al., 2005; Kügemann & Polatidis, 2020). This study shows that guidance holds only above a grid-carbon threshold. Below it, on a coal-heavy grid, the ranking inverts and the cheapest electric pathway becomes the dirtiest, so electrification and decarbonization separate into two decisions rather than one. The trajectory itself is familiar; the contribution is the grid condition attached to it, which turns a general prescription into a contingent one and names the grid state under which it fails.

The second contribution is integrative. Strategic foresight, scenario planning, and real options are usually drawn on separately, foresight to argue that anticipating alternative futures builds adaptive capability (Marinković et al., 2022; Haarhaus & Liening, 2020), scenario planning to map those futures, and real options to value the timing of an irreversible commitment (Trigeorgis & Reuer, 2017). This study couples them into one operable sequence: foresight frames the ESG-constrained fleet decision, the scenario matrix supplies the discrete states of the world a real-options assessment needs, and the early-warning signals become the triggers on which the option to commit is exercised. Each strand gains something in the coupling. Real options gains an explicit, decision-relevant state space instead of an assumed stochastic process; scenario planning gains a commit-or-defer decision rule instead of stopping at description; and foresight gains a concrete capital-allocation application in which the monitoring routine itself becomes the dynamic capability the firm retains (Teece et al., 1997).

The third contribution concerns the structure of the uncertainty itself. In this decision, the force that defines the scenario

axes, energy cost, is also the largest single driver of each pathway's economics. Hence, it enters the problem twice: once as the axis that sorts the futures and once as the fuel or electricity bill that decides which pathway is cheap within each. That double role is why a single-point valuation misleads in a specific way: the diesel incumbent reads as affordable in a cheap-diesel case and ruinous in an expensive one from the very same model, so the ranking is governed by a price the firm does not set. Robustness across futures, rather than expected value against one, is therefore the fitting decision criterion for this class of problem, and the coupling of foresight, scenarios, and options is the machinery that delivers it. For strategic management theory, the case sharpens why a firm facing this kind of endogenous, self-reinforcing uncertainty should decide by robustness rather than by forecast.

Practical implications for managers, investors, and policymakers

The cost and carbon rankings pulling apart is not particular to this contractor. Fuel or electricity dominates a haul fleet's lifetime cost, so a pathway that uses cheap grid electricity almost always wins on cost. At the same time, carbon runs the other way only because the Barito grid's emission factor, at roughly 1.1 to 1.2 kilograms of CO_2 per kilowatt-hour, sits above the level at which grid charging would match diesel on emissions. The result is structural. Any operator charging from a grid dirtier than that breakeven point faces the same inversion, and any operator on a cleaner grid does not. For the many mine fleets on the coal-heavy regional grids of Kalimantan, Sumatra, and comparable developing-economy coal basins, the transferable rule is to test the local grid emission factor against the diesel-equivalent breakeven before treating electrification as decarbonization, and to read on-site solar generation as the lever that resolves the tension where the grid cannot.

For corporate executives and investors, the case draws a sharper line than a cost table would. An executive weighing the fleet decision should read grid-charged electrification as the option that looks cheapest on paper yet quietly worsens the carbon record the firm is about to disclose. Hence, the pathway that protects the listing is the solar-charged fleet rather than the lowest-cost one. For an investor screening the contractor, watch the source of the charge. An electrification plan on a coal grid without captive solar cuts costs while increasing Scope 2 emissions, and only a solar-backed plan delivers the auditable low-carbon record that supports the valuation. The decision therefore couples an operational choice to corporate ESG strategy, and the framework makes that coupling visible before the capital is committed rather than after.

For policymakers and regulators, the case marks four levers, each of which changes the decision it describes. The pace of grid decarbonization binds when grid-charged electrification becomes genuinely clean, so a firm commitment to cleaner generation, or to hydro capacity such as the Muara Juloi scheme, would shift the calculation more than any incentive aimed at the trucks themselves. Carbon-price enforcement is the second lever, since a price above roughly Rp 100 per kilogram of CO_2-equivalent would fold the emissions penalty into the grid-charged pathway's cost and realign the cheapest option with the cleanest. Disclosure design is the third: a mandate built on IFRS S2 that requires Scope 2 grid emission factors to be reported in full would stop a grid-charged fleet from being presented as decarbonization when it in fact raises emissions, which is the exact misreading the carbon result here warns against. The fourth lever is support for behind-the-meter renewable generation, because captive solar turns electrification from a carbon liability into a pathway that is both cost-competitive and disclosure-ready for firms heading to public markets.

The analysis carries several implications for how a capital-intensive firm should decide under uncertainty. The first is procedural. Faced with an irreversible fleet investment whose payoff depends on prices and policies it cannot forecast, the contractor is better served by structuring the choice around robustness across futures than by optimizing against a single projected case. That is a real-options posture: hold a flexible bridging position now, keep the option to electrify open, and commit the larger capital only once the signals that govern the payoff have resolved. The early-warning indicators in Table 4 are the triggers that tell the firm when to exercise.

The second implication is about competitive position. The pathway that survives the futures, solar-charged electrification, also builds a defensible advantage: it strips diesel-price volatility from cost-per-tonne. It produces the auditable low-carbon record that clients with decarbonization commitments and investors screening for ESG increasingly reward. For a contractor heading into a 2028 listing under mandatory sustainability disclosure, that record is strategic capital. Grid-charged electrification exposes the trap: it is the cheapest option on paper, but because it raises fleet emissions on a

coal grid, it would worsen the very disclosure the firm is about to be held to, damaging rather than building the ESG position that supports the listing. The decision therefore couples operational choice to corporate ESG strategy, and the framework makes that coupling explicit rather than leaving it to be discovered after the money is spent.

The third implication is organizational. The exercise leaves behind a repeatable decision-making routine, a foresight routine the firm can run again as the same uncertainties resurface in later capital cycles, and that routine, with ongoing monitoring of early-warning signals, is itself a capability that outlasts this decision. Operationally, the sequenced pathway lets the firm transition without a disruptive all-at-once conversion of a productive fleet, phasing the change against the arrival of the enabling conditions rather than betting availability and cost-per-tonne on a single leap.

The study rests on a single case, and its findings are specific to one contractor, one site, and one grid, so the quadrant judgments should not be read as transferable constants. What transfers is the cycle and one qualitative finding: on a coal-heavy grid, the cheapest electrification pathway can be the worst on carbon, and solar self-generation breaks the tension. The method also involves judgment calls. The driving forces were ranked by impact and unpredictability through structured discussion rather than formal elicitation, and reducing them to two axes is a deliberate simplification that other analysts might make differently. The scenario set is a deductive two-by-two, a coarse cut of a larger uncertainty space. The cost and carbon inputs carry their own modeling assumptions, the most load-bearing of which is the electric truck's energy demand, and the pathway comparison inherits that sensitivity. None of these unsettles the direction of the result. Each marks where a more resourced analysis would go next.

E. CONCLUSION AND RECOMMENDATION

A mining contractor choosing how to decarbonize a haul fleet is making a strategic investment decision under uncertainty it does not control, and the right tool must frame the futures and compare the options within them at the same time. This study ran a full scenario-planning cycle for one contractor in Central Kalimantan, from the driving forces in its environment, through the two critical uncertainties and the four futures they define, to the pathway each future favors. Solar-charged electrification suits the futures that matter and holds up across all four. The diesel incumbent is sound only in a benign, cheap-diesel world, and grid-charged electrification, the cheapest pathway on cost, is the wrong move on carbon because a coal-heavy grid turns electrification into a source of emissions rather than a cure.

For managers, the contribution is a decision-making tool, not a verdict. It shows how to handle an irreversible commitment under deep uncertainty by holding a flexible bridge, keeping the option to electrify open, and committing the larger capital only when defined early-warning signals, several of them already moving in mid-2026, confirm the future is turning. It locates where competitive advantage lies, in a fleet that is both cost-resilient to fuel shocks and demonstrably low-carbon. It ties that advantage to the firm's ESG strategy and its 2028 listing, because the pathway that improves the disclosed carbon record is the one that strengthens the investor case, while the cheapest pathway would quietly weaken it. The wider lesson is that on a coal-heavy grid, electrification and decarbonization are not the same decision, and only a foresight approach that tests each pathway against the futures, rather than optimizing for today's prices, keeps a firm from confusing the two.

F. REFERENCES

Amer, M., Daim, T. U., & Jetter, A. (2013). A review of scenario planning. *Futures, 46*, 23–40. https://doi.org/10.1016/j.futures.2012.10.003

BloombergNEF. (2025). *Lithium-ion battery pack prices fall to $108 per kilowatt-hour, despite rising metal prices*. Bloomberg New Energy Finance.

Bradfield, R., Wright, G., Burt, G., Cairns, G., & Van der Heijden, K. (2005). The origins and evolution of scenario techniques in long-range business planning. *Futures, 37*(8), 795–812. https://doi.org/10.1016/j.futures.2005.01.003

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Furr, N. R., & Eisenhardt, K. M. (2021). Strategy and uncertainty: Resource-based view, strategy-creation view, and the hybrid between them. *Journal of Management,*

47(7), 1915–1935. https://doi.org/10.1177/01492063211011760

Garvin, D. A., & Levesque, L. C. (2006). *A note on scenario planning* (HBS No. 9-306-003). Boston, MA: Harvard Business School.

Haarhaus, T., & Liening, A. (2020). Building dynamic capabilities to cope with environmental uncertainty: The role of strategic foresight. *Technological Forecasting and Social Change, 155*, 120033. https://doi.org/10.1016/j.techfore.2020.120033

Kügemann, M., & Polatidis, H. (2020). Multicriteria decision analysis of road transportation fuels and vehicles: A systematic review and classification of the literature. *Energies, 13*(1), 157. https://doi.org/10.3390/en13010157

Marinković, M., Al-Tabbaa, O., Khan, Z., & Wu, J. (2022). Corporate foresight: A systematic literature review and future research trajectories. *Journal of Business Research, 144*, 289–311. https://doi.org/10.1016/j.jbusres.2022.01.097

Meiliani, F., Djazuli, A., & Utami, D. (2024). Determinan sustainable growth pada perusahaan sektor barang konsumen non-primer di Indonesia. *Motivasi: Jurnal Manajemen dan Bisnis, 9*(1), 88–97. https://doi.org/10.32502/mti.v9i1.8390

Montibeller, G., Gummer, H., & Tumidei, D. (2006). Combining scenario planning and multicriteria decision analysis in practice. *Journal of Multicriteria Decision Analysis, 14*(1–3), 5–20. https://doi.org/10.1002/mcda.403

Pradnyani, I. G. A. A., & Widhiastuti, N. L. P. (2024). Peran profitabilitas dalam memoderasi pengaruh kebijakan dividen dan struktur modal terhadap nilai perusahaan. *Motivasi: Jurnal Manajemen dan Bisnis, 9*(1), 37–47. https://doi.org/10.32502/mti.v9i1.7936

Ram, C., Montibeller, G., & Morton, A. (2011). Extending the use of scenario planning and MCDA for the evaluation of strategic options. *Journal of the Operational Research Society, 62*(5), 817–829. https://doi.org/10.1057/jors.2010.90

Ramirez, R., & Wilkinson, A. (2014). Rethinking the 2×2 scenario method: Grid or frames? *Technological Forecasting and Social Change, 86*, 254–264. https://doi.org/10.1016/j.techfore.2013.10.020

Rohendi, H., Ghozali, I., & Ratmono, D. (2024). Environmental, social, and governance (ESG) disclosure and firm value: The role of competitive advantage as a mediator. *Cogent Business & Management, 11*(1), 2297446. https://doi.org/10.1080/23311975.2023.2297446

Schoemaker, P. J. H. (1995). Scenario planning: A tool for strategic thinking. *Sloan Management Review, 36*(2), 25–40.

Shell. (2025). *The energy security scenarios: Energy and AI*. Shell plc.

Stewart, T. J., French, S., & Rios, J. (2013). Integrating multicriteria decision analysis and scenario planning—Review and extension. *Omega, 41*(4), 679–688. https://doi.org/10.1016/j.omega.2012.09.003

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Tokac, B., Zhang, Q., & Sari, Y. A. (2025). Environmental and economic comparison of diesel and electric trucks in open-pit mining operations. *Journal of Cleaner Production, 507*, 145540. https://doi.org/10.1016/j.jclepro.2025.145540

Trigeorgis, L., & Reuer, J. J. (2017). Real options theory in strategic management. *Strategic Management Journal, 38*(1), 42–63. https://doi.org/10.1002/smj.2593

Tzeng, G.-H., Lin, C.-W., & Opricovic, S. (2005). Multicriteria analysis of alternative-fuel buses for public transportation. *Energy Policy, 33*(11), 1373–1383. https://doi.org/10.1016/j.enpol.2003.12.014

Van der Heijden, K. (1996). *Scenarios: The art of strategic conversation*. Chichester, England: John Wiley & Sons.

Wack, P. (1985). Scenarios: Uncharted waters ahead. *Harvard Business Review, 63*(5), 73–89.

Wright, G., Bradfield, R., & Cairns, G. (2013). Does the intuitive logics method, and its recent enhancements, produce "effective" scenarios? *Technological Forecasting and Social Change, 80*(4), 631–642.

https://doi.org/10.1016/j.techfore.2012.09.003

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Thousand Oaks, CA: Sage.

Ziegler, M. S., & Trancik, J. E. (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline. *Energy & Environmental Science, 14*(4), 1635–1651. https://doi.org/10.1039/D0EE02681F