Five Cost Categories and a Discount Rate: Making HVAC Lifecycle Comparisons Defensible

Architecture, Computational Methods, and Field Evidence from MileSoft Lifecycle Cost Analysis

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Abstract

Commercial HVAC tenders routinely require a 10 to 15 year lifecycle cost analysis, and most of what is submitted is energy consumption multiplied by a horizon. That is not a lifecycle cost. A defensible analysis carries five cost categories — first cost, energy, maintenance, refrigerant, and replacement — discounts each to present value, and states the sensitivity of its conclusion to the assumptions it could not know.

This paper presents the architecture and computational methods of MileSoft Lifecycle Cost Analysis, a guided workflow that builds a comparison in stages: cost details for each option, a year-by-year energy model, return on investment and breakeven, an electrical-infrastructure analysis, and a carbon account. Its distinguishing property is that the energy term is not entered but derived from the upstream equipment selections, so the comparison and the engineering cannot disagree.

We state the discounted cash-flow formulation, the breakeven condition that follows from it, the sensitivity treatment that separates a robust conclusion from a fragile one, and the electrical-infrastructure translation from connected load to transformer sizing. The work follows the lifecycle-costing conventions codified in ISO 15686-5 and NIST Handbook 135, and carries refrigerant exposure under Regulation (EU) 2024/573.

The product's published record reports that buyers increasingly require a 15-year total-cost comparison and that an honest analysis frequently reverses a first-cost decision. A four-module deployment at an HVAC OEM, in which this module was one of four, reported a 12 percentage-point uplift in proposal-to-order conversion; that result belongs to the programme and is not attributed to this module alone.

Keywords: HVAC lifecycle cost analysis; Total cost of ownership; ISO 15686-5; NIST Handbook 135; Net present value; Discounted payback; Breakeven year; Energy escalation sensitivity; Refrigerant phase-down cost; Electrical infrastructure sizing; Carbon accounting; TCO comparison for tenders

1 Introduction

Commercial HVAC tenders routinely ask for a 10 to 15 year lifecycle cost analysis. What is usually submitted in response is annual energy consumption multiplied by the horizon, occasionally with a maintenance allowance appended. That is not a lifecycle cost, and the difference is not pedantry — it is the difference between an analysis that can change a decision and one that merely accompanies it.

A lifecycle cost carries five categories, discounts them, and states what it does not know. First cost is certain. Energy depends on a consumption estimate and a price trajectory. Maintenance depends on a service regime. Refrigerant now depends on a regulatory phase-down. Replacement depends on service life. Only the first of these is a number; the rest are assumptions, and an analysis that hides that is less useful than one that exposes it.

This paper describes a tool built so the analysis is defensible under challenge. Its central architectural property is that the energy term is derived from the upstream equipment selections rather than entered by hand — so the lifecycle model and the engineering cannot drift apart, which is the most common way such analyses fail scrutiny.

1.1 The decision an honest analysis reverses

The reason lifecycle analysis matters commercially is that it frequently reverses a first-cost ranking. A higher-efficiency option with a larger capital cost recovers the difference through energy and then continues to accumulate advantage across the remaining horizon. The product's own record states the point plainly: nine times out of ten, an honest lifecycle analysis would have changed the conversation.

That claim cuts in an uncomfortable direction for the party running the analysis. A lifecycle model built to justify a preselected option is easy to construct and easy to detect, because its conclusion does not survive a change in discount rate or escalation assumption. The defensibility of the method is therefore not a technical nicety — it is what distinguishes an analysis that persuades from one that is discounted as advocacy.

> An analysis whose ranking flips between 4% and 7% energy escalation has not identified the better option. It has identified an assumption.

1.2 Contributions

1. A lifecycle formulation carrying five discounted cost categories rather than an energy-times-horizon approximation.
2. An energy term derived from the upstream equipment selections rather than entered, so the comparison inherits the engineering rather than restating it.
3. Sensitivity reported as a stability range on the ranking rather than as a point estimate with an appendix.

4. An electrical-infrastructure translation from connected load to transformer sizing, and an eight-dimension capability reference framework.

2 Background and Related Work

Lifecycle costing is a codified discipline rather than a convention, and two documents define it for constructed assets and for energy projects respectively.

2.1 The costing conventions

ISO 15686-5 provides requirements and guidelines for performing lifecycle cost analyses of buildings and constructed assets and their parts, whether new or existing. It defines lifecycle costing as accounting for costs and cash flows arising from acquisition through operation to disposal, and frames the typical use as either a comparison between alternatives or an estimate of future costs at portfolio, project or component level.

NIST Handbook 135 supplies the complementary methodology for energy and water conservation projects, explaining the lifecycle cost method, defining the measures of economic performance used, and setting out the assumptions and procedures to follow. It originated in 1980 and has been revised since, most recently toward high-performance building objectives.

The practical value of both is that they fix what must be included and how it must be discounted. An analysis that omits replacement cost, or compares undiscounted cash flows, is not a stricter or looser version of the method — it is outside it, and a reviewer who knows the standards will treat it accordingly.

2.2 Refrigerant as a cost trajectory

Regulation (EU) 2024/573, in force from 11 March 2024, tightens the phase-down of hydrofluorocarbon production and consumption and sets phase-out dates where alternatives are technically and economically feasible. For a 15-year analysis this converts refrigerant from a commissioning charge into a trajectory.

The mechanism is supply contraction rather than direct regulation of the buyer: as quota tightens, the cost of topping up a machine on a phasing-down refrigerant rises, and at the far end of the horizon availability itself becomes a question. A lifecycle model carrying refrigerant as a fixed annual figure understates the cost of the option that depends on it most.

2.3 Failure modes of spreadsheet lifecycle analysis

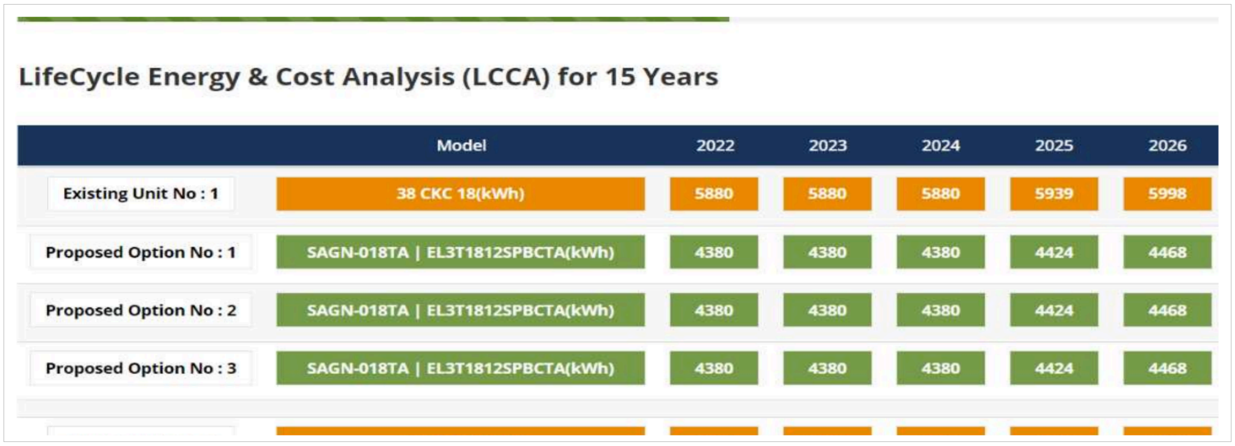
- Energy times horizon. Annual consumption multiplied by years, with no discounting, no escalation and no derating of equipment as it ages.
- Energy entered by hand. The consumption figure is retyped from a selection into a separate spreadsheet, so a change to the selection silently invalidates the analysis.

- Categories omitted. Replacement and refrigerant are left out because they are uncertain, which biases the comparison toward whichever option those categories would have penalised.
- Point estimate presented as certainty. A single discount rate and escalation assumption produce one answer with no indication of how narrowly it holds.
- Baseline chosen to flatter. The comparison baseline is set at minimum compliance rather than at the option the client would otherwise buy.

> The second failure is the most consequential and the least visible. A lifecycle model whose energy figure was correct when it was typed can be wrong by the time it is submitted, and nothing in the document indicates that.

3 System Overview

The module is a guided nine-step wizard supporting single-unit, multi-unit and new-construction comparisons. It builds the analysis in stages: cost details for each existing and proposed option, a year-by-year energy model, return on investment and breakeven, an electrical-infrastructure analysis, and a carbon account.



LifeCycle Energy & Cost Analysis (LCCA) for 15 Years

	Model	2022	2023	2024	2025	2026
Existing Unit No : 1	38 CKC 18(kWh)	5880	5880	5880	5939	5998
Proposed Option No : 1	SAGN-018TA | EL3T1812SPBCTA(kWh)	4380	4380	4380	4424	4468
Proposed Option No : 2	SAGN-018TA | EL3T1812SPBCTA(kWh)	4380	4380	4380	4424	4468
Proposed Option No : 3	SAGN-018TA | EL3T1812SPBCTA(kWh)	4380	4380	4380	4424	4468

Figure 1. The multi-year energy and cost analysis. Each existing and proposed option carries an annual consumption with year-on-year escalation and an age-related derating factor, priced across the horizon. The energy figures derive from the upstream equipment selection rather than from a parallel estimate — the property that makes the comparison defensible under challenge.

3.1 Where the energy number comes from

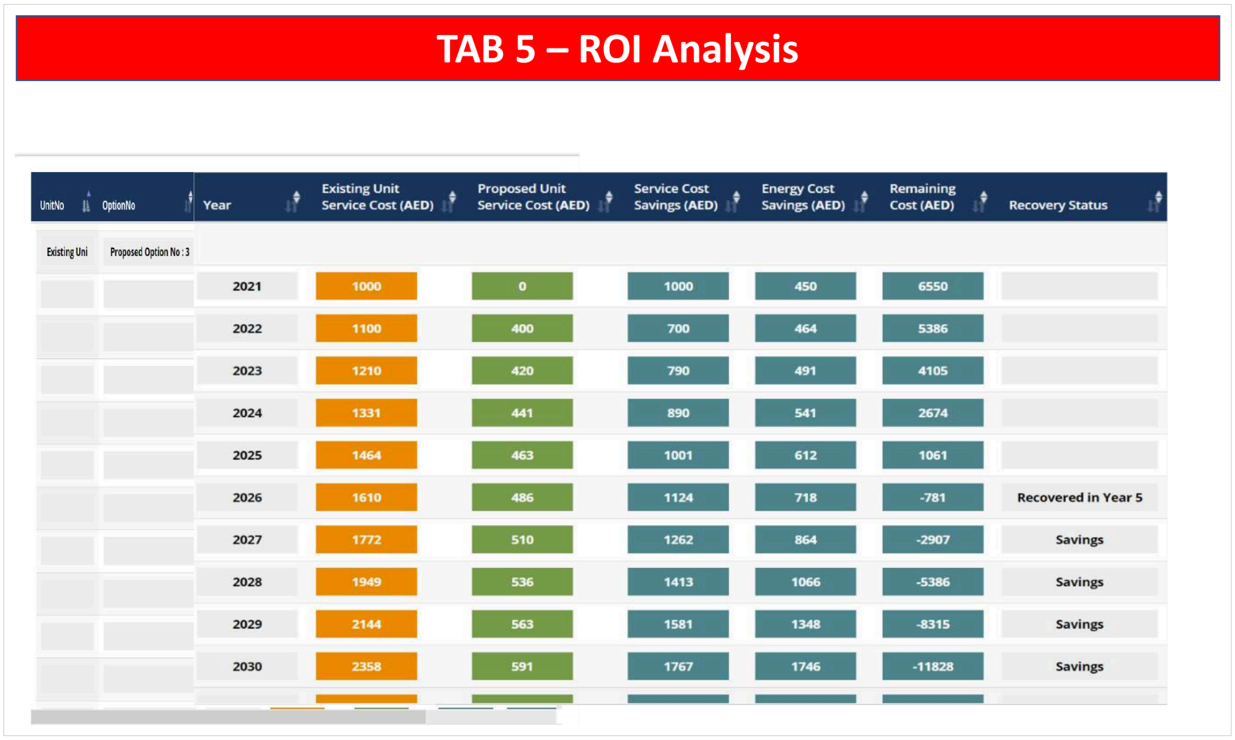
This is the architectural decision the rest of the module rests on. Annual consumption for each option is produced by the equipment selection that specified it — the chiller module's part-load rating, the air handler's specific fan power, the recovery device's net annual gain — rather than entered into the lifecycle model separately.

The consequence is that the analysis cannot drift from the engineering. Where the two are separate artefacts, a late change to a coil or a chiller updates one and not the other, and the divergence is invisible in the submitted document. Where they share a source, a change propagates or the analysis refuses to run.

It also changes what a challenge means. A reviewer disputing the energy figure is disputing the equipment selection — a technical argument with certified data behind it — rather than disputing a number in a spreadsheet with no provenance.

3.2 Return, breakeven and the recovery schedule

The comparison resolves into a year-by-year accounting of service cost, energy-cost saving and remaining unrecovered capital, from which the breakeven year is identified explicitly rather than inferred from a chart.



TAB 5 – ROI Analysis

UnitNo	OptionNo	Year	Existing Unit Service Cost (AED)	Proposed Unit Service Cost (AED)	Service Cost Savings (AED)	Energy Cost Savings (AED)	Remaining Cost (AED)	Recovery Status
Existing Uni	Proposed Option No : 3							
		2021	1000	0	1000	450	6550	
		2022	1100	400	700	464	5386	
		2023	1210	420	790	491	4105	
		2024	1331	441	890	541	2674	
		2025	1464	463	1001	612	1061	
		2026	1610	486	1124	718	-781	Recovered in Year 5
		2027	1772	510	1262	864	-2907	Savings
		2028	1949	536	1413	1066	-5386	Savings
		2029	2144	563	1581	1348	-8315	Savings
		2030	2358	591	1767	1746	-11828	Savings

Figure 2. The return and breakeven schedule. A year-by-year accounting of service cost, energy saving and remaining unrecovered capital identifies the breakeven year explicitly — here year six — from which net present value and discounted payback follow. Stating the year rather than a duration lets a client compare it against their own holding period.

Reporting the breakeven year rather than a payback duration is a deliberate presentation choice. A three-year payback is an abstraction; year six is a date a facilities manager can set against a lease term, a refurbishment cycle or a disposal plan.

3.3 Electrical infrastructure and carbon

Two further stages distinguish the module from a pure cash-flow model. The electrical-infrastructure analysis translates connected load into utility-side consequence — apparent power and transformer sizing at the project's power factor and utilisation — which is where a more efficient option occasionally avoids a capital cost far larger than its own price premium.

The carbon account carries direct and indirect emissions across the horizon, which for a refrigerant-bearing option is not a restatement of the energy term. Under a tightening phase-down these two stages increasingly decide comparisons that the energy term alone would leave close.

4 Computational Methods

Notation is collected in Appendix A; worked numerical examples in Appendix B.

4.1 The discounted lifecycle cost

Lifecycle cost is first cost plus the present value of every subsequent cash flow across the analysis horizon, following the discounted-cash-flow convention codified in ISO 15686-5 and NIST Handbook 135.

$$LCC = C(0) + \text{SUM over years } t = 1..N \text{ of } [\, C(energy,t) + C(maintenance,t) + C(refrigerant,t) + C(replacement,t) \,] \,/\, (1 + \text{discount rate})\hat{}t \qquad \text{(lcc)}$$

where C(0) is first cost including equipment, installation and commissioning, and the four annual terms are energy, maintenance, refrigerant and replacement in year t. N is the analysis horizon and d the discount rate.

The energy term is itself a product of three time-varying quantities rather than a constant: annual consumption, which rises as equipment ages through a derating factor; the unit energy price, which escalates; and the operating profile, which the upstream selection established.

$$C(energy, t) = E(0) \text{ x } (1 + derating)\hat{}t \text{ x } p(0) \text{ x } (1 + escalation)\hat{}t \qquad \text{(energy)}$$

where E(0) is first-year consumption from the equipment selection, delta the annual performance derating as the machine ages, p(0) the current unit energy price, and g the annual energy price escalation.

4.2 Net present value and the breakeven year

A comparison between a proposed option and a baseline reduces to the present value of their annual differences, less the additional capital the proposed option requires.

$$NPV = -dC(0) + \text{SUM over } t \text{ of } dC(t) \,/\, (1+d)\hat{}t, \text{ and the breakeven year } t^* \text{ is the smallest } k \text{ for which the discounted savings to date have recovered the extra capital} \qquad \text{(npv)}$$

where dC(0) is the additional first cost of the proposed option and dC(t) the annual operating saving it produces in year t. Breakeven is defined on discounted rather than nominal savings, which pushes it later than a simple payback calculation would.

> Defining breakeven on discounted savings is the conservative choice and the honest one. A nominal payback calculation reports an earlier year, and the difference grows with the discount rate — which is exactly when the distinction matters most.

4.3 Sensitivity as a stability range

The two assumptions a lifecycle conclusion is most sensitive to are the discount rate and the energy escalation rate, and neither is knowable. Rather than presenting a point estimate, the tool reports the range over which the ranking between options is stable.

$$S = \textit{the set of discount-rate and escalation-rate pairs for which the proposed option remains preferred} \quad \text{(stability)}$$

a conclusion is robust where S covers the plausible range of both parameters, and fragile where the boundary of S falls inside it. Reporting the boundary rather than a single point is what allows a reviewer to judge the recommendation against their own assumptions.

The practical form this takes is a comparison run at escalation of 4% and again at 7% per year. If the ranking holds at both, the recommendation is a recommendation. If it flips, the analysis has established that the decision depends on an energy-price forecast, which is a materially different and more useful finding than a false certainty.

4.4 Electrical infrastructure

Connected load translates into utility-side consequence through power factor and transformer utilisation, and the resulting sizing occasionally dominates the comparison.

$$kVA = \textit{connected load} / \textit{power factor}, \; kVA(\textit{transformer}) = kVA / \textit{utilisation factor} \quad \text{(kva)}$$

where L is connected electrical load, pf the power factor and u the target transformer utilisation. The transformer step is discrete, so a modest reduction in connected load can cross a rating boundary and avoid an entire unit of capital cost.

This discreteness is why the term deserves separate treatment rather than being folded into first cost. Energy savings accrue smoothly; a transformer either is or is not required. An efficient option that avoids a transformer upgrade can be cheaper on day one, which no purely operational comparison would reveal.

5 Reported Outcomes and Field Evidence

Three kinds of number, separated as in the other papers in this series.

5.1 Figures published for this module

The product's own record states that commercial HVAC tenders routinely require a 10 to 15 year lifecycle cost analysis, that buyers increasingly want a 15-year total-cost comparison, and that an honest analysis would have changed the conversation nine times out of ten. The last is a claim about how often lifecycle ranking differs from first-cost ranking, not a measured software outcome.

No adoption figure, time saving or accuracy claim is published for this module beyond the modelled scenario below. That is worth noting rather than obscuring: the module's published record largely describes what a defensible analysis requires rather than reporting what the tool has achieved.

5.2 A deployment in which this module was one of four

MileSoft's published HVAC case study describes a deployment at an HVAC OEM in which Lifecycle Cost Analysis was installed alongside AHU, FCU and Chiller Selection, and is described there as a multi-year total-cost comparison across equipment options — a sales lever in efficiency-driven tenders. The programme reported a 12 percentage-point uplift in proposal-to-order conversion and a 70% reduction in selection-cycle time.

> Those figures belong to the four-module programme. This module's individual contribution was not isolated, and this paper does not claim it.

The conversion figure is the one most plausibly connected to this module specifically, since a lifecycle comparison is a commercial instrument rather than an engineering one, and the case study names it as a sales lever. But the published data cannot separate that effect from the other three modules or from the process change that accompanied them.

5.3 Modelled engineer-hour recovery

Table 1. Published model parameters and the default-case result. The published assumption is that a manual 20-year TCO analysis takes about four hours against about twenty minutes in the tool.

Parameter	Default
Manual analysis time	240 minutes
Analysis time in MileSoft	20 minutes
Analyses per month	8
Engineer-hours released per year	352

This model has the most credible baseline of the six HVAC modules. Four hours for a manual 20-year comparison across five cost categories, with discounting and a sensitivity run, is if anything conservative — and unlike the other modules the automated output is genuinely comparable in scope to the manual one, because what has been automated is the arithmetic rather than the engineering judgement.

It is also the module where the volume assumption matters most. Eight analyses a month is a low count, and the resulting 352 hours arises from the size of each task rather than their frequency — so the figure is sensitive to whether a firm produces lifecycle comparisons routinely or only on request.

6 Discussion

6.1 Derivation is what makes the analysis survive review

A lifecycle analysis is a persuasive document, and persuasive documents are read adversarially. The reviewer's first move is to ask where the energy number came from. If the answer is a spreadsheet cell, the analysis is advocacy; if the answer is the equipment selection with certified performance data behind it, the argument moves to the equipment — which is where it belongs.

This is why deriving rather than entering the energy term is not a convenience feature. It changes the class of the document from an estimate to a consequence, and it is the difference between a lifecycle comparison that wins a tender and one that is politely set aside.

6.2 Reporting fragility is a feature, not a weakness

There is a commercial temptation to present a single confident number. A recommendation saying the proposed option is better at 4% escalation and worse at 7% looks weaker than one that simply says it is better.

It is not weaker; it is complete. A client making a capital decision on a 15-year horizon has their own view of energy prices, and giving them the boundary lets them apply it. Withholding the boundary produces a document that is easy to agree with and easy to dismiss once the assumption is discovered — and it will be discovered, because the assumption is the first thing a competent reviewer looks for.

6.3 A capability reference framework for lifecycle-costing tooling

Table 2. Capability reference framework. Each dimension is answerable by demonstration against a running system.

Dimension	Question the tool must answer by demonstration
D1 Derived energy	Change an equipment selection. Does the lifecycle analysis update, or keep its old figure?
D2 Five categories	Are first cost, energy, maintenance, refrigerant and replacement carried separately?
D3 Discounting	Are future cash flows discounted, and is the discount rate an explicit input?
D4 Escalation and derating	Does annual energy cost carry both price escalation and equipment performance derating?
D5 Sensitivity range	Is the stability boundary of the ranking reported, or only a point estimate?
D6 Discounted breakeven	Is breakeven defined on discounted savings, or on nominal ones?
D7 Electrical infrastructure	Is connected load translated into transformer sizing, with its discrete cost step?
D8 Refrigerant trajectory	Is refrigerant a rising cost across the horizon, or a fixed annual figure?

D1 is the test that separates an integrated tool from a spreadsheet with a better interface. Change the chiller and watch whether the lifecycle model notices.

6.4 Generalisability

The formulation is the standard discounted cash-flow method and generalises to any capital-versus-operating comparison. What is specific here is deriving the energy term from equipment selections, which requires those selections to exist in the same system — so the advantage described in Section 6.1 is available only where the lifecycle tool and the selection tools share a workspace. A standalone lifecycle calculator, however well built, cannot offer it.

7 Threats to Validity and Limitations

1. The nine-times-in-ten claim is unquantified. It is published in the product's own record as a characterisation of how often lifecycle ranking differs from first-cost ranking, without a sample, a population, or a definition of the comparison.
2. Confounded deployment result. The 12 percentage-point conversion uplift belongs to a four-module deployment with concurrent process change, and this module's contribution was not isolated.
3. A lifecycle model is only as good as its inputs. Maintenance cost, service life and refrigerant leak rate are assumptions with wide plausible ranges, and the method presented here makes them explicit rather than accurate.
4. Derating is applied as a constant rate. Equation (energy) uses a single annual performance derating, whereas real degradation is condition-dependent and often step-like around maintenance events.
5. Discount rate is a client property, not an engineering one. The tool takes it as an input; a selection that is favourable at one organisation's cost of capital may not be at another's, and this paper offers no guidance on choosing it.
6. No accuracy validation. No comparison is published between the module's predicted lifetime cost and realised cost on a completed installation, which is the measurement that would establish the method rather than the arithmetic.

The last limitation is inherent rather than incidental. A 15-year prediction cannot be validated inside a product cycle, which is precisely why the discipline emphasises transparent assumptions over confident outputs.

8 Future Work

- Realised-versus-predicted tracking. Following completed installations against their submitted lifecycle model, even for the first three to five years, would begin to establish which cost categories are estimated well and which are not.

- Condition-dependent derating. Replacing the constant annual derating in Equation (energy) with a maintenance-event model would better represent how equipment performance actually decays.
- Refrigerant price trajectories. Carrying published quota-contraction schedules into the refrigerant term, rather than a flat annual figure, would make the phase-down a quantified cost rather than a stated risk.
- Stochastic sensitivity. The current treatment reports a stability boundary in two parameters; sampling the joint distribution of all uncertain inputs would give a probability that the ranking holds rather than a range in which it does.
- Carbon price integration. The carbon account currently reports emissions; carrying a carbon price trajectory would let emissions enter the cash-flow comparison directly rather than sitting beside it.

9 Conclusion

Tenders ask for a lifecycle cost analysis and usually receive energy multiplied by a horizon. The difference matters because a lifecycle comparison frequently reverses a first-cost ranking, and a reversal is only persuasive if the analysis behind it survives adversarial reading.

This paper has described a tool built for that reading: five discounted cost categories rather than one, an energy term derived from the upstream equipment selections rather than entered by hand, breakeven defined on discounted savings rather than nominal ones, sensitivity reported as the range over which the ranking is stable, and an electrical-infrastructure term whose discrete cost step occasionally decides the comparison outright.

The capability reference framework of Section 6.3 is offered as the durable contribution, and its first question is the one that distinguishes an integrated tool from a spreadsheet with a better interface: change the equipment selection, and see whether the lifecycle analysis notices.

Appendix A Nomenclature

Table 3. Symbols and abbreviations used in this paper.

Symbol / term	Meaning
LCC	Lifecycle cost — first cost plus the present value of all subsequent cash flows
C(0)	First cost: equipment, installation and commissioning
C(energy, t)	Energy cost in year t
C(maintenance, t)	Maintenance and service cost in year t
C(refrigerant, t)	Refrigerant top-up and handling cost in year t
C(replacement, t)	Component replacement cost falling in year t
N	Analysis horizon in years
d	Discount rate
E(0)	First-year energy consumption, derived from the equipment selection
delta	Annual performance derating as equipment ages
p(0)	Current unit energy price
g	Annual energy price escalation rate
NPV	Net present value of the proposed option against the baseline
dC(0)	Additional first cost of the proposed option
dC(t)	Annual operating saving of the proposed option in year t
t*	Breakeven year on discounted savings
S	Set of discount and escalation rates over which the ranking is stable
L	Connected electrical load
pf	Power factor
u	Target transformer utilisation factor
TCO	Total cost of ownership

Appendix B Worked Numerical Examples

Appendix B.1 A fifteen-year comparison, discounted

Two options serve the same duty over a 15-year horizon at a discount rate of 8%. The baseline costs 4,200,000 in capital and consumes 620,000 kWh per year; the proposed option costs 5,400,000 and consumes 486,000 kWh. Energy is priced at 9.50 per kWh, escalating at 5% per year. Annual performance derating is 1% for both. Maintenance is 95,000 for the baseline and 118,000 for the proposed option, escalating at 4%.

First-year energy cost, from Equation (energy): baseline 620,000 x 1.01 x 9.50 x 1.05 = 6,246,555; proposed 486,000 x 1.01 x 9.50 x 1.05 = 4,896,320. The first-year operating saving is 1,350,235 in energy less 23,000 in additional maintenance, or 1,327,235.

The additional capital is 5,400,000 — 4,200,000 = 1,200,000. Discounting the first year at 8% gives 1,327,235 / 1.08 = 1,228,921 — already more than the additional capital. Applying Equation (npv), the breakeven year t* is 1: the proposed option recovers its premium inside the first year and accumulates advantage for the remaining fourteen.

> That result is unusually clean because the energy differential is large relative to the capital differential. The interesting cases are the ones where it is not — which is what the sensitivity treatment in the next example is for.

Appendix B.2 When the ranking depends on an assumption

Change the example so the options are closer: the proposed option costs 7,600,000 — a premium of 3,400,000 — and consumes 560,000 kWh against the baseline's 620,000. Everything else holds.

First-year energy saving is now 60,000 kWh x 1.01 x 9.50 x 1.05 = 604,013, less 23,000 additional maintenance, giving 581,013. At 5% escalation and an 8% discount rate the discounted savings over 15 years sum to approximately 5.55 million, comfortably exceeding the 3.4 million premium. Applying Equation (npv), net present value is positive and the proposed option wins.

Now run it at 4% escalation: discounted savings fall to about 5.16 million — still positive. At 7% escalation they rise to about 6.42 million. The ranking holds across the whole range, so by the criterion of Equation (stability) the recommendation is robust and can be stated as one.

Had the premium been 6,000,000 instead, the same run would give a negative net present value at 4% escalation and a positive one at 7%. That is a materially different finding, and reporting it as such — the decision depends on your view of energy prices — is more useful to a client than either point estimate presented alone.

Appendix B.3 The transformer step

The baseline option presents a connected load of 385 kW at a power factor of 0.88 and a target transformer utilisation of 0.80. Applying Equation (kva): kVA = 385 / 0.88 = 437.5, and kVA(transformer) = 437.5 / 0.80 = 546.9 — which requires a 630 kVA transformer, the next standard rating.

The proposed option's connected load is 352 kW. kVA = 352 / 0.88 = 400.0, and kVA(transformer) = 400.0 / 0.80 = 500.0 — which fits a 500 kVA unit.

A 33 kW reduction in connected load, about 8.6%, has crossed a rating boundary and avoided a transformer upgrade. The capital avoided by that single step can exceed the equipment premium outright, and no purely operational comparison would surface it — which is why the electrical-infrastructure stage is a separate step in the wizard rather than a line in the cost table.

Appendix B.4 The published engineer-hour model

MileSoft's published model assumes a manual 20-year total-cost analysis takes about four hours against about twenty minutes in the tool, at eight analyses per month.

Time saved per analysis is (240 — 20) / 60 = 3.667 h. Annual analyses are 8 x 12 = 96. Engineer-hours released are 3.667 x 96 = 352 h per year.

Unlike the other five HVAC modules, this comparison is close to like for like: a four-hour manual analysis and a twenty-minute automated one produce documents of similar scope. The saving that the model does not count is the one this paper argues is larger — the analyses that are never produced at all because four hours cannot be found, and the tender that is therefore answered on first cost.

Data provenance

Every quantitative claim in this paper resolves to one of the entries below. Figures marked as modelled estimates are not deployment measurements; their assumptions are stated.

Metric	Reported value	Provenance
Lifecycle analysis horizon required by commercial HVAC tenders	10-15 years	**Product specification** /products/lifecycle — Stated in the Lifecycle Cost Analysis blog post.
Engineer-hours released per year, lifecycle cost analysis	352 h/yr (modelled)	**Modelled estimate** A manual 20-year TCO analysis takes ~4 h; ~20 min in MileSoft; 8 analyses per month, 96 per year; Model and defaults published in src/data/roiModels.ts
Proposal-to-purchase-order conversion	+12%	**Operator-reported — A EUROVENT-certified AHU manufacturer**

Metric	Reported value	Provenance
Selection-cycle time	approx. 70% reduction	**Operator-reported — A EUROVENT-certified AHU manufacturer**

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