The Queue Is the Cost: Pricing Grid-Connection Delays across New Assets

A capital-allocation framework for renewable, industrial and data-centre projects

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Abstract

Grid-connection queues have become a critical development constraint for renewable generation, industrial facilities and data centres. A connection offer can contain a distant date, evolving reinforcement scope, milestone obligations and cost estimates that change as the network and surrounding queue change. Treating the offered date as certain can overstate value, expose development capital too early and create customer and financing obligations the project cannot meet.

This paper develops the Grid-Connection Delay Pricing Framework. It maps the application, study, offer, site, permits, reinforcement, equipment, construction and energisation chain; distinguishes requested, reserved, deliverable and dependable capacity; and prices development spend, land carry, construction disruption, revenue deferral, escalation, financing carry and mitigation. It compares firm, non-firm, phased, behind-the-meter, storage, demand-response, relocation and exit options across renewable, industrial and data-centre archetypes.

The International Energy Agency identifies grids as a global bottleneck for supply, demand and storage and highlights the concentrated local impact of data-centre demand [1]-[3]. FERC Order No. 2023 and the US Department of Energy i2X roadmap address queue backlogs through cluster studies, readiness, technology and process reform [4]-[6]. Ofgem, the UK Government and NESO have moved Great Britain from first-come allocation toward ready-and-needed criteria, queue milestones and strategic alignment [7]-[10].

The central conclusion is that queue time is an economic exposure that belongs inside capital allocation, valuation and financing. A project should use a probability-weighted energisation path and predefined wait, mitigate, relocate or exit thresholds. Four tables and three figures translate the framework into a transaction method. All numerical examples are hypothetical management assumptions used solely to demonstrate the method; they are not observations, forecasts, valuation conclusions or investment recommendations.

JEL Classification: G31, G32, L51, L94, Q40, Q42, Q48

Keywords: grid connection queue, interconnection delay, data centre power, renewable project finance, industrial electrification, connection risk, energisation, capital allocation

1. DEFINE THE INVESTMENT DECISION

A grid-connection offer is a development pathway rather than an energisation guarantee. The investment decision is how much capital to expose, and on what conditions, before capacity, timing and reinforcement cost become sufficiently reliable.

The working file should identify the governing connection agreement, study, network dependency, responsible party and decision date. Technical and commercial conclusions should remain traceable to current authoritative evidence.

A practical review asks how much capacity is deliverable, when it can energise, what must be built, which costs can change and what mitigation preserves value. The output should be a gated capital decision rather than reliance on one offered date.

2. TREAT QUEUE POSITION AS A CONTINGENT RIGHT

A queue position can preserve access to a scarce network opportunity, but its economic value depends on milestones, study outcomes, security, termination rights and the probability that the project reaches energisation.

The assessment should distinguish contracted terms, network estimates and management scenarios. Developers, customers, lenders and advisers should use one reconciled capacity definition, critical path and cost register.

The issue should be translated into dated actions, evidence tests and quantified scenario adjustments. Contracted rights, estimates, contingencies and optional investments should remain visible as separate lines.

3. SEPARATE CAPACITY FROM CERTAINTY

Offered megawatts, connection date and firmness can each change. The model should distinguish requested capacity, reserved capacity, deliverable capacity and dependable operating capacity under the executed agreement.

The decision should be revisited when study results, queue rules, milestones or reinforcement dates change. Every assumption affecting value should have an owner, validation method and expiry date.

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4. DISTINGUISH THE THREE ASSET ARCHETYPES

Renewables export variable generation, industrial facilities require process-reliable supply and data centres require dense, continuous load. Their exposure to timing, curtailment, redundancy and alternative supply differs materially.

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5. MAP THE CONNECTION PROCESS

The process map should connect application, study, offer, acceptance, design, land, permits, reinforcement, equipment, construction, testing and energisation to contractual milestones and capital decisions.

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Table 1. Connection pathway and capital gate

Stage	Evidence	Capital exposed	Principal uncertainty	Gate decision
Application	Capacity, site and technical data	Fees, land option and advisers	Queue entry and study assumptions	Apply, resize or relocate
Study and offer	Study results, scope, date and cost	Deposits, design and security	Reinforcement and restudy	Accept, negotiate or exit
Development	Site control, permits and milestones	Land, engineering and long-lead reservations	Queue survival and approvals	Advance or hold
Construction	Network and project works	EPC, equipment and financing	Interface completion and energisation	Mobilise or phase
Energisation	Tests, metering and operating rights	Working capital and customer ramp	Firmness, curtailment and reliability	Operate, mitigate or expand

The pathway is generic; executed agreements, network rules and project requirements govern each transaction.

6. DEFINE THE REQUESTED CAPACITY

Developers should reconcile peak demand or export, ramp, power factor, harmonics, redundancy, growth and auxiliary load. Overstatement can inflate network works while understatement can strand the site.

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7. DEFINE FIRM AND NON-FIRM SERVICE

Firm service supports dependable operations within agreed standards. Non-firm or flexible service can accelerate connection, but curtailment rules, notice, compensation and operating consequences must be modelled.

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8. VALIDATE THE POINT OF CONNECTION

Distance, voltage, fault level, topology, substation capacity and route constraints shape cost and schedule. A superficially close connection point can still depend on remote reinforcement.

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9. IDENTIFY ENABLING REINFORCEMENT

Transmission, distribution, substation, protection, stability and control works should be separated into project-specific and wider-system upgrades. Dependencies should be traced to the critical path.

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10. CONVERT MILESTONES INTO INVESTMENT GATES

Land, planning, design, financing and construction milestones can determine queue survival. Each milestone needs evidence, responsibility, cure rights and a board decision on continued capital exposure.

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11. PROVE PROJECT READINESS

Readiness regimes increasingly prioritise projects that can demonstrate site control, planning progress, technology definition and delivery capability. Evidence quality can determine queue position and connection date.

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12. SECURE DURABLE SITE CONTROL

The connection case should align land rights with route, substation, cable, easement and access requirements. Expiry or conditionality in one parcel can undermine the whole programme.

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13. ALIGN PLANNING AND ENVIRONMENTAL APPROVALS

Grid works and the underlying asset may follow different approval routes. The programme should identify critical surveys, consents, stakeholder interfaces and judicial-review exposure.

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14. UNDERSTAND THE STUDY PROCESS

Feasibility, system-impact, facilities and detailed-design studies test increasingly precise configurations. The model should reflect study sequencing, restudy risk, assumptions and responsibility for data.

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15. PRICE DEPOSITS AND SECURITIES

Application fees, study deposits, milestone securities and reinforcement payments consume liquidity before revenue. Refundability, draw conditions and timing should be reflected in sources and uses.

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16. UNDERSTAND COST ALLOCATION

Network costs can be shallow, deep, shared, socialised or reallocated after other projects withdraw. The project should identify which amounts are capped, estimated, indexed or subject to true-up.

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17. MODEL UPGRADE-SCOPE UNCERTAINTY

Study outcomes can add substations, lines, dynamic studies, stability equipment or protection changes. Scenario ranges should connect each scope change to capital, schedule and capacity.

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18. PRICE NETWORK-DELIVERY RISK

A connection date may depend on works controlled by the network company, transmission owner, contractors and permitting bodies. The contract should clarify relief, liability, reporting and completion evidence.

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19. MAP EQUIPMENT SUPPLY CHAINS

Transformers, switchgear, cables, protection systems and high-voltage equipment can have long lead times. Procurement strategy should address reservation, specifications, testing, logistics and storage.

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20. MONITOR REGULATORY REFORM

Queue rules are changing across major markets. Project decisions should use current methodologies, transition provisions and evidence requirements rather than historical first-come processes.

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Figure 1. Connection dependency map for new assets

The diagram shows the evidence chain that controls an investable energisation date.

21. MODEL QUEUE REPRIORITISATION

Readiness and strategic-need tests can move projects forward, backward or out of the firm pipeline. The model should assign outcomes to evidence and policy scenarios without assuming protected priority.

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22. PROTECT AGAINST LOSS OF POSITION

Failure to meet milestones, pay security or maintain an executable project can trigger termination or capacity reduction. Governance should monitor every cure and notice deadline.

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23. CONTROL PROJECT MODIFICATIONS

Changes in technology, capacity, site, phasing or ownership can trigger restudy or a new application. Change control should quantify the connection consequence before the wider project approves a variation.

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24. TEST CAPACITY REDUCTION

A smaller connection can accelerate delivery, reduce reinforcement or preserve queue status. The economic test should compare lost output or computing capacity with avoided delay and capital.

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25. DESIGN PHASED ENERGISATION

Staged capacity can bring forward commissioning and revenue while wider works continue. The programme should specify phase dates, technical limits, interface works and conversion to final capacity.

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26. ASSESS TEMPORARY AND FLEXIBLE CONNECTIONS

Temporary, interruptible or non-firm arrangements can bridge a delay. Their value depends on curtailment frequency, operating flexibility, fuel alternatives and contract compatibility.

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27. TEST BEHIND-THE-METER SUPPLY

On-site generation can support resilience or early operations, subject to fuel, emissions, permits and economics. The design must coordinate islanding, protection and eventual grid integration.

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28. TEST ON-SITE GENERATION ECONOMICS

Gas, solar, wind, geothermal or other supply should be evaluated on full delivered cost, availability, construction time and carbon exposure. A temporary solution can become a stranded asset.

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29. INTEGRATE STORAGE AND HYBRID ASSETS

Storage can manage peaks, ramp limits, curtailment and outage resilience. It cannot create energy and should be sized against the actual operating profile and connection constraints.

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30. USE DEMAND RESPONSE DELIBERATELY

Flexible industrial processes and computing workloads can reduce peak capacity or accept curtailment. The operating case should define controllable load, recovery time, service effects and incentives.

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Table 2. Connection-delay risk-allocation matrix

Risk	Project responsibility	Network responsibility	Shared control	Required evidence
Queue readiness	Maintain site, permits, data and milestones	Apply published criteria consistently	Cure and evidence process	Register, declarations and notices
Study and restudy	Provide stable technical inputs	Complete studies to required standards	Assumptions and change control	Models, study reports and decisions
Reinforcement cost	Fund allocated customer works	Deliver network works and transparent estimates	Scope and true-up	Cost schedule and design baseline
Connection date	Progress project dependencies	Manage network critical path	Reporting and mitigation	Integrated programme and milestones
Curtailment	Operate within agreed limits	Apply dispatch and access rules	Flexible service design	Metering, notices and operating records
Failed connection	Manage exposed project capital	Apply termination and refund terms	Transition and dispute process	Account reconciliation and closing record

Allocation depends on the connection agreement, market rules, project contracts and cause of delay.

31. PRESERVE RELOCATION OPTIONS

Alternative sites can protect value when one connection path deteriorates. Comparable diligence should cover land, network rights, customers, fibre, water, labour, permits and tax.

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32. MANAGE THE DEVELOPMENT PORTFOLIO

A portfolio approach allocates capital across connection options until evidence differentiates them. Governance should prevent sunk-cost bias and avoid financing multiple speculative positions indefinitely.

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33. QUANTIFY DEVELOPMENT SPEND AT RISK

Studies, design, land, permits, advisers and deposits accumulate before final certainty. The model should show committed, cancellable, refundable and irrecoverable spend at every gate.

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34. QUANTIFY LAND CARRYING COST

Rent, option fees, rates, security and owner commitments continue during delay. Land rights should remain long enough to cover downside connection dates and extension mechanics.

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35. QUANTIFY CONSTRUCTION DISRUPTION

Early mobilisation can create idle labour, demobilisation, resequencing and storage costs when energisation slips. EPC terms should align notice-to-proceed with credible network milestones.

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36. QUANTIFY DELAYED REVENUE

Delay shifts energy sales, product output, compute capacity and contracted service revenue. The model should reflect ramp-up, customer churn, market price changes and expiry of incentives.

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37. QUANTIFY CUSTOMER CONSEQUENCES

Customers may have service dates, minimum capacity, liquidated damages or termination rights. Connection uncertainty should flow through the commercial contracting strategy.

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38. MODEL ESCALATION AND INFLATION

Equipment, labour, civil works and network contributions can escalate over a multi-year delay. Indexation should be applied to the relevant cost base and timing.

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39. MODEL FINANCING CARRY

Commitment fees, interest, hedging, letter-of-credit cost and equity opportunity cost accrue before operations. Draw timing should follow actual construction and security requirements.

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40. CONTROL HEDGE EXPOSURE

Interest, currency, power and equipment hedges can become mismatched when the schedule moves. The treasury plan should define extension, close-out and rehedging authority.

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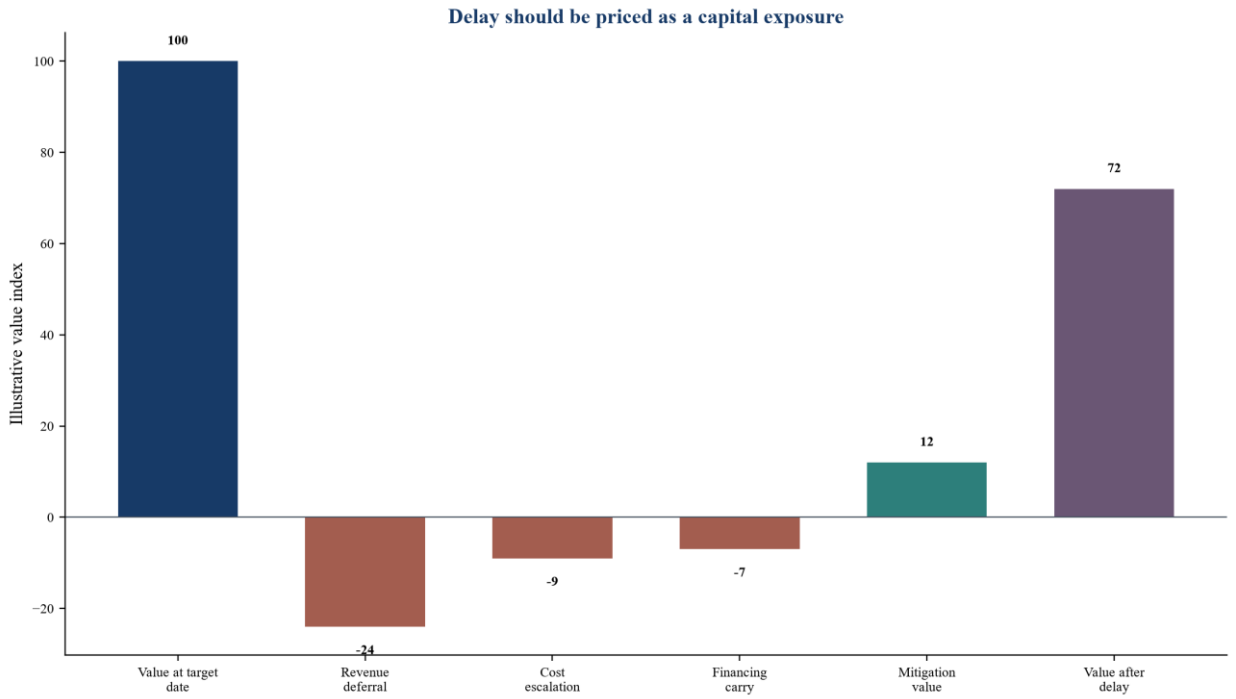

Figure 2. Illustrative value erosion from connection delay

Values are hypothetical management assumptions and demonstrate the valuation bridge only.

41. ADJUST THE DISCOUNT RATE AND PROBABILITY

Connection uncertainty affects cash-flow timing and outcome probability. The model should avoid double counting by separating scenario probabilities from risk already reflected in the discount rate.

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42. BUILD THE DELAY-VALUE BRIDGE

The bridge should start with value at the target connection date and show revenue deferral, escalation, financing carry, lost incentives, mitigation cost and option value.

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43. USE A PROBABILITY-WEIGHTED ENERGISATION DATE

A single contractual date can overstate certainty. The project should maintain a distribution informed by studies, dependencies, regulatory status and delivery evidence.

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44. SET THE WAIT, MITIGATE OR EXIT RULE

The board should define thresholds for continued waiting, mitigation capital, capacity reduction, relocation or exit. The rule should update as evidence and sunk cost change.

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45. APPLY THE FRAMEWORK TO RENEWABLES

Renewable projects should test export capacity, curtailment, grid-code compliance, support expiry, equipment procurement and power-sale obligations across connection scenarios.

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46. APPLY THE FRAMEWORK TO INDUSTRIAL ASSETS

Industrial facilities should test process continuity, commissioning sequence, captive supply, product contracts, demand flexibility and the cost of under-utilised fixed assets.

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47. APPLY THE FRAMEWORK TO DATA CENTRES

Data centres should test energisation by phase, redundant feeds, backup duration, workload portability, customer delivery commitments, fibre and cooling dependencies.

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48. DESIGN A SCALABLE CAMPUS

A campus can sequence substations, halls and customer capacity around confirmed power. The master plan should avoid overbuilding shared infrastructure ahead of connection certainty.

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49. EVALUATE CO-LOCATION

Co-location with generation can reduce some network dependency but introduces matching, transmission, market, permitting and reliability questions. Physical proximity alone does not ensure dependable supply.

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50. BUILD THE POWER-TO-COMPUTE ARCHITECTURE

The architecture should map grid capacity, on-site generation, storage, backup, cooling and workload flexibility to critical and deferrable computing loads.

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Table 3. Hypothetical connection-delay and debt-service sensitivity

Scenario	Connection delay	Additional capital, USD m	Capacity at first energisation	Minimum DSCR	Decision implication
Base connection	None	0	100% firm	1.34x	Proceed through normal gates
Phased energisation	12 months	28	45% then 100%	1.17x	Align customers and debt draw by phase
Non-firm bridge	18 months	42	70% curtailable	1.08x	Value depends on flexible operations
Full delay	36 months	96	100% after reinforcement	0.82x	Requires new liquidity and covenant reset
Relocation	24 months	135	100% firm at alternative site	1.12x	Compare avoided long-tail queue risk

All values are hypothetical management assumptions used only to demonstrate the framework.

51. BUILD SOURCES AND USES

Sources should match development, security, reinforcement, mitigation and construction uses by timing and certainty. Contingency should reflect study and schedule risk.

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52. TEST DEBT-SERVICE SENSITIVITIES

Lenders should test connection delay, cost increase, phased capacity, curtailment, customer delay and weaker utilisation. The model should show minimum DSCR and liquidity runway.

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53. ALIGN COVENANTS AND MILESTONES

Financing covenants should reflect evidence-driven connection gates, long-stop dates, cost-overrun support and draw conditions. A covenant should prompt action before liquidity is exhausted.

The assessment should distinguish contracted terms, network estimates and management scenarios. Developers, customers, lenders and advisers should use one reconciled capacity definition, critical path and cost register.

The issue should be translated into dated actions, evidence tests and quantified scenario adjustments. Contracted rights, estimates, contingencies and optional investments should remain visible as separate lines.

54. REVIEW INSURANCE AND FORCE MAJEURE

Delay may fall outside traditional delay-in-start-up coverage where no insured physical damage occurs. Contract and insurance analysis should identify retained exposure.

The decision should be revisited when study results, queue rules, milestones or reinforcement dates change. Every assumption affecting value should have an owner, validation method and expiry date.

The objective is an executable connection strategy that aligns engineering, contracts, customers and finance. Capital should advance only when the evidence supporting the next stage is commensurate with the amount at risk.

55. ALIGN CUSTOMERS AND OFFTAKE

Power-purchase, product-sale, capacity and colocation agreements should use dates and remedies consistent with connection uncertainty. Conditional commitments can preserve demand without creating unfinanceable liability.

The working file should identify the governing connection agreement, study, network dependency, responsible party and decision date. Technical and commercial conclusions should remain traceable to current authoritative evidence.

A practical review asks how much capacity is deliverable, when it can energise, what must be built, which costs can change and what mitigation preserves value. The output should be a gated capital decision rather than reliance on one offered date.

56. RUN THE MODEL GATE

This gate confirms a reconciled probability-weighted schedule, scenario cash flows, mitigation options and board thresholds. Assumptions should have sources and owners.

The assessment should distinguish contracted terms, network estimates and management scenarios. Developers, customers, lenders and advisers should use one reconciled capacity definition, critical path and cost register.

The issue should be translated into dated actions, evidence tests and quantified scenario adjustments. Contracted rights, estimates, contingencies and optional investments should remain visible as separate lines.

57. RUN THE RIGHTS GATE

This gate confirms queue status, milestones, site control, permits, cost allocation, security and change rights under current rules.

The decision should be revisited when study results, queue rules, milestones or reinforcement dates change. Every assumption affecting value should have an owner, validation method and expiry date.

The objective is an executable connection strategy that aligns engineering, contracts, customers and finance. Capital should advance only when the evidence supporting the next stage is commensurate with the amount at risk.

58. RUN THE TECHNICAL GATE

This gate confirms capacity, firmness, reinforcement, equipment, phasing, alternatives and the evidence supporting the network critical path.

The working file should identify the governing connection agreement, study, network dependency, responsible party and decision date. Technical and commercial conclusions should remain traceable to current authoritative evidence.

A practical review asks how much capacity is deliverable, when it can energise, what must be built, which costs can change and what mitigation preserves value. The output should be a gated capital decision rather than reliance on one offered date.

59. RUN THE COMMERCIAL AND FINANCING GATE

This gate confirms customer dates, revenue, sources and uses, liquidity, debt resilience and the conditions for wait, mitigate, relocate or exit.

The assessment should distinguish contracted terms, network estimates and management scenarios. Developers, customers, lenders and advisers should use one reconciled capacity definition, critical path and cost register.

The issue should be translated into dated actions, evidence tests and quantified scenario adjustments. Contracted rights, estimates, contingencies and optional investments should remain visible as separate lines.

60. ADOPT THE DECISION RECORD AND 90-DAY PLAN

The final record should state the selected connection strategy, exposed capital, evidence conditions, mitigation budget, owners, dates and fallback. The first 90 days should close the largest value uncertainties.

The decision should be revisited when study results, queue rules, milestones or reinforcement dates change. Every assumption affecting value should have an owner, validation method and expiry date.

The objective is an executable connection strategy that aligns engineering, contracts, customers and finance. Capital should advance only when the evidence supporting the next stage is commensurate with the amount at risk.

Table 4. Illustrative 90-day connection-risk programme

Period	Workstream	Core actions	Decision output	Accountable owner
Days 1-15	Rights and queue	Reconcile agreement, queue status, milestones, security and current rules	Confirmed connection perimeter	Counsel and connection lead
Days 16-30	Technical baseline	Validate capacity, point, studies, reinforcement and equipment	Network critical path	Grid engineer
Days 31-45	Project readiness	Verify land, permits, design, EPC, customers and data	Readiness evidence register	Development director
Days 46-60	Scenario economics	Model delay, phasing, non-firm supply, on-site options and relocation	Comparable value cases	Financial adviser
Days 61-75	Financing and contracts	Align sources, covenants, customers, hedges and long-stop dates	Financeable mitigation plan	Sponsors and lenders
Days 76-90	Decision record	Set capital cap, evidence gates, owners, dates and exit thresholds	Approved connection strategy	Authorised project board

Timing is indicative and should be adapted to the applicable network process and project stage.

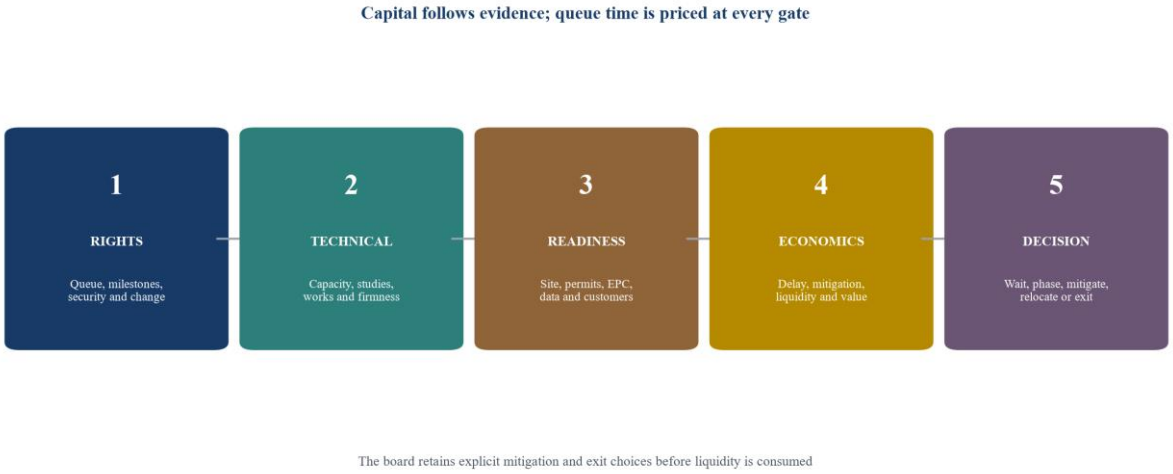

Figure 3. Five gates for connection-capital approval

Each gate requires documented evidence before the next capital commitment.

The framework makes grid-connection uncertainty visible before it consumes the project's liquidity and customer credibility. It links queue rights and engineering dependencies to capital exposure, valuation and financing.

Execution should proceed through evidence-based gates. A project that can phase, flex, mitigate or relocate retains option value; a project committed around an unsupported date can convert grid delay into an enterprise-level loss.

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