

Value Engineering as a Strategy for Cost Optimization in Construction Projects

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Abstract- Value engineering offers a structured way to examine whether construction functions can be delivered at a lower cost while maintaining the performance required by clients and users. Its application becomes problematic when the term is used for price reductions or specification changes without checking their consequences over the asset life. This focused narrative review examines the contribution of function analysis, stakeholder participation, alternative development and life-cycle evaluation to construction cost optimisation. Selected academic research and public procurement guidance are synthesised into a proposed framework connecting the definition of value with technical approval and benefit verification. An illustrative ten-year calculation compares three compliant system alternatives and demonstrates how the lowest initial cost can produce a higher whole-life cost. Sensitivity analysis identifies the operating-cost assumption at which the preferred alternative changes. The review finds a clear conceptual basis for evaluating function and cost together, while highlighting limits in the transferability of reported savings and the implementation of structured methods. The proposed framework supports transparent decisions on design and construction alternatives and is adaptable to Saudi project contexts. Its contribution is an auditable decision process; its numerical results are illustrative and do not constitute observed project savings or empirical validation.

Keywords: value engineering; construction cost optimisation; function analysis; life-cycle costing; stakeholder requirements; design alternatives; value management.

I. INTRODUCTION

Construction cost optimisation requires decisions about what an asset must achieve and how those functions should be delivered. A lower capital budget can be beneficial, but only when the resulting design continues to meet the intended need. An alternative that reduces installation expenditure while increasing failure, maintenance or replacement costs may transfer expenditure rather than remove it. Value engineering provides a framework for examining these

consequences before a decision becomes difficult to reverse.

The central research problem concerns the relationship between the intended method and its practical use. A value study should define requirements, compare feasible alternatives and measure the results of implementation. The analysis therefore focuses on how the method can support defensible decisions rather than presenting a catalogue of assumed savings percentages.

This paper treats value engineering as a structured examination of alternatives for an agreed function. Value management provides a wider setting in which stakeholders define and maintain the meaning of value across the project. The distinction is useful because a technically economical alternative may still conflict with the client's operating needs. A decision framework should connect the two levels while preserving clear technical and commercial accountability.

The analysis applies to building systems, materials, layouts and construction methods. It is particularly relevant when project teams have several feasible alternatives and enough time to evaluate their interfaces. Saudi construction projects provide one application context, but this review does not claim to measure national adoption or establish country-specific savings. Its purpose is to develop a defensible method for judging alternatives and verifying the benefits of implementation.

II. BACKGROUND AND LITERATURE REVIEW

2.1 Function as the basis of value

Function analysis begins with the outcome a component or system must achieve. An enclosure may need to protect occupants, control heat transfer and resist moisture. An air-conditioning installation may

need to maintain specified indoor conditions within acoustic, energy and maintenance constraints. Naming the product alone can conceal alternative ways to achieve those outcomes. A functional description creates a basis for comparing solutions without prematurely committing to a particular material or supplier.

Building-function assessment should distinguish the outcomes required by different stakeholders. A hospital, warehouse and retail fit-out may place different priorities on reliability, adaptability and appearance. Project-specific requirements must therefore be agreed before ranking alternatives. Fixed weights copied from another project can obscure these differences and produce an unsuitable recommendation.

2.2 Evidence on implementation

A value-engineering exercise should document which stages were completed and how each proposal preserves the required function. Treating the exercise solely as cost reduction leaves performance assumptions unresolved. Workshop approval should therefore be supported by technical assessment, implementation planning and subsequent verification rather than being treated as proof of savings.

Implementing value engineering requires organisational capacity as well as a procedure. Teams need appropriate technical skills, access to project information and participation from the people authorised to approve changes. The importance of each condition varies with project type and procurement arrangements. A proportionate implementation plan should address the project's actual constraints.

2.3 Cost over the asset life

Life-cycle costing provides a monetary basis for comparing alternatives with different operating and replacement profiles. Economic and environmental information can be considered together when their assumptions and measurement boundaries are disclosed. Actual construction decisions still require project-specific inputs; a general analytical method does not establish the savings that an individual project will achieve.

The cost boundary must be explicit. Installation, energy, inspections, maintenance, component replacement and end-of-life treatment may all matter, depending on the decision. Costs should be compared over a common service period and expressed on a consistent price basis. Using a short period for a long-lived alternative can hide later benefits; ignoring an early replacement can exaggerate the attractiveness of a cheaper product. Uncertain assumptions should be examined through scenarios rather than concealed within a single total.

2.4 Group decisions and evidence quality

Value assessment can be organised around requirements, group decisions, measurement and supporting tools. The process should make responsibilities clear and preserve a record of the assumptions behind each recommendation. Computer-aided comparisons can improve traceability, but they do not replace judgement about technical suitability or the reliability of cost inputs.

Procurement planning should connect project requirements with delivery choices. Technical, commercial and operational teams should agree how proposals will be evaluated and approved. The proposed framework combines these responsibilities into a practical process; it is an analytical proposal rather than a claim of compliance with any particular procurement regime.

III. RESEARCH AIM OBJECTIVES AND QUESTIONS

The aim is to develop a structured framework for applying value engineering to construction cost optimisation while preserving required function and acceptable risk. Five objectives are pursued: clarify the distinction between function-based optimisation and indiscriminate cost reduction; identify how stakeholder requirements shape the evaluation; explain the use of life-cycle cost and sensitivity analysis; propose an implementation and verification process; and identify research needs for testing the process in construction projects.

Three questions guide the review. RQ1 asks how project teams can define and protect essential functions while generating alternatives. RQ2 asks how alternatives with different capital and operating costs

should be compared. RQ3 asks which organisational controls are necessary for forecast benefits to become verified outcomes. These questions connect design reasoning with procurement and operation, avoiding an assumption that workshop approval alone demonstrates successful implementation.

IV. REVIEW METHODOLOGY

The study uses a focused narrative review and an original illustrative economic calculation. Publicly accessible publisher material, research abstracts, institutional records and official guidance were consulted on 12 September 2026. Search terms included value engineering, value management, construction cost optimisation, function assessment, implementation barriers and life-cycle costing. The selected academic literature falls within 2020–2025. The supplied cloud-infrastructure paper guided presentation and section structure only; its technical content and references were not used as construction evidence.

Sources were retained when they directly addressed construction value management, functional evaluation, implementation or an explicitly relevant cost-assessment method. Promotional case descriptions without a clear analytical basis were excluded. Evidence was appraised qualitatively for relevance, context, research method and the extent to which it supported the claim being made. Where complete articles were unavailable, interpretation was limited to accessible abstracts and author or institutional records. No unreported project-level results were inferred from titles.

The synthesis grouped evidence under function definition, participation, economic comparison and implementation control. It did not conduct an exhaustive bibliographic database search, statistical meta-analysis or formal quality-scoring exercise. Accordingly, no screening totals or pooled savings percentages are presented. The worked example uses disclosed assumptions so that its calculation can be reproduced. It demonstrates how rankings change; it is not a case study, field dataset or validation of the proposed framework.

V. THEMATIC FINDINGS AND ANALYSIS

5.1 Protecting essential requirements

The first stage is to identify essential functions and the evidence needed to confirm them. Requirements should be stated in measurable terms where possible: capacity, loading, thermal performance, acoustic limits, accessibility, maintainability or service availability. Performance conditions also matter. A system that meets its rating under one set of operating conditions may not meet the project's actual duty. The technical baseline should therefore identify both the target and the circumstances under which it applies.

Mandatory requirements should be assessed before scoring discretionary benefits. An alternative that fails a critical safety or performance condition should not remain eligible merely because it is cheaper. Where requirements are unclear, clarification is part of the value study rather than an assumption delegated to a vendor. This sequence makes functional assessment an explicit condition of approval.

Stakeholder participation should be organised around knowledge and decision responsibility. Designers understand technical intent; contractors understand installation and sequencing; operators understand access and maintenance; and clients determine acceptable service outcomes. Participation does not require every stakeholder to approve every detail. It requires the decision to include the people whose responsibilities or asset use will materially change. Table 1 connects the principal stages with their supporting evidence and approval conditions.

Table 1. Proposed stages, evidence and decision conditions for value engineering.

Stage	Required evidence	Decision condition
Define function	Performance targets and operating conditions	Client and technical requirements agreed
Generate alternatives	Options and interface assumptions	Feasible paths to required function
Screen compliance	Calculations and technical submissions	Essential requirements satisfied
Evaluate value	Comparable estimates and life-cycle scenarios	Trade-offs and uncertainty disclosed
Implement and verify	Approved revisions and actual performance	Benefits demonstrated or forecast updated

5.2 Generating genuinely different alternatives

Alternative development should test the design approach rather than substitute products without analysis. Opportunities may include simplifying geometry, standardising repeated components, changing installation sequences or reducing unnecessary interfaces. The aim is to explain why the alternative requires fewer resources for the same service outcome. A substitution with no documented functional comparison is insufficient evidence of value improvement.

For example, repeated room layouts could support standardised service modules, but the evaluation would need to include transport, lifting, connection tolerances and future access. A different facade assembly could affect structural supports, cooling demand, fire performance and cleaning. These are proposed analytical examples, not observed case results. They illustrate why the boundary of the

assessment should extend beyond the component whose price first attracts attention.

Generating ideas and selecting ideas should be distinct activities. Premature rejection can prevent useful combinations from being explored, while unfiltered enthusiasm can produce unrealistic proposals. A practical approach first records alternatives and assumptions, then applies technical screening, economic comparison and implementation review. The final recommendation should retain rejected options and the reasons for rejection so that future teams do not repeatedly investigate the same unsuitable proposal.

5.3 Evaluating capital and whole-life consequences

An initial cost estimate should include the resources required to implement the change: design revisions, coordination, approvals, mock-ups, testing and any interruption to planned work. These amounts can reduce or eliminate an apparent material saving. Alternatives should be assessed at the same level of design maturity. Comparing a fully detailed baseline with a preliminary alternative creates an artificial advantage for the less developed option.

For longer-lived assets, discounted life-cycle cost can be expressed as initial cost plus the present value of operating, maintenance, replacement and disposal expenditure, less any residual value. The discount rate, analysis period and treatment of inflation should be consistent across options. Financing charges should not be added indiscriminately to a calculation already structured around a financing-based discount rate; the modelling perspective must be clear to avoid double counting.

Environmental indicators can be reported alongside monetary results when reliable data are available. A cost preference and an environmental preference may differ. Monetary conversion is appropriate only if the valuation method is defensible and disclosed. A transparent decision can acknowledge a trade-off rather than combine incompatible quantities into a single unexplained score. The assessment requires project-specific economic and environmental evidence.

5.4 Illustrative life-cycle comparison

Consider three hypothetical alternatives for a building-services system. All are assumed to satisfy the same technical requirements and to provide the required service for a ten-year comparison period. The baseline has an initial cost of SAR 1,000,000, annual operating and maintenance expenditure of SAR 120,000, and a SAR 100,000 replacement in year six. Alternative A costs SAR 900,000 initially, requires SAR 150,000 annually and a SAR 150,000 replacement in year six. Alternative B costs SAR 1,080,000 initially, requires SAR 85,000 annually and a SAR 70,000 replacement in year six.

The calculation uses constant-price cash flows and an illustrative real discount rate of 5%. Annual costs occur at each year-end; replacement expenditure occurs at the end of year six. Residual value, disposal cost, taxes and any further replacements are set to zero for this simplified demonstration. All initial implementation costs are assumed included. The rate and costs are assumptions, not market quotations or a recommended financial policy.

Table 2. Hypothetical life-cycle assumptions and calculated results. Annual costs occur at year-end; results rounded.

Assumption or result	Baseline	Alternative A	Alternative B
Initial cost, SAR thousands	1,000	900	1,080
Annual cost, SAR thousands	120	150	85
Year 6 replacement, SAR thousands	100	150	70
Analysis period, years	10	10	10
Real discount rate	5%	5%	5%
Life-cycle cost, SAR thousands	2,001.2	2,170.2	1,788.6
Saving versus baseline, SAR thousands	0.0	-169.0	212.6

The ten-year annuity factor at 5% is 7.7217, and the year-six discount factor is 0.7462. Life-cycle cost therefore equals initial cost plus annual expenditure multiplied by 7.7217 plus the year-six replacement multiplied by 0.7462. The resulting present values are approximately SAR 2,001,230 for the baseline, SAR 2,170,193 for A and SAR 1,788,583 for B. Figure 1 presents the rounded component values.

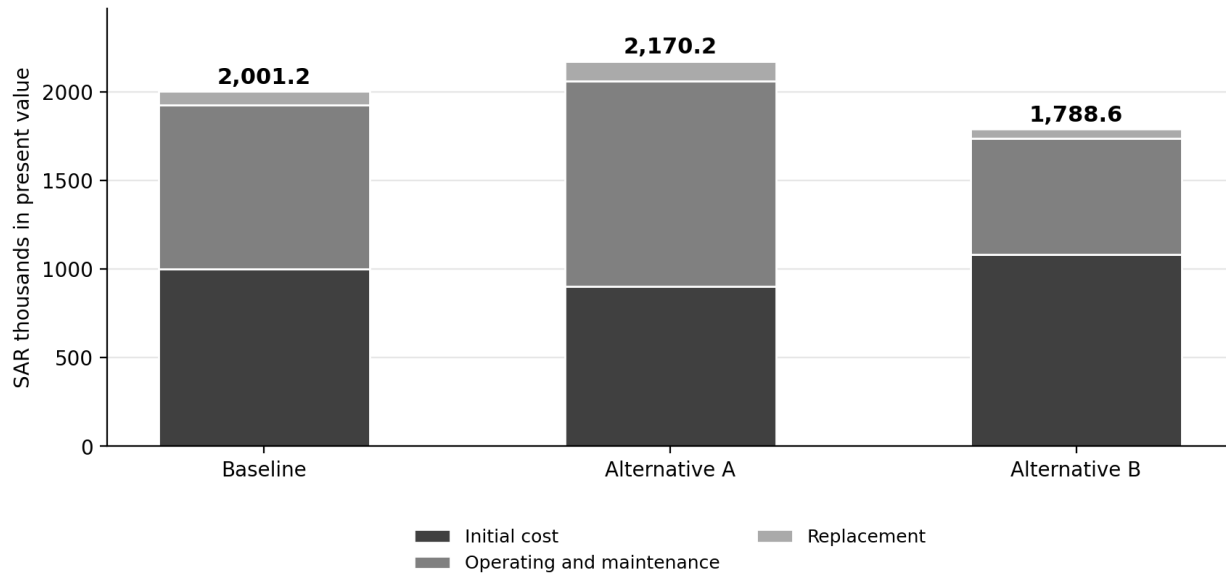


Figure 1. Hypothetical ten-year discounted costs at 5%. Calculated from Table 2; illustrative, not observed project data.

Alternative A reduces initial expenditure by SAR 100,000 but increases life-cycle cost by approximately SAR 168,963 against the baseline. Alternative B requires SAR 80,000 more initially but reduces the calculated life-cycle cost by approximately SAR 212,647, or 10.6%. These are results of the stated hypothetical inputs only. They do not estimate the savings achievable by value engineering generally, nor do they show that every more efficient system will justify a higher initial price.

5.5 Sensitivity and affordability

Sensitivity analysis identifies which assumptions determine the ranking. Holding other inputs constant, B's annual operating and maintenance cost could rise from SAR 85,000 to approximately SAR 112,539 before its life-cycle cost equals the baseline. Above that threshold, its cost advantage disappears. This break-even value tells the evaluator where stronger evidence is most useful: the annual cost forecast matters more than confidence in an attractive headline saving.

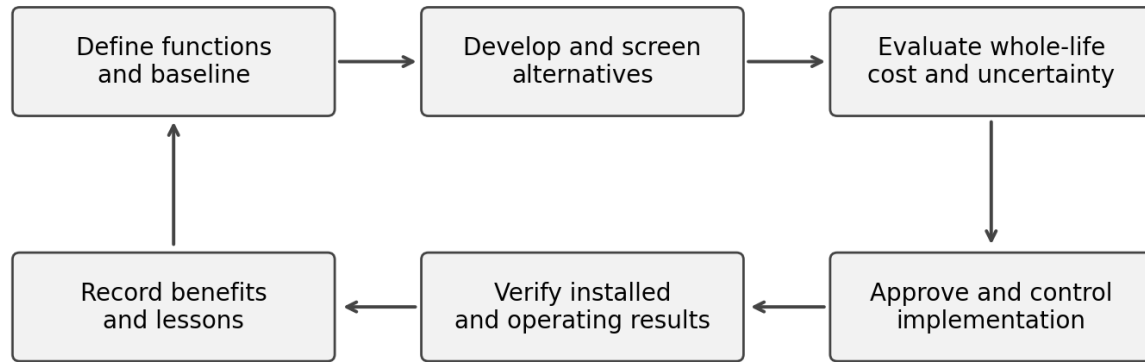
Changing the discount rate also affects the relative importance of later expenditure. At illustrative real rates of 3% and 8%, B's savings against the baseline are approximately SAR 243,682 and SAR 173,758 respectively. The ranking remains unchanged within

that tested range, but this does not establish robustness to untested service-life or operating assumptions. The scenarios hold all other inputs fixed and do not claim to represent the full distribution of possible outcomes.

Whole-life economy and immediate affordability remain distinct. An owner facing a hard capital limit may be unable to select B even if its forecast life-cycle cost is lower. The decision should then record the budget constraint and investigate other compliant configurations or financing arrangements separately. Labelling the lowest affordable option as the universally best-value option would conceal the trade-off. The framework makes that constraint visible rather than assuming it can be ignored.

VI. DISCUSSION AND PROPOSED FRAMEWORK

Figure 2 presents the proposed process. It begins with requirements and a baseline, develops and screens alternatives, evaluates life-cycle consequences and then requires implementation approval. Technical failure returns the proposal for revision; an approved proposal proceeds to controlled delivery and benefit verification. The feedback loop captures actual performance for later decisions. This is a proposed governance model and has not been validated through a project intervention.



Proposed framework • feedback informs the next decision

Figure 2. Proposed value-engineering implementation and verification process.

The synthesis suggests that methodological completeness is more useful than counting the number of proposals generated. A workshop can produce many ideas while leaving the main functional or operating questions unresolved. Conversely, one well-supported change can be valuable if it is implemented and its effects are verified. The participation and capability barriers described in the literature support paying attention to how decisions are made, although they do not establish a universal staffing model.

The financial record should distinguish gross opportunity, approved forecast benefit and verified benefit. Gross opportunity is a preliminary comparison before implementation costs and uncertainty are fully assessed. Approved forecast benefit incorporates the agreed design, estimate and assumptions. Verified benefit uses actual installation and operating evidence over the relevant period. An approved change that is never installed should not remain in the realised-savings total.

Responsibility for measuring benefits should be assigned when the decision is approved. The project team can confirm installation quantities and final account costs; the operating team can assess energy, maintenance and service performance. Some benefits will only become observable after handover. Where measurement periods are short, forecasts should

remain labelled as forecasts. This creates continuity between design decisions and asset operation instead of allowing the value study to end with a workshop report.

VII. PRACTICAL IMPLICATIONS FOR SAUDI CONSTRUCTION PROJECTS

For Saudi projects, the framework can be applied to repeated building elements, mechanical and electrical systems, industrial facilities and fit-out work. Any proposal involving equipment performance should be assessed against the relevant project duty and site conditions. Procurement availability, local maintenance capability and replacement lead times should be included where they affect service continuity. These are application considerations, not claims that one configuration is suitable for all Saudi locations or sectors.

Owners should define the value study early enough for options to influence the design without excessive rework. The practical advantage of early evaluation is that more design choices remain open; its economic benefit still depends on the quality of the proposal. Later changes may also be justified, but they should include redesign, abortive work, procurement and programme consequences. The commercial assessment should follow the project's governing arrangements.

A portfolio-level record can make completed studies more useful. Each record should identify the original function, alternative, application conditions, cost basis, approval and measured result. Reusing a decision without its conditions is risky: an alternative that worked on one project may have unsuitable loading, maintenance or installation requirements on another. The recommended knowledge record therefore preserves both the benefit and the limits of applicability.

Contractual incentives should make it clear how approved benefits and implementation responsibilities are allocated. A supplier or contractor has little reason to invest in developing alternatives if the process is unclear or their contribution cannot be recognised. Equally, sharing a forecast benefit before technical verification may encourage optimistic estimates. An agreed evidence requirement supports fair evaluation without presuming that every proposal merits adoption.

VIII. LIMITATIONS AND FUTURE RESEARCH

The review uses a limited, purposively selected evidence base. It does not claim comprehensive coverage of construction value-engineering studies, and the selected literature includes different countries, methods and project contexts. Several sources address broader value management rather than the precise effect of a particular design change. These differences restrict causal conclusions and prevent the calculation of a general savings rate.

The illustrative example assumes identical functional compliance and known cost schedules. Real projects face uncertainty in utilisation, tariffs, equipment life and maintenance capability. The analysis does not quantify those uncertainties probabilistically. Its simplified zero residual-value assumption should also be reconsidered where alternatives retain different service potential at the end of the assessment period. These limitations are material to interpreting the numerical results.

Future research should follow approved alternatives through procurement, construction and operation. Comparable project studies could test whether documented function analysis predicts better outcomes than price-based substitution. Researchers

should report rejected and unsuccessful alternatives as well as successful ones to reduce selection bias. Saudi studies could examine how project scale, procurement arrangements, technical approval times and operating responsibilities influence the proportion of forecast benefits eventually verified.

Digital decision tools also deserve evaluation, but their contribution should be measured through decision quality and implementation outcomes. A model that generates more alternatives is not necessarily improving value. Useful experiments would compare the accuracy of cost inputs, identification of interface effects, transparency of trade-offs and reliability of post-occupancy predictions. Such work could test and refine the proposed framework without assuming that automation resolves incomplete project information.

IX. CONCLUSION

Value engineering supports construction cost optimisation when alternatives are evaluated against clearly defined functions, implementation requirements and costs over an appropriate service period. The reviewed literature provides a basis for structured assessment while identifying persistent challenges in skills, participation and methodological application. The illustrative analysis shows why an initial saving can become a life-cycle penalty and how sensitivity analysis can identify decisive assumptions. The proposed framework connects functional screening, economic comparison, controlled implementation and benefit verification. Its practical value lies in making decisions traceable; its effectiveness and savings potential require testing with actual project and operating data.

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