

Own the Battery, Sell the Optimisation: Tolling Agreement Economics

Dispatch Rights Lifecycle Funding and the Owner Optimiser Bargaining Interval

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Abstract

Battery tolls separate asset ownership from the right to optimise market use. Their financing economics depend on measured capability, payment deductions, charging-cost allocation, lifecycle expenditure and counterparty collection. This paper develops a contract and cash-flow framework using disclosed primary announcements, market procedures and a municipal agreement attachment, with explicit limits on what those sources establish.

An authored hypothetical 100 MW two-hour battery illustrates ten-year owner and optimiser cash flows. Senior debt sized to 1.35 times minimum coverage is £24.879 million, while owner unlevered NPV at an assumed 8% discount rate is negative £17.111 million. The owner's break-even first-year nameplate toll of £11.001 million exceeds the optimiser's £9.635 million ceiling. The resulting empty bargaining interval identifies a combined economic shortfall that reallocating toll payments alone cannot resolve.

Separate stresses distinguish capability loss, permanent payment loss and delayed collection. A six-invoice delay produces £4.160 million of gross receivables, with no additional month-end funding under the stated retained-surplus convention. Permanent payment loss produces a £5.109 million annual-boundary funding gap. These calculated outcomes remain confined to their hypothetical assumptions. The paper proposes evidence requirements for negotiation, financing, acquisition diligence and counterparty replacement.

JEL Classification: G12, G32, L94, Q41, Q48

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1. The ownership and optimisation decision

An investment decision about a battery toll should identify the services being sold, the obligations retained by the owner and the cash available after those obligations are performed. A fixed payment can be analysed alongside maintenance, performance deductions, replacement expenditure and counterparty exposure. The investment committee should receive an owner cash-flow statement and a separate optimiser statement, connected by the same contract definitions. This analytical separation makes each party's exposure visible without assigning an unsupported market value to the contract.

Enspired's explanation distinguishes tolling, fully merchant and floor structures, including floor arrangements with a cap. Its examples illustrate possible payment designs; they do not disclose

representative executed pricing or establish complete protection against technical and counterparty loss. [1] These categories provide starting points for comparing proposals. The proposed evaluation should use each draft's actual waterfall, eligible revenue definition and operating envelope.

The principal financing question is the amount and timing of cash that remains dependable under defined adverse conditions. Recommended analysis includes reduced capability, delayed payment, disputed deductions and replacement of the optimiser. The numerical assumptions for those conditions must be presented as hypothetical unless supported by project documents. An attractive headline toll requires an equally clear statement of what the owner must spend and deliver throughout its term.

2. What the public evidence establishes

Public announcements provide useful examples of commercial structures. Their disclosed terms should remain attached to their dates, counterparties and conditions. A statement that an agreement was signed establishes the issuer's reported transaction status at publication. Subsequent operation, fulfilment of conditions and collection of contracted cash require separate evidence. An investment appraisal should record the available document, its authority and the questions that remain open.

Table 1. Selected announced battery contracting structures

Structure and announcement	Announced capacity	Tenor	Payment or indexation	Disclosed boundary
Shell, Bramley; 6 August 2024 body dateline [2]	100 MW / 330 MWh	Seven years	Fixed-price toll; indexation undisclosed	Full performance and security terms undisclosed
Drax, Coalburn; 19 February 2026 [3]	200 MW / 800 MWh	Fifteen years from COD	Fixed annual fee; no indexation	Capacity Market and certain ancillary revenues excluded; FID and operation conditions
Drax, West Burton; 30 January 2026 [4]	250 MW / 500 MWh	Ten years from COD	Annual payment indexed to UK CPI	Capacity Market revenue excluded; FID and operation conditions
Neoen, AGL; 14 April 2022 [7]	70 MW / 140 MWh virtual product	Seven years	Price and indexation undisclosed	NSW virtual product backed by Canberra asset; retained network-service capability

Announcement evidence only. Undisclosed means the cited announcement does not state the term. BW ESS gives a body dateline of 6 August 2024 and a header date of 5 August 2024; the table uses its body dateline. Capacities retain the announced basis; current operation and amendments are not established here.

The West Burton announcement contains two different timing statements: a 2028 target in its highlights and commercial operation by H2 2029 in its contractual conditions. Both should be retained when describing that historical announcement. Neither establishes actual commissioning. [4] A transaction review should resolve such differences through the operative agreement and current milestone certificates.

Quinbrook announced financial close and construction commencement for Supernode's first stage on 11 April 2024, alongside Origin's full-capacity long-term offtake commitment. The announcement does not disclose the complete payment, performance or financing package. [8] Financial close evidence can therefore support transaction history while leaving detailed risk

allocation open. The evidence register should also distinguish an executed agreement, a municipal attachment, a product description and a market rule.

3. Physical dispatch and virtual settlement

The contemplated contract should define whether the customer receives authority over an identified physical battery, a financially settled battery profile, or a specified combination. This distinction should appear in the commercial summary, dispatch protocol and settlement calculation. A physical asset description alone leaves important questions about the service that the buyer can actually instruct or receive.

Neoen's 2022 AGL announcement describes a virtual battery product in New South Wales backed by Capital Battery in Canberra. It identifies five-minute virtual charging and discharging instructions and continued network-service capability for Neoen. [7] This is a historical example of a disclosed virtual structure. Its terms should not be translated into exclusive physical dispatch authority or a current valuation assumption.

For a proposed physical toll, the analytical schedule should identify the command originator, authorised operator, communications route and instruction hierarchy. The owner should retain clearly defined safety and equipment-protection authority. The commercial agreement should explain the consequences when a valid instruction cannot be executed, including the evidence required to attribute the cause. Recommended causes include equipment unavailability, communications failure, network restrictions and instructions outside the agreed envelope.

For a proposed virtual product, the settlement schedule should specify the reference price, location, interval, virtual inventory, efficiency convention and permitted instruction changes. The parties should test settlement under negative prices, missing data and a difference between the reference location and the physical connection. Any physical hedge supporting the product should be analysed separately, using its own constraints and cash flows.

4. Measuring the service that can be delivered

The proposed performance schedule should distinguish power, usable energy, efficiency and availability. MW identifies a rate of charging or discharge. MWh identifies an energy quantity over time. A transaction model should state the measurement boundary for each input and explain whether auxiliary consumption, conversion losses or connection limits are included. These definitions are analytical prerequisites for comparing proposals on a consistent basis.

Recommended diligence begins with the connection agreement, operating restrictions, metering diagram and test protocol. The reviewer should reconcile the capability promised to the buyer with the capability demonstrated at the delivery point. Installed equipment specifications and delivery-point test results should occupy separate fields. The proposed contract should define test conditions, recalibration, observation rights, tolerances and treatment of a contested result.

Table 2. Proposed responsibility and evidence matrix

Attribute	Required definition	Owner diligence	Optimiser diligence
MW	Charge/discharge rate and connection boundary	Demonstrated capability and restrictions	Instruction limits and concurrent commitments
MWh	Usable energy and inventory boundary	Test evidence and restoration plan	Starting inventory and replenishment responsibility

Attribute	Required definition	Owner diligence	Optimiser diligence
Dispatch	Command and override hierarchy	Safety authority and response record	Valid instructions and communications audit
Revenue	Rights by product and interval	Retained rights and deduction exposure	Assigned receipts and settlement access
Cost	Charging, losses, fees and auxiliaries	Retained expenditure and reimbursement rights	Purchase responsibility and invoice reconciliation

Analytical diligence recommendations; allocations require agreement and are not asserted as standard or executed terms.

Availability calculations should specify the relevant hours, required capability, partial derating, maintenance, testing and buyer-attributable interruptions. Recommended modelling should calculate deductions from those definitions and disclose the interval logic underlying any annual percentage.

5. Revenue rights and dispatch priority

The proposed revenue schedule should list each product, its beneficiary, the relevant interval and the capacity reserved to deliver it. Recommended categories include energy trading, capacity commitments, frequency services and other explicitly contracted services. Every retained right should be reconciled with the dispatch authority sold under the toll. The same physical capability should have a documented priority when obligations overlap.

Drax's Coalburn announcement assigns operational control and dispatch rights to Drax while excluding Capacity Market and certain ancillary revenues from the revenues it retains. [3] That disclosed carve-out supports a specific diligence question: how do the operative documents coordinate obligations associated with the excluded receipts? The announcement leaves the detailed coordination and remedies undisclosed.

NESO's response terms effective 31 July 2026 address third-party commitments that impair contracted response delivery. Clauses 12.1–12.5 include notification, potential termination, replacement-service costs and specified limits or exceptions. [6] These provisions belong to the applicable response arrangements. A bilateral toll requires its own allocation of resulting charges, dispatch conflicts and evidential responsibilities.

The recommended priority schedule should identify who reserves capability, who can release it and who bears the cost of an avoidable conflict. Proposed reporting should show available power, available energy and committed services together. The parties should define how a network instruction, safety restriction or emergency instruction affects toll payment and retained revenues.

Recommended floor or profit-sharing diligence should identify treatment of charging costs, fees and penalties. Any proposed cap should state its reset period and loss treatment. No representative market terms are assumed.

6. Charging energy, losses and imbalance

Charging responsibility should be documented from energy procurement through settlement. The proposed allocation should identify who purchases energy, who submits schedules, who funds collateral and who receives subsequent corrections. Separate treatment should be specified for station use, operational charging, commissioning, tests and charging outside valid instructions. Each category should reconcile to metered quantities and invoices.

The publicly accessible Anaheim/Roadhouse agreement text allocates charging-energy costs and specified delivery and imbalance charges to the buyer under section 4.1; section 4.2 addresses seller responsibility for station use. [14] This is an example of disclosed drafting. Execution, amendments and current project status have not been verified.

Ellexon describes the BSC as a multi-party legal framework underpinning electricity trading in Great Britain. [5] The proposed agreement should distinguish the market-facing account from the party bearing the expense economically. A pass-through should state the settlement evidence, permissible adjustments, invoice timing and dispute process.

Recommended modelling should preserve the direction of energy and cash separately. Purchased charging energy, discharged energy and losses should use consistent measurement boundaries. Negative purchase prices should retain their sign. Additional fees or taxes should be represented only where their applicability and allocation are established, or explicitly identified as hypothetical assumptions.

Recommended liquidity analysis should follow proposed invoice and settlement calendars, testing delayed statements, disputed deductions and meter corrections. Reconciliation should connect instructions, meter intervals, market statements and invoices. These proposed controls require project-specific implementation.

7. Degradation and the operating envelope

The proposed operating envelope should connect commercial dispatch rights to the equipment and maintenance obligations supporting them. Recommended inputs include permitted charge and discharge rates, energy limits, temperature restrictions, inventory limits and throughput allowance. The contract should explain how these restrictions change after a test, repair or replacement. A dispatch right needs a defined technical boundary throughout the delivery term.

SAM documentation distinguishes calendar degradation from cycle degradation and provides different battery-life modelling options. Their methods combine degradation differently and allow specified replacement schedules or thresholds. [16] The documentation supports transparent methodology. It does not provide a warranted life, degradation coefficient or augmentation price for the contemplated asset.

The proposed cycle allowance should identify the reference capacity, measured throughput and treatment of partial cycles. A compensation mechanism needs an agreed economic purpose, payment date and permitted use. The parties should obtain engineering evidence before assigning a relationship between a cycle count, capacity loss and replacement expenditure.

Recommended financial analysis should connect the agreed operating envelope to a stated restoration strategy. The owner should identify who purchases replacement equipment, funds the reserve, approves downtime and bears performance deductions during the work. An augmentation payment and an augmentation reserve serve different functions and should have distinct cash-flow treatment. The model should avoid charging the same expenditure twice.

Recommended throughput reporting should define charged or discharged energy and partial-cycle counting. Hypothetical degradation assumptions should state their limitations; manufacturer warranties and project tests remain separate diligence requirements.

8. Market participation and credit boundaries

The proposed toll should allocate registration, bidding, metering, settlement and compliance. Diligence should record approvals, renewals and consequences of suspension for the relevant jurisdiction and participation model.

AEMO's current registration page describes Integrated Resource Provider requirements and exemptions for integrated resource systems. Its Energy Limit Validation guidance, modified 31 July 2026, describes optional BDU energy-bid fields and storage-capacity validation. [9; 10] These materials support registration and bidding diligence; they do not establish a private toll's charging-cost allocation or performance guarantee.

The NEM Credit Limit Procedures version 9.0, effective 3 June 2024, describe participant prudential calculations. [11] AEMO's current procedures page states that cash credit support becomes available from 1 November 2026, after this paper's research date. [17] The transaction review should verify the operative requirements at closing and distinguish market credit support from bilateral security and debt-service reserves.

FERC's 2018 Order 841 announcement concerns storage participation in RTO/ISO capacity, energy and ancillary markets. [12] CAISO's storage guidance identifies scheduling coordination, metering, certification and telemetry requirements for its participation arrangements. [13] These sources have defined institutional scopes. Neither establishes uniform US toll terms or an ERCOT participation framework.

Recommended liquidity analysis should identify which entity posts each form of support, the relevant trigger, release conditions and competing demands on cash. The model should separate a collateral posting from an expense and record any assumed recovery date. Project-specific legal and market advice remains necessary to confirm the applicable obligations.

9. Counterparty continuity and financing diligence

Proposed credit diligence should identify the payment obligor, guarantor, security provider and recourse limits. Recommended downside cases should distinguish late payment, disputed entitlement, sustained default and termination, with separate collection assumptions and liquidity consequences.

Energy Vault's September 2025 Form 10-Q, signed on 10 November 2025, reports Cross Trails commercial operation and a ten-year Gridmatic toll. It separately reports a fully funded senior secured facility, maturity in July 2032 and a minimum debt-service coverage ratio. [15] This issuer disclosure establishes historical reported project facts. It provides no representative debt-sizing rule or complete toll agreement.

The Anaheim attachment includes financing accommodation in Article 14 and a form of collateral-agent consent in Exhibit S. The form contains placeholders, including cure timing. [14] Its contents support diligence questions about notice, cure, transfer and replacement ownership; they do not establish completed lender step-in arrangements.

Recommended closing requirements should include executed documents, satisfied conditions precedent, confirmed authority, security effectiveness and an agreed transition protocol. A successor optimiser should receive the data and access needed to reconcile outstanding

settlements and operate within approved restrictions. The proposed agreement should specify responsibilities during a transition and the treatment of receipts, invoices and stored energy.

Recommended termination analysis should separate contractual entitlement from assumed recovery, with dated replacement costs, unpaid fees and collateral proceeds. Unevidenced merchant or refinancing proceeds should be labelled hypothetical.

10. Assumptions and modelling boundaries

The numerical case is an authored hypothetical 100 MW battery with 200 MWh of usable energy delivered at the grid connection. It tests a ten-year toll and a two-hour capability requirement. Every price, cost, financing term and physical trajectory in this case is an assumption. The case has no connection to the commercial terms of the announced projects discussed earlier. Monetary tables use millions of pounds, with calculations performed before display rounding.

Usable energy follows 200, 196, 192, 188 and 184 MWh in the first five years. An assumed £8 million augmentation at the start of year six restores 200 MWh, followed by the same sequence. Calendar availability is 98%. These inputs describe a payment capability test. They provide no chronological dispatch, state-of-charge simulation, warranty validation or engineering demonstration that multiple services can be delivered simultaneously.

The optimiser's assumed market contribution is already net of purchased charging energy, losses, market fees and imbalance. Its independent trajectory is specified directly. Physical owner stresses leave that trajectory unchanged; any corresponding optimiser cash comparison would therefore be conditional on an artificial earnings boundary. The owner stress results reported below stand separately from a forecast of the optimiser's actual operational response.

Table 3. Authored inputs and valuation boundaries

Input	Value	Unit or timing
Reference power	100.000	MW
Reference grid-deliverable energy	200.000	MWh
Capacity test duration	2.000	hours
Usable energy, years 1-5	200.000, 196.000, 192.000, 188.000, 184.000	MWh; repeated in years 6-10
Base calendar availability	98.000%	available hours
First-year nameplate toll	8.500	£m
Annual toll indexation	2.000%	annual
First-year owner opex	1.600	£m
Annual opex inflation	2.000%	annual
Authored cash-tax allowance	0.400	£m each year
Initial capex / unrestricted WC	55.000 / 1.000	£m at close
Lifecycle contribution, years 1-5	1.600	£m per year
Actual augmentation	8.000	£m at start of year 6 (t5)
Senior interest / minimum DSCR	6.000% / 1.350	annual interest / times
Term / unlevered discount	10 / 8.000%	years / annual
Initial optimiser net contribution	11.500	£m; declines 3% annually
Initial optimiser operating fee	0.400	£m; grows 2% annually
Optimiser initial funding	0.000	£m capex, WC and collateral

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Usable MWh is already grid-deliverable. Net market contribution includes charging energy, losses, market fees and imbalance. Tax is a fixed modelling allowance. Zero asset resale and excluded unspecified end-of-life costs apply.

11. Converting capability into collected toll

The annual earned toll multiplies an indexed nameplate fee by calendar availability and the usable-energy fraction. The reference-energy denominator is 200 MWh. Capping the energy fraction at one excludes payment for capability beyond the contracted reference. A commercial agreement would need its own test procedure, measurement resolution and treatment of excused outages. The assumed formula is:

$$\hat{T}_y = F_0(1+g)^{y-1} a_y \min(1, \frac{E_y}{E_*}) \quad (1)$$

Here the first-year nameplate fee is £8.5 million, annual indexation is 2%, available-hours fraction is 98% and the usable-energy input follows the stated sequence. Paid fractions fall from 98% to 90.16% before augmentation. Annual toll cash consequently declines from £8.330 million to £8.295 million during years one to five despite fee indexation. After the energy reset, year-six toll cash rises to £9.197 million.

For the base case, every earned amount is collected at the relevant year-end. Collected toll enters cash flow available for debt service, abbreviated CFADS, after owner operating costs, the cash-tax allowance and restricted lifecycle contributions:

$$CFADS_y = C_y^T - O_y - X_y - R_y \quad (2)$$

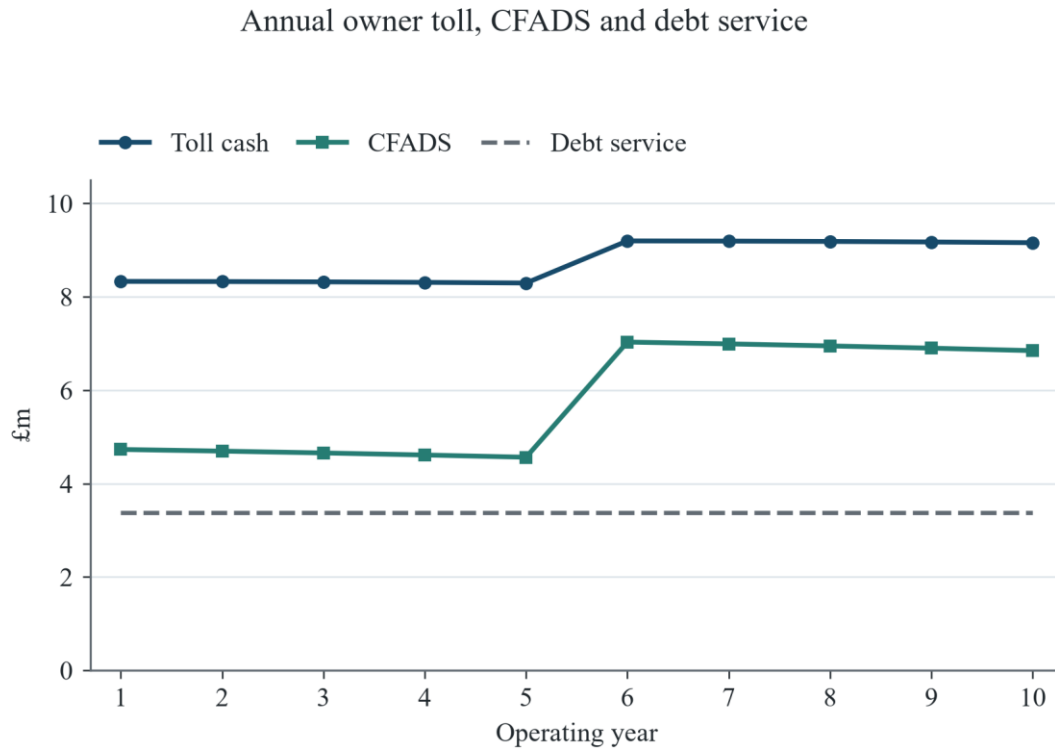
The £0.4 million annual tax allowance is an authored cash deduction with no tax-law interpretation. Lifecycle contributions of £1.6 million in each of the first five years reduce CFADS. Their accumulated £8 million pays for augmentation; deducting that expenditure again from CFADS would charge the same funded requirement twice.

Table 4. Annual owner toll and financeable cash

Year	Paid (%)	Earned (£m)	Collected (£m)	CFADS (£m)
1	98.000	8.330	8.330	4.730
2	96.040	8.327	8.327	4.695
3	94.080	8.320	8.320	4.655
4	92.120	8.309	8.309	4.612
5	90.160	8.295	8.295	4.563
6	98.000	9.197	9.197	7.030
7	96.040	9.193	9.193	6.991
8	94.080	9.186	9.186	6.948
9	92.120	9.174	9.174	6.900
10	90.160	9.159	9.159	6.847

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Base collection equals earned toll. Paid factor equals available-hours fraction times usable-energy capability. CFADS deducts opex, cash tax and £1.6m annual restricted lifecycle contributions in years 1-5.

Figure 1. Annual owner toll, CFADS and fixed senior service



Authored hypothetical base case. Earned toll is collected in full. CFADS includes opex, fixed cash tax and lifecycle contributions in years 1-5. Actual augmentation uses the restricted account and is not deducted again. Monetary values are GBPm.

12. Debt sizing and amortisation

Senior debt is sized against the lowest annual base CFADS, £4.563 million in year five. The authored minimum coverage requirement is 1.35 times, interest is 6%, and debt is repaid through ten equal year-end payments. These assumptions yield annual service of £3.380 million and an initial draw of £24.879 million. The expression combines the binding cash-flow test with the present value of an annuity:

$$D_0 = \frac{\min_y \text{CFADS}_{y,\text{base}}}{k} \frac{1 - (1+r)^{-n}}{r} \quad (3)$$

Annual interest equals opening debt multiplied by 6%. Principal equals the fixed service amount less interest. The final payment extinguishes principal. Table 5 provides the entire amortisation schedule so that the binding coverage year can be distinguished from the final repayment year. A first-year-only coverage calculation would overlook the deterioration before augmentation.

This sizing exercise assumes the same minimum coverage definition across all years. It contains no cash sweep, sculpted amortisation, refinancing, hedge cost, facility fee or distribution covenant. Each of those would require an additional contractual input. Original debt service remains fixed in the downside cases. Recalculating smaller debt after a payment or capability loss would answer a new-financing question and would conceal the original lender's exposure.

Table 5. Fixed senior amortisation schedule

Year	Opening (£m)	Interest (£m)	Principal (£m)	Closing (£m)
1	24.879	1.493	1.888	22.992
2	22.992	1.380	2.001	20.991

Year	Opening (£m)	Interest (£m)	Principal (£m)	Closing (£m)
3	20.991	1.259	2.121	18.870
4	18.870	1.132	2.248	16.622
5	16.622	0.997	2.383	14.239
6	14.239	0.854	2.526	11.713
7	11.713	0.703	2.678	9.036
8	9.036	0.542	2.838	6.197
9	6.197	0.372	3.008	3.189
10	3.189	0.191	3.189	0.000

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Equal annual service is £3.380m, paid at year-end. Interest is 6% of opening debt. Year 5 base CFADS binds the 1.350 minimum DSCR. Original debt remains fixed in all downsides.

13. Funding uses and restricted accounts

At financial close, uses comprise £55 million of project capex, £1 million of unrestricted working capital and a debt-service reserve account of £1.690 million. The reserve equals half one annual senior payment. Debt and owner equity of £32.811 million fund total uses of £57.690 million. Table 6 reconciles those sources and uses without classifying restricted cash as available operating liquidity.

The lifecycle reserve starts at zero, receives £1.6 million each year for five years and reaches £8 million at the end of year five. It is spent at the start of year six. The debt-service reserve remains untouched throughout the model. It is released only after the final senior payment. Availability of a reserve to make an actual payment would depend on its account agreement and withdrawal conditions; this model supplies no assumed draw.

All owner operating surpluses after debt service are retained. This convention materially influences the later collection-delay test. A transaction distributing those surpluses could need more liquidity, which would require a separately dated distribution schedule. Working capital is already present in the unrestricted cash ledger at inception. The operating ledger receives no second working-capital release at maturity.

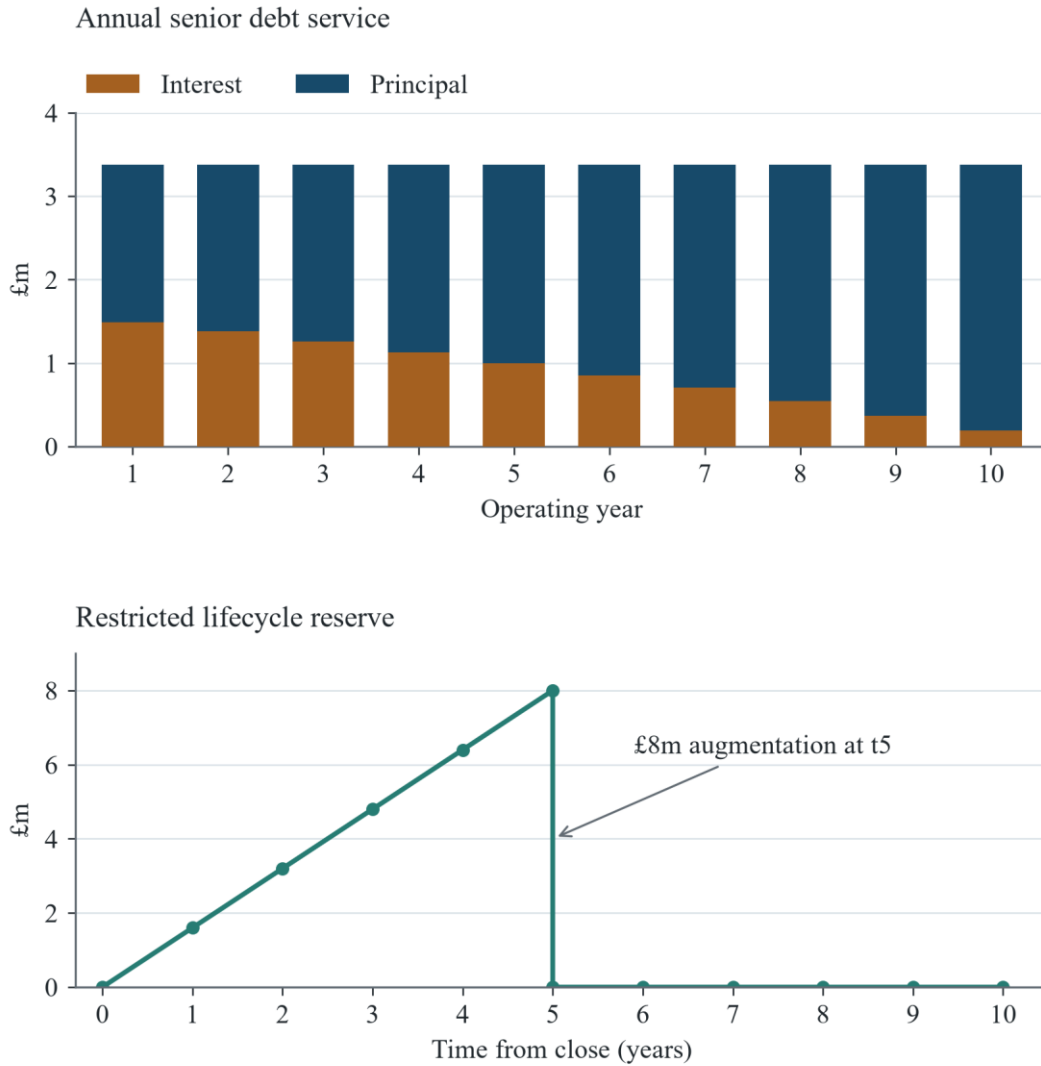
Table 6. Sources and uses at financial close

Side	Item	£m
Source	Senior debt	24.879
Source	Owner equity	32.811
Sources total	Debt plus equity	57.690
Use	Project capex	55.000
Use	Unrestricted opening WC	1.000
Use	Restricted DSRA	1.690
Uses total	Capex plus WC plus DSRA	57.690

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. DSRA is half one annual debt service, separate from unrestricted WC, unused during stress and released only after final service. Lifecycle reserve is built through subsequent cash contributions.

Figure 2. Amortising debt and restricted lifecycle funding

Debt service and the funded lifecycle reserve



Authored hypothetical base case. Equal annual service is split into interest and principal. The reserve line shows annual closing balances from £1.6m contributions during years 1-5 and £8m spending at start of year 6, time 5. Both t5 balances are shown. DSRA is a separate restricted account, excluded from this reserve line.

14. Owner investment value

The owner valuation measures unlevered project cash at an authored 8% discount rate. It invests capex and working capital at time zero, deducts actual augmentation at time five, and recovers the £1 million working-capital investment once at year ten. No asset resale value is assigned. Debt draw, debt service and the debt-service reserve are excluded from this unlevered calculation:

$$NPV_O = -I_0 - W_0 + \sum_{y=1}^{10} \frac{C_y^T - O_y - X_y}{(1+d)^y} - \frac{J_6}{(1+d)^5} + \frac{W_0}{(1+d)^{10}} \quad (4)$$

Annual operating cash is collected toll less opex and the fixed cash-tax allowance. Internal lifecycle contributions are excluded because they transfer cash between project accounts. Actual

augmentation is deducted once at its expenditure date. The different treatment of lifecycle funding in CFADS and unlevered valuation follows the different questions being answered: annual debt coverage and economic investment value.

The calculated owner NPV is negative £17.111 million. Base debt coverage meets the assumed requirement through sizing, while the investment fails the assumed unlevered return test. This result supports a separate approval decision for investment value. It does not measure an observed project's return or establish a suitable market discount rate.

Decommissioning, restoration, recycling and unspecified end-of-life liabilities remain unestimated. Adding a positive terminal value would require evidence for the remaining capability, recontracting opportunity and disposal costs. The zero-resale convention offers a transparent boundary for this example; it gives no engineering or legal conclusion about end-of-life obligations.

Table 7. Dated owner unlevered cash flows

Time (years)	Cash-flow item	Cash (£m)	8% factor	PV (£m)
0.000	Close: capex plus opening WC	-56.000	1.000	-56.000
1.000	Year 1 operating cash after tax	6.330	0.926	5.861
2.000	Year 2 operating cash after tax	6.295	0.857	5.397
3.000	Year 3 operating cash after tax	6.255	0.794	4.966
4.000	Year 4 operating cash after tax	6.212	0.735	4.566
5.000	Year 5 operating cash after tax	6.163	0.681	4.195
5.000	Start of year 6: actual augmentation	-8.000	0.681	-5.445
6.000	Year 6 operating cash after tax	7.030	0.630	4.430
7.000	Year 7 operating cash after tax	6.991	0.583	4.079
8.000	Year 8 operating cash after tax	6.948	0.540	3.754
9.000	Year 9 operating cash after tax	6.900	0.500	3.452
10.000	Year 10 operating cash after tax	6.847	0.463	3.171
10.000	Terminal WC recovery	1.000	0.463	0.463
Total	Owner unlevered NPV			-17.111

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Annual operating cash is at year-end. Year 5 operating cash and start-year-6 augmentation both fall at t5. WC returns once at t10. Internal reserve transfers, debt and DSRA are excluded. PV totals use unrounded values.

15. Optimiser economics and the cost boundary

The optimiser starts with £11.5 million of already-net annual market contribution, declining by 3% each year. A separate operating fee starts at £0.4 million and increases by 2%. Toll paid to the owner is deducted once. Table 8 shows the resulting annual cash path using the same physical payment and indexation basis as the owner receives.

No additional charging-energy or efficiency deduction is made because those items have already been netted from the market-contribution input. A live transaction should identify the source and reconciliation of each deduction. Gross market revenue with charging costs omitted would produce a different result. A market forecast would also need interval-level prices, dispatch constraints, eligibility and operational costs that this authored example does not supply.

The calculated optimiser NPV is positive £7.769 million at 8%. Annual optimiser cash becomes negative in years seven to ten. Positive aggregate NPV therefore leaves a separate obligation to fund those later payments. The model assumes zero initial optimiser capex, working capital and collateral. Actual requirements for those uses would need to be added before assessing a particular counterparty's affordability or credit capacity.

The two cash models reconcile the toll transfer exactly. Changing that transfer reallocates value between the parties when every other input is held fixed. It does not establish additional combined project value.

Table 8. Annual optimiser cash after toll

Year	Net market (£m)	Toll (£m)	Fee (£m)	Net cash (£m)
1	11.500	8.330	0.400	2.770
2	11.155	8.327	0.408	2.420
3	10.820	8.320	0.416	2.084
4	10.496	8.309	0.424	1.762
5	10.181	8.295	0.433	1.453
6	9.875	9.197	0.442	0.237
7	9.579	9.193	0.450	-0.065
8	9.292	9.186	0.459	-0.353
9	9.013	9.174	0.469	-0.630
10	8.743	9.159	0.478	-0.894

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Net market contribution is already after charging energy, losses, market fees and imbalance. Fee is the separate operating fee. Optimiser initial capex, WC and collateral are zero. Cash occurs at each year-end; years 7-10 are negative despite positive aggregate NPV.

16. The bargaining interval

A reservation-fee calculation solves each party's NPV at zero using the same ten-year physical payment factor and discount convention. Let H denote the present value of one unit of indexed nameplate fee after availability and energy deductions. Let K denote the owner's required present-value recovery of investment and operating costs, and B the optimiser's present-value market contribution after its separate operating fee. The possible fee interval is:

$$F_O = \frac{K}{H}, F_M = \frac{B}{H}, F_O \leq F_0 \leq F_M \quad (5)$$

The common payment factor H is 6.842833. The owner's first-year nameplate fee floor is £11.001 million, and the optimiser's fee ceiling is £9.635 million. The owner floor exceeds the ceiling by £1.365 million. No fee produces nonnegative NPV for both parties at 8% under this case's assumptions. The base £8.5 million fee allocates a negative owner NPV alongside a positive optimiser NPV.

Combined NPV is negative £9.342 million. Fee bargaining alone cannot close that combined gap because the toll cancels between the parties. An investment committee would need to examine the assumptions for capex, operating cost, service life and net market contribution, or decline the

proposed structure. Evidence would be required for each proposed improvement. Increasing residual value or future revenue without support would merely change the assumption set.

The interval is an analytical negotiation tool. It is not an observed bid range or a legal entitlement to a particular return. Optional wear compensation is excluded from these base reservation fees.

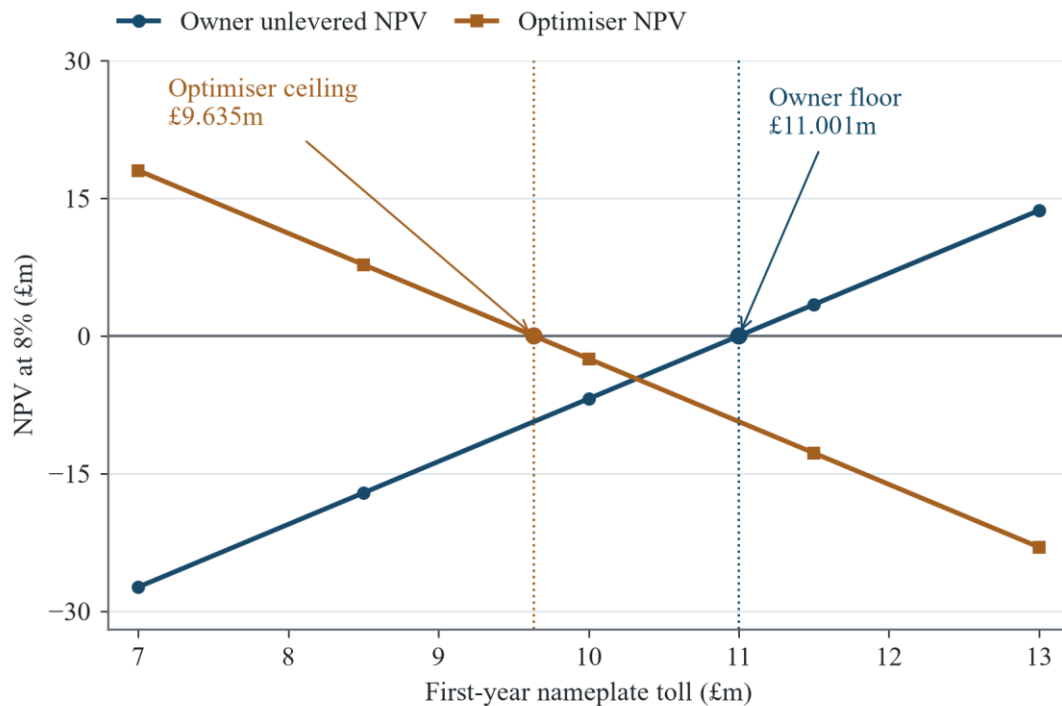
Table 9. Reservation fees and combined value

Measure	Result	Unit or interpretation
Owner unlevered NPV	-17.111	£m
Optimiser NPV	7.769	£m
Combined NPV	-9.342	£m
Owner first-year nameplate fee floor	11.001	£m
Optimiser first-year nameplate fee ceiling	9.635	£m
Optimiser ceiling less owner floor	-1.365	£m
Common discounted payment factor	6.843	factor
Feasible fee interval	Empty	owner floor exceeds ceiling

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Both fee roots use the same ten-year annual timing, 8% discount, physical payment factor and 2% indexation. Owner is unlevered; optimiser has zero initial funding. Toll transfers cancel from combined value. Optional wear is excluded.

Figure 3. Owner and optimiser reservation-fee bounds

Reservation fees and the empty bargaining interval



Authored hypothetical fee sensitivity at 2% indexation with other base inputs fixed. Source fee points are joined by their exact linear NPV relationship. Both parties use ten annual year-end cash flows discounted at 8%. Owner valuation is unlevered; optimiser initial capex, WC and collateral are zero. Owner floor exceeds optimiser ceiling. Extra-wear payments are excluded.

17. Debt coverage under owner downside cases

Table 10 applies five downside cases to the original £3.380 million annual debt service. Flat nominal toll reduces minimum DSCR to 1.163 times. Combining flat toll with 5% owner opex inflation reduces it to 1.100 times. Those cases retain positive annual cash after service, while falling below the assumed 1.35 sizing requirement. Covenant breach and inability to pay are distinct outcomes requiring the actual facility definitions.

An 80% availability assumption in year three reduces that year's DSCR to 0.925 times. A separate year-four energy stress uses 80% of the scheduled 188 MWh, or 150.4 MWh, and gives 0.873 times. Each creates a negative single-year cash margin after service. Retained earlier cash covers those margins under the no-distribution convention, with no additional annual-boundary funding calculated.

Permanent loss of 50% of toll collection in years three to five produces minimum DSCR of 0.123 times and a maximum annual-boundary funding gap of £5.109 million. Negative theoretical balances identify missing funding. The schedule assumes no rescue capital and provides no evidence that a lender would permit continued operation on those terms.

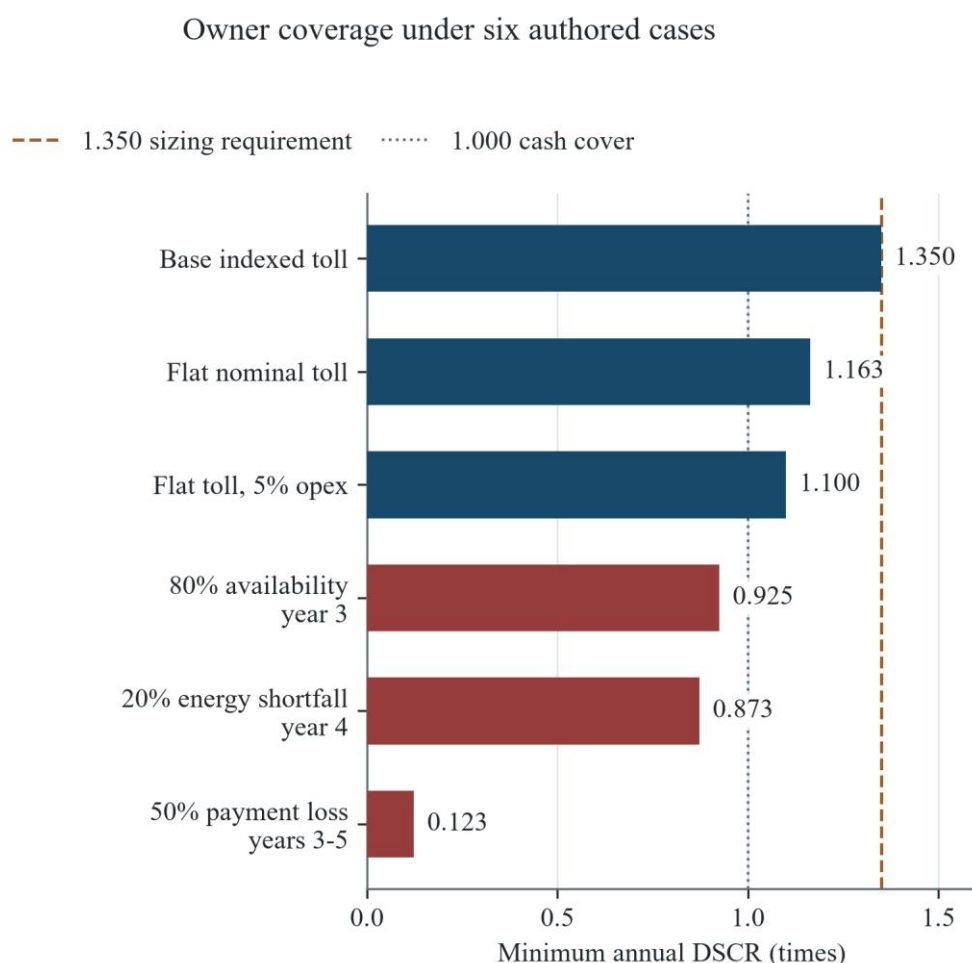
Market earnings are not forecast in these owner receipt stresses. Counterparty insolvency, debt acceleration, termination recovery and replacement dispatch would require separate assumptions. DSRA remains restricted and unused in every case.

Table 10. Owner downside coverage and funding

Owner case	Min DSCR (x)	Funding (£m)	Owner NPV (£m)
Base indexed toll	1.350	0.000	-17.111
Flat nominal toll	1.163	0.000	-21.445
Flat toll; 5% opex inflation	1.100	0.000	-22.928
80% availability in year 3	0.925	0.000	-18.324
20% energy shortfall in year 4	0.873	0.000	-18.333
50% payment loss in years 3-5	0.123	5.109	-26.290

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Funding avoids negative theoretical cash at annual boundaries, with £1m opening cash and no distributions. Original debt is fixed. Year 4 energy is 150.4 MWh. Payment loss is permanent, with no assumed recovery. No optimiser stress valuation is shown.

Figure 4. Minimum owner debt-service coverage across six cases



Authored hypothetical owner stresses use original fixed debt and equal annual service. DSCR is CFADS divided by service. The 1.350 sizing requirement and 1.000 cash-cover references are distinct. The 50% payment-loss case is permanent loss in years 3-5 and requires additional annual-boundary funding. DSRA is unused. No optimiser stress NPV is presented.

18. Dated invoices and collection liquidity

The monthly test splits each annual earned toll into twelve equal invoices. Normal collection occurs at each month-end. In the delayed case, invoices for months 25 to 30 are withheld in full and recovered at month 37 end together with that month's invoice. The case assumes no interest, penalty, permanent loss or ordinary collection lag. Monthly opex, tax allowance and lifecycle contributions equal one-twelfth of annual amounts; debt service remains annual.

Gross receivables reach £4.160 million at month 30 and remain there through month 36. Minimum month-end unrestricted cash is £0.779 million at month 36. Additional month-end funding is zero because the £1 million opening cash and retained prior surpluses cover the collection delay. Minimum opening cash for a zero month-end floor on this specific retained-surplus path is £0.221 million.

Receivables measure the unpaid exposure. Additional funding measures the cash deficit after available retained cash. Treating the £4.160 million receivable as an equal external funding requirement would overstate the result for this case. An owner distributing earlier surpluses would need a revised cash path before relying on the zero-funding finding.

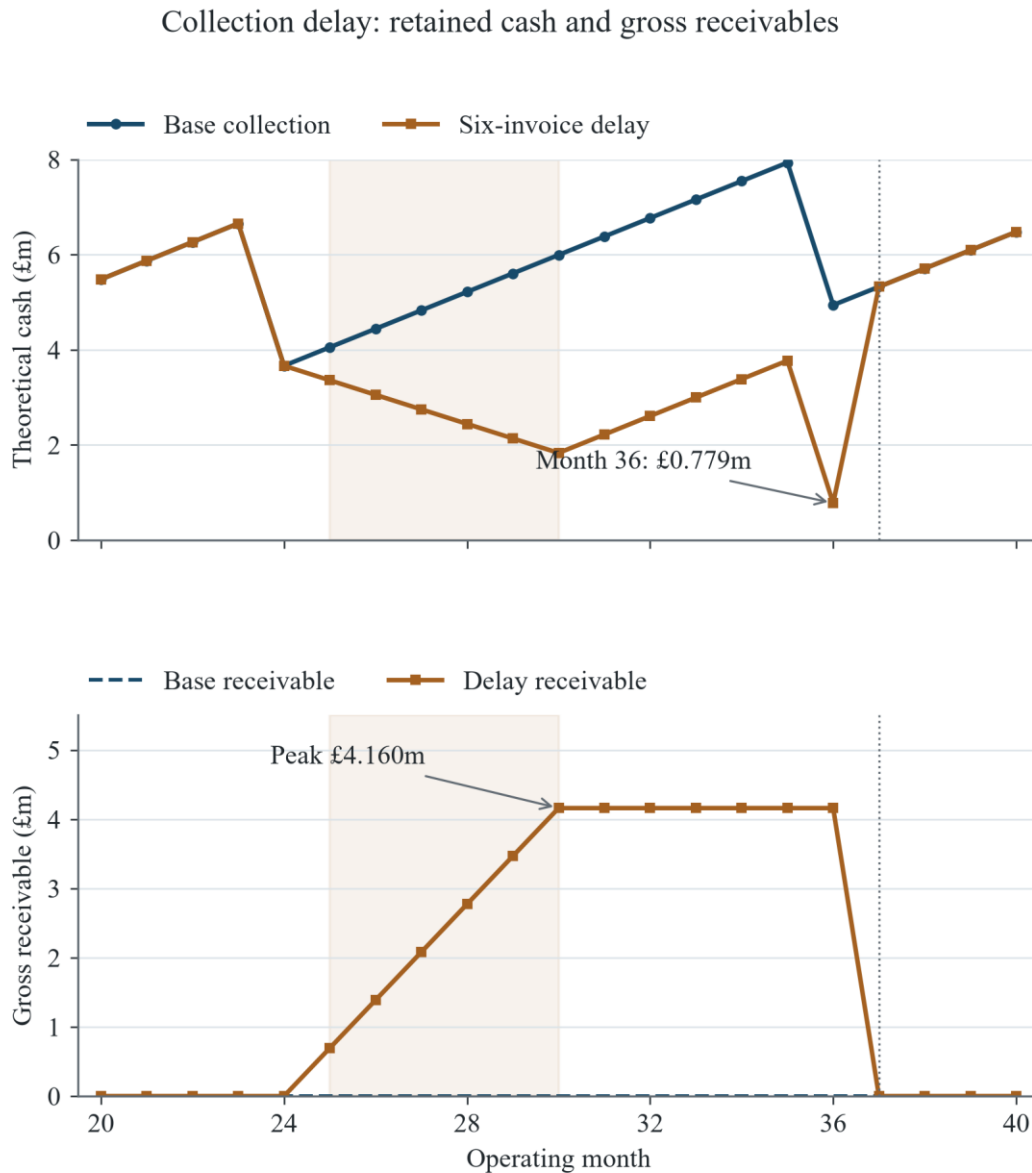
The calculation nets transactions at month-end. Intramonth ordering, disputed deductions and collateral draw timing remain unspecified. It establishes no intraday liquidity result. After the authored recovery, base and delay cash paths reconverge. The annual valuation in section 14 retains its stated timing convention; no monthly delay discount adjustment is embedded in that benchmark.

Table 11. Selected monthly collection-delay checkpoints

Month	Base cash (£m)	Delay cash (£m)	Delay AR (£m)	Recovery (£m)
24	3.664	3.664	0.000	0.000
25	4.052	3.359	0.693	0.000
26	4.440	3.053	1.387	0.000
27	4.828	2.748	2.080	0.000
28	5.216	2.442	2.773	0.000
29	5.604	2.137	3.467	0.000
30	5.992	1.832	4.160	0.000
35	7.931	3.771	4.160	0.000
36	4.939	0.779	4.160	0.000
37	5.323	5.323	0.000	4.160

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Closing theoretical cash is shown. Normal base receivables are zero. Months 25-30 invoices are unpaid until month 37, when six arrears and the current invoice are collected. Recovery column is arrears cash only. Minimum delay cash is month 36 after annual service. Additional month-end funding is zero; DSRA and collateral are unused. Intra-month sequencing is unspecified.

Figure 5. Monthly collection delay and retained-cash liquidity



Authored hypothetical paths shown for months 20-40. Shading marks invoices 25-30 withheld in full; the month 37 dotted line marks six-invoice recovery with the current invoice. Cash is retained without distributions. Peak receivable and cash erosion are £4.160m; minimum delayed closing cash is £0.779m in month 36, so additional month-end funding is zero.

DSRA and collateral are unused. Intra-month sequencing is unspecified. Monetary values are GBPm.

19. Sensitivity and negotiation evidence

The fee grid tests first-year nameplate tolls of £7 million, £8.5 million, £10 million, £11.5 million and £13 million. Indexation ranges from zero to 4%. Table 12 extracts the five fee cases at 2% indexation. Original debt service is unchanged. The grid displays how owner coverage and investment value change alongside optimiser affordability, without presenting the selected fees as market quotations.

A second grid independently varies calendar availability from 80% to 100% and first-year already-net market contribution from £8 million to £15 million. The output recalculates both reservation fees and records whether a bargaining interval exists. Availability changes the

payment factor. Each net market input is separately authored; the grid contains no estimated engineering or trading relationship between lower availability and market earnings.

These controls identify assumptions requiring diligence. A fee offer should be traced to the bidder's dispatch evidence, eligible revenue, transaction costs and collateral plan. The owner should reconcile its cost estimate, augmentation scope, connection constraints and operating contract to the same date and asset boundary. Both parties should review the entire fee trajectory rather than its first-year headline.

A positive cell represents a result under its own inputs. It supplies no probability, expected-case selection or protection against omitted costs. Counterparty approval should retain the underlying schedules and the assumptions that would invalidate the proposed fee interval.

Table 12. First-year fee sensitivity at 2% indexation

Fee (£m)	Owner NPV (£m)	Optimiser NPV (£m)	Min DSCR (x)
7.000	-27.376	18.034	0.917
8.500	-17.111	7.769	1.350
10.000	-6.847	-2.495	1.783
11.500	3.417	-12.759	2.216
13.000	13.681	-23.023	2.649

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. Fee is first-year nameplate toll. Other base assumptions and original senior debt are retained. NPVs use 8% annual discounting. Separate fee/indexation and availability/market grids remain in the frozen numerical package.

20. Cycling compensation and lifecycle funding

The optional wear case assumes 300 equivalent cycles in each of years one to five and 250 thereafter, against an allowance of 250. An authored charge of £0.020 million per excess cycle produces £1 million annually for the first five years. Every receipt enters a separate restricted wear account. It contributes zero incremental bankable CFADS, and the original debt remains unchanged.

This account is separate from the £8 million augmentation reserve already funded by the owner. The wear account ends at £5 million in year ten. Its permitted use and terminal release are unspecified, so no owner extra-wear NPV is assigned. No engineering relationship is claimed between the assumed cycles, energy trajectory and augmentation cost. SAM's distinction between calendar and cycle life reinforces the need to state the selected life-model method separately.[16]

The optimiser pays the compensation as an actual additional case outflow. Its present value is £3.993 million, reducing optimiser NPV to £3.777 million and its fee ceiling to £9.052 million. Ring-fencing can support a defined lifecycle purpose while reducing available cash for the optimiser; the release and expenditure terms remain essential to valuing the owner's benefit.

Contract drafting should specify the throughput meter, counting interval, correction mechanism, annual allowance and access to records. The independent engineer would need to validate any claimed physical relationship before those charges could support an augmentation plan or a change to warranted performance.

Table 13. Optional excess-wear restricted account

Year	Wear receipt (£m)	Restricted (£m)	Optimiser Δ (£m)	Net cash (£m)
1	1.000	1.000	-1.000	1.770
2	1.000	2.000	-1.000	1.420

Year	Wear receipt (£m)	Restricted (£m)	Optimiser Δ (£m)	Net cash (£m)
3	1.000	3.000	-1.000	1.084
4	1.000	4.000	-1.000	0.762
5	1.000	5.000	-1.000	0.453
6	0.000	5.000	0.000	0.237
7	0.000	5.000	0.000	-0.065
8	0.000	5.000	0.000	-0.353
9	0.000	5.000	0.000	-0.630
10	0.000	5.000	0.000	-0.894

Authored hypothetical inputs and calculated results. Monetary values are GBPm (£m). Display values are rounded to three decimals from full-precision evidence. 300 cycles annually in years 1-5 and 250 thereafter are compared with a 250-cycle allowance; the £0.020m excess-cycle payment is entirely restricted. Restricted is the closing separate wear account.

Optimiser Δ is incremental cash impact; Net cash is optimiser cash after wear. Base bankable CFADS and debt are unchanged. The account ends at £5m. Terminal use/release is unspecified and owner extra-wear NPV is unassigned.

21. Payment default and replacement economics

The delayed-collection and permanent-loss cases require different contractual responses. A collection delay creates a dated receivable and liquidity requirement. Permanent loss changes economic recovery. Early termination creates a replacement period, potential close-out exposures and a new revenue contract. The agreement should define the event, notice, cure procedure and payment consequences before a model assigns recovery cash.

A proposed security package should be tested against the obligations it actually secures. A guarantee may cover a defined payment category, expire before a disputed amount is resolved, or require particular demand documents. Cash collateral may be restricted to a different market-facing obligation. This paper assigns no collateral receipt because its terms, draw conditions and collection dates have not been specified. Legal enforceability and counterparty capacity require transaction-specific review.

Replacement planning should identify the market accounts, operating data, telemetry access and personnel needed to appoint a successor. A physically functioning battery can require additional qualification or settlement arrangements for a changed operator. The owner and lenders should obtain a costed transition plan with dependencies and responsible parties. A candidate successor's name does not establish its readiness or an executable replacement fee.

Termination valuation should separate accrued unpaid amounts from the cost of replacing future rights. Any mitigation, set-off, discount rate and liability cap needs a consistent definition. Lender recovery should be dated alongside continuing operating costs, restricted accounts and debt obligations. An assumed immediate termination payment would otherwise conceal the funding requirement during a dispute or handover.

22. Financing consent and acquisition diligence

A proposed lender review should address payment enforceability, security assignment, notice, cure, permitted substitution and the operational consequences of enforcement. These are transaction-specific diligence recommendations.

The Anaheim attachment's financing provisions and incomplete consent form provide disclosed drafting examples.[14]

An acquisition buyer should reproduce earned amounts, actual receipts, deductions and reserve movements using settlement records. The remaining toll term should be compared with the

remaining debt term, augmentation schedule and equipment support. Changes of control may affect consent or security requirements. A contract with a fixed fee can still contain performance obligations requiring future expenditure.

Valuation should identify the exact rights conveyed with the asset. Retained Capacity Market or other revenues may sit outside the toll's settlement perimeter. Exclusivity may restrict a new owner's ability to use uncontracted capacity. The buyer should test whether data, software access and dispatch arrangements survive both ownership transfer and counterparty replacement. Any missing consent or operational dependency belongs in the closing conditions and valuation assumptions.

The underwriting record should preserve the contract version, performance schedule and financial model used for approval. Subsequent amendments need a clear comparison of cash rights, operational limits and credit support. Reusing a historic valuation multiple would leave those changes unmeasured.

23. An evidence sequence for commercial close

Table 14 proposes an evidence sequence for negotiating and financing a toll. It starts with the asset's measured connection and performance boundary, followed by dispatch authority, service eligibility and cash allocation. The sequence connects each proposed obligation to the party able to demonstrate or manage it. It is an analytical closing framework, with no claim that a named lender or counterparty has accepted these requirements.

The commercial team should begin with a settlement example covering an ordinary month, a capability reduction, a disputed deduction and a missed payment. Each example should reconcile the agreement's defined terms to the payment calculation and cash date. Technical review should then test whether the underlying dispatch envelope and planned maintenance can support the promised rights. Legal and accounting review should address the resulting facts and jurisdiction rather than assume that the label toll determines treatment.

Funding documents should reconcile account restrictions and distribution permissions with the liquidity analysis. Approval should identify the minimum cash balance relied upon, the permitted source of any shortfall and the evidence required before a reserve can be released. A cash model containing negative balances needs an explicit financing decision; a positive ending balance does not fund an earlier deficit.

After close, the monitoring pack should reconcile invoices, receipts, availability tests, throughput, restricted balances and upcoming lifecycle works. Exceptions need a named decision owner and a record of their effect on the cash model. This makes the commercial agreement reviewable as operations and counterparty circumstances change.

Table 14. Proposed evidence required for a financeable toll

Decision	Required evidence	Accountable review	Model consequence
Paid capacity	Connection limits and agreed capability test	Engineer and owner	MW MWh and payment factor
Dispatch perimeter	Rights schedule and priority protocol	Owner and optimiser	Eligible revenue and availability
Cost allocation	Worked energy and settlement reconciliation	Commercial and market teams	Single cost deduction
Lifecycle funding	Engineering scope and restricted-account terms	Engineer and lender	Contribution and expenditure dates

Decision	Required evidence	Accountable review	Model consequence
Counterparty exposure	Credit assessment and security instruments	Credit and legal teams	Collection and recovery assumptions
Debt durability	Original debt terms and downside schedules	Lender and sponsor	Coverage and funding gaps
Replacement	Access rights and costed transition dependencies	Operations and legal teams	Handover cost and revenue interruption
Investment approval	Dated owner and optimiser valuations	Investment committee	Fee interval and unsupported assumptions

Analytical recommendations for transaction-specific review; no universal lender standard or legal approval is claimed.

24. Conclusions and research limitations

The authored model demonstrates a specific commercial constraint. Debt can be sized to meet a chosen coverage requirement while the owner's investment NPV remains negative. Under the supplied assumptions, the owner requires a higher fee than the optimiser can afford, leaving an empty bargaining interval. The combined shortfall survives a reallocation of toll payments. Investment approval therefore requires an evidenced change in underlying economics or a decision to reject the proposal.

The payment-delay test also establishes a narrower, useful distinction. Unpaid exposure reaches £4.160 million, while retained earlier surpluses keep the month-end account positive. Permanent payment loss produces a funding gap under a separate scenario. Both findings depend on the stated cash-retention, payment and reserve conventions. Neither establishes the required liquidity for an actual asset or the probability of a counterparty event.

Public announcements support comparisons of selected disclosed structures. They leave fee schedules, many deductions and security details undisclosed. The reviewed municipal attachment supplies more contractual detail, with execution and subsequent amendments unverified. Historical issuer reporting and market procedures retain their stated dates and jurisdictions. These sources do not establish representative toll pricing or a general return premium.

Further research would require executed contracts, interval operating data, independent engineering assessment and actual financing proposals. Those inputs would support chronological dispatch modelling, project-specific degradation, credit-sensitive payment timing and a valuation of replacement rights. The framework here provides reproducible questions and cash identities for that work, with every numerical result confined to its authored assumptions.

Frequently Asked Questions

What does a battery tolling agreement sell?

The agreement defines rights to use or settle specified battery capability in exchange for a payment. A physical dispatch arrangement and a virtual battery product require different operational and settlement definitions. The operative contract determines retained revenues, deductions and obligations.

Does a fixed toll establish a positive investment return?

Investment value depends on the fee, physical payment factor, costs, lifecycle expenditure and collection. In the authored case, debt is sized to meet the assumed coverage requirement while owner unlevered NPV remains negative. The return test therefore needs a separate calculation.

How should augmentation enter the financial model?

The example deducts restricted reserve contributions when testing annual bankable CFADS and deducts actual augmentation expenditure once in unlevered valuation. Internal reserve transfers are excluded from that valuation. Funding and expenditure dates must reconcile to avoid counting the same requirement twice.

What does an empty bargaining interval mean?

Under the stated inputs and discount convention, the owner's reservation fee exceeds the optimiser's affordable fee. A change in fee alone cannot make both NPVs nonnegative. An evidenced change in underlying economics, a different supported assumption set or rejection of the proposal is required.

Does an unpaid invoice equal a funding requirement?

Gross receivables and additional funding are separate measures. The delayed-collection case retains earlier surpluses, leaving month-end cash positive despite a £4.160 million receivable. Different distributions, payment ordering or reserve restrictions would require a new dated liquidity calculation.

Can these numerical results be used as market toll prices?

Every numerical project input is an authored hypothetical assumption. The calculations provide a reproducible analytical example, with no claim about representative pricing, default probability or actual project performance. Transaction decisions require executed terms, engineering evidence and current financing and market inputs.

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