THE CARBON INTEGRITY DIVIDE

Article 6, Industrial Carbon Accounting and the New Rules of Credible Climate Value

GLOBAL MARKETS | INDUSTRIAL POLICY | CARBON ACCOUNTING | ESG | CLIMATE FINANCE

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Evidence reviewed through 12 October 2026. This document separates verified observations, institutional assessments, projections and original author analysis.

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How to read this study

Parts I and II establish the accounting distinctions and the original seven-ledger framework. Part III tests the framework across twenty sectors and technologies. Part IV compares sixteen regulatory and market systems without ranking them. Part V provides forty-two auditable controls. Parts VI and VII develop scenario and implementation logic. Part VIII records factual boundaries and sources.

Evidence notation: [01] through [39] refers to the source register. Original author analysis is identified as a proposed framework, control, interpretation or illustrative scenario. Figures describing future dates are reported as announced plans rather than completed outcomes.

EXECUTIVE INTELLIGENCE

Executive thesis

Carbon markets are entering a phase in which the legal meaning of a tonne matters as much as its price. A tonne reported in a corporate inventory is not automatically a transferable credit. A credit retired in a voluntary registry is not automatically an internationally transferred mitigation outcome. A product footprint is not a national inventory. A border-adjustment certificate is not an offset. These distinctions are now operational questions for boards, exporters, project developers, governments and assurance providers. [01][03][10][14]

The paper argues for a shift from single-number carbon narratives to reconciled, evidence-bearing claims. A credible climate statement should identify its physical boundary, the intervention that produced a change, the registry and legal status of any unit, the national accounting treatment, the product or corporate reporting treatment, and the precise public claim. The absence of any one layer does not necessarily invalidate all climate action. It does limit what a buyer or issuer can assert. This is the organising proposition of the Seven-Ledger Integrity Architecture, introduced here as original author analysis.

Three developments make the issue urgent. The World Bank reports 87 direct carbon-pricing policies and coverage of just over 29 percent of global greenhouse-gas emissions in its 2026 assessment. The UNFCCC approved the first Article 6.4 issuance in February 2026 and expanded eligible methodology coverage during the year. The EU CBAM definitive regime began in January 2026, while new corporate accounting and claims standards continued to evolve. [01][03][04][10][14][16]

The World Bank reports more than US$107 billion in carbon-pricing revenues in 2025. This figure concerns public revenues from direct carbon-pricing instruments, not the size of the voluntary carbon-credit market. The same report records an eight-percent increase in carbon-credit issuance between 2024 and 2025, with modest overall price weakness and premiums for selected categories. Treating these different markets as one market creates analytical error. [01]

The central governance problem is a mismatch between accounting boundaries, commercial instruments and public language. A project developer may accurately report monitored methane destruction while a buyer overstates its contribution to corporate decarbonisation. A manufacturer may buy a renewable-energy attribute while its physical electricity demand remains connected to a fossil-intensive grid. A government may authorise an international transfer while the buyer fails to explain corresponding-adjustment treatment. Each situation requires separate evidence, not a single reputational judgement.

This paper does not endorse a specific government policy or rank national systems. It sets out comparative options, operating tests, financing implications and technical controls. The seven-ledger framework, decision trees, control library and illustrative scenarios are author-developed analytical proposals, not external standards or observed empirical outcomes.

Executive evidence dashboard

Verified indicator	Date and scope	Interpretation
87 direct carbon-pricing policies	World Bank, May 2026 [01]	Counts policy instruments, not credit programmes
Just over 29% of global GHG emissions covered	World Bank, May 2026 [01]	Coverage is not the same as a uniform effective carbon price
More than US$107 billion public revenues	2025, World Bank [01]	Public carbon-pricing revenue, not voluntary credit turnover

First Article 6.4 credit issuance approved	February 2026, UNFCCC [03]	Approval was subject to the stated appeal period
CBAM definitive regime started	1 January 2026, European Commission [10]	Border mechanism is not a carbon offset programme
ISO 14068:2026 published	September 2026, ISO [18]	Replaced ISO 14068-1:2023
SBTi Net-Zero Standard V2.0 published	June 2026, SBTi [16][17]	Validation opens February 2027 under published transition plan
GHG Protocol-ISO joint standard planned	Q4 2028 target, GHG Protocol [14]	Future publication date, not current enforceable standard

What the paper contributes

A seven-ledger accounting architecture separating physical inventories, contractual attributes, project mitigation, unit registries, national adjustments, product footprints and public claims.

A 42-control assurance library covering data provenance, additionality, baselines, leakage, permanence, authorisation, registry operations, consumer claims, trade exposure and governance.

Sector-specific pathways for industrial production, energy, mining, agriculture, land use, aviation, shipping and engineered removals.

A board-level decision model distinguishing a compliance obligation, a mitigation investment, a carbon credit, a product footprint and a reputational claim.

An evidence hierarchy that keeps verified observations, modelled projections, institutional opinions and author propositions distinct.

PART I | THE MARKET AND ACCOUNTING ARCHITECTURE

1. Why a tonne is not a single financial instrument

The same physical reduction can be described in several systems without becoming interchangeable across them. An emission avoided against a project baseline is a counterfactual quantity. A corporate inventory records emissions within an organisational or value-chain boundary. A credit represents a unit issued under programme rules. An international transfer adds host-country authorisation and national-accounting consequences. A CBAM obligation relates to embedded emissions in covered imported goods. Confusing these quantities creates the illusion of fungibility where no common legal claim exists. [03][10][14][32]

A useful classification starts with the object being measured. Is the object an emitting facility, a product, a project, a corporate group, a sovereign inventory or a registered unit? The second question is whether the measurement is physical, contractual, counterfactual or legal. The third asks who has authority to assert ownership or use. A buyer should not accept a generic tonne label when the underlying instrument answers different questions.

The economic implication is material. A compliance allowance derives value from a regulated cap or tax obligation. A credit derives value from demand for eligible mitigation units and from the credibility of the programme and project. A product carbon footprint is information about emissions intensity, not itself a saleable mitigation unit. A contractual electricity attribute supports specified market-based accounting under applicable rules, not a claim that the grid physically changed at the same moment.

A practical procurement rule is to identify the intended use before selecting an instrument. Procurement teams should record whether a unit is being acquired for legal surrender, CORSIA cancellation, voluntary contribution, corporate target implementation or another defined purpose. Legal, finance, sustainability and communications teams should approve the intended use independently.

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Timing	Reporting period, vintage, methodology version	Periods mixed without reconciliation
Rights	Contract, registry status, authorisation where relevant	Ownership or use inferred without evidence
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Author interpretation: the issue is best treated as a system of linked controls rather than a single carbon price or credit-quality rating. The next chapters apply this discipline to seven independent ledgers and to sector-specific decisions.

2. The size and shape of carbon pricing in 2026

The World Bank reports 87 carbon-pricing policies, average direct carbon prices near US$21 per tonne of carbon dioxide equivalent and just over 29 percent global emissions coverage in its 2026 review. Revenue exceeded US$107 billion in 2025. These are different indicators: policy count, price, coverage and revenue. None by itself measures the quantity of additional mitigation caused by pricing. [01][02]

A carbon tax fixes a price and allows emissions quantities to respond. An emissions trading system constrains or manages allowance supply and permits prices to respond. Both systems can include exemptions, free allocation, offsets, price corridors or other design features. A price published for one jurisdiction is therefore not directly comparable with a price in another without considering sector coverage, effective incidence, rebates and exemptions.

The market also contains crediting mechanisms and result-based finance. These instruments typically depend on a counterfactual baseline and verification of outcomes. Their economic logic differs from allowance scarcity. A buyer who compares an allowance price with a voluntary credit price without eligibility and claim analysis risks treating unlike assets as substitutes.

For board planning, the correct exposure is a vector rather than one price: direct compliance liability, border adjustment exposure, procurement costs for attributes, capital expenditure for abatement, residual emissions and claims risk. Each component has its own uncertainty and decision horizon.

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3. Physical emissions inventories and the accounting boundary

The greenhouse-gas inventory is the foundation of credible corporate climate management. Scope 1 covers direct sources controlled or owned by the organisation under the chosen consolidation approach. Scope 2 addresses emissions associated with purchased energy. Scope 3 addresses other value-chain categories. The specific rules and disclosures depend on the applicable standard and reporting programme. [14][15][27]

An inventory should specify the organisational boundary, facilities, consolidation method, reporting period, gas coverage, emission factors, activity data, calculation methods and recalculation policy. Without these fields, apparent annual progress may reflect acquisitions, divestments, changed factors or boundary shifts rather than operational decarbonisation.

Physical inventory totals should remain distinguishable from market-based contractual reporting and from claimed impacts of separate actions. The GHG Protocol announced in July 2026 a future consolidated standard with ISO, targeted for publication in the fourth quarter of 2028. Its interim discussion of multi-statement reporting emphasises separation rather than indiscriminate netting. [14]

For a mining group, physical emissions include fuel combustion, process emissions where relevant and purchased electricity. Supplier emissions and product use may fall into Scope 3 categories depending on the business. A low-carbon certificate or credit does not erase measured diesel consumption. The correct treatment is to report the inventory and the separate instrument transparently.

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4. Market-based electricity claims and temporal matching

Electricity certificates and power purchase agreements are contractual mechanisms. Their accounting treatment differs from the physical electricity flow on a grid. The GHG Protocol Scope 2 revision process reflects disagreements about geographic matching, temporal matching, deliverability and the relationship between reported inventories and real-world system impacts. The 2026 consultation findings did not settle every question. [14][15]

A buyer operating continuously should distinguish annual matching from hourly matching. Annual procurement of renewable attributes equal to annual consumption does not establish that low-

emission electricity served every hour of the load. Hourly matching may improve temporal specificity but increases data requirements and can alter procurement cost and feasibility.

An effective control system preserves meter readings, generation certificates, retirement records, market boundaries and the time interval of matching. Claims should name the reporting method. A phrase such as renewable-powered can conceal important differences between onsite generation, direct wire, contracted supply and annual attribute procurement.

The analytical test is to distinguish three statements: what the facility consumed physically, which attributes it acquired contractually, and what system-level emissions impact its investment produced. These are related but not interchangeable statements.

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5. Project baselines and the counterfactual problem

A carbon-crediting project quantifies a difference between a monitored project outcome and an estimated baseline. The baseline is a counterfactual: what emissions or removals would have occurred without the intervention. Its credibility depends on data, methodology, conservative assumptions and monitoring. The Article 6.4 Supervisory Body updated standards on additionality and baseline-setting in October 2026. [06][07]

A baseline can be distorted by optimistic activity forecasts, outdated technology assumptions, weak comparison groups or selective project boundaries. The resulting unit may be verified against programme rules while remaining sensitive to the quality of those rules. Verification confirms conformity to a defined method. It does not remove all model uncertainty.

An investment committee should therefore ask whether the project would proceed without carbon revenue, whether common practice is changing, whether law already requires the activity and whether the baseline updates as technology becomes normal. These are tests of additionality and baseline conservatism, not accusations about individual projects.

The practical implication is to price uncertainty explicitly. A unit with a transparent, conservative baseline and repeated independent monitoring offers different risk characteristics from a unit dependent on a long-range, poorly observable counterfactual.

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6. Additionality as a financing and causal question

Additionality concerns whether an intervention delivers mitigation beyond the relevant baseline and would have occurred without the crediting incentive or under prevailing requirements. Different methodologies use financial, barrier, common-practice, regulatory or performance tests. No single test is equally informative in every sector. [06][19][20]

In an industrial project, the additionality question often centres on the investment decision. A waste-heat recovery system may save energy and money without credit revenue. A methane-abatement project may be financially unattractive absent credit income. A new renewable plant may be built for commercial reasons unrelated to carbon finance. Each requires project-specific evidence.

The most informative record is contemporaneous. Investment committee papers, alternative project evaluations, financing conditions, tariff assumptions and regulatory obligations are stronger evidence than retrospective statements. A claimed financial barrier should be consistent with the project model and with actual investment behaviour.

For buyers, additionality due diligence should distinguish programme approval from project-level evidence. The ICVCM Core Carbon Principles provide a programme and methodology quality threshold. They do not replace scrutiny of the unit vintage, project, issuance record and intended claim. [19][20]

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7. Leakage and displacement across boundaries

Leakage occurs when an intervention changes emissions outside the defined project boundary. Forest protection may shift land-use pressure to another area. Industrial shutdown may relocate production rather than eliminate demand. A facility-level efficiency improvement may increase output enough to offset part of the savings. Leakage assessment therefore requires a system boundary wider than the immediate project. [19][30]

The appropriate method depends on the activity. Land-use projects may require monitoring of displaced deforestation or agricultural production. Industrial projects may require output-normalised

analysis and market effects. Energy projects may require dispatch modelling. A universal leakage discount is rarely a substitute for a relevant causal model.

Corporate inventories and project crediting handle displacement differently. A company may report a reduction within its own boundary while emissions rise elsewhere in the value chain. A crediting project may need to deduct leakage under its methodology. Neither result alone establishes the net global effect of the intervention.

The control response is a leakage register with a named mechanism, geographic scope, monitoring variable, expected direction, uncertainty range and escalation trigger. Buyers should examine whether the leakage treatment remains credible when the project scales.

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8. Permanence, reversals and storage liability

A reduction in fossil fuel combustion and a tonne of carbon stored in a forest or engineered reservoir do not have identical reversal characteristics. Some removals store carbon for decades or centuries subject to management, fire, disease, land-use or physical containment risk. The UNFCCC has adopted standards addressing removals and non-permanence under Article 6.4. [08][09]

Permanence analysis should distinguish the expected storage duration, reversal mechanisms, monitoring period, buffer or insurance arrangements, replacement obligations and legal liability after project termination. A buffer pool may absorb some reversals but cannot be treated as a guarantee against correlated catastrophic losses.

Engineered storage also requires a defined system boundary. Capture efficiency, energy use, transport, injection, leakage detection and long-term monitoring influence net removals. A nominal tonne injected is not automatically equal to a net tonne removed after lifecycle emissions and losses.

A buyer should match the durability of the unit to the claim being made. Where a claim implies permanent neutralisation of long-lived fossil emissions, the burden of demonstrating equivalence is especially high. This is a claim-integrity principle rather than a declaration that all shorter-duration storage lacks value.

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9. Article 6.2 and sovereign accounting

Article 6.2 enables cooperative approaches involving internationally transferred mitigation outcomes under agreed accounting and reporting arrangements. Host-country authorisation, first transfer, corresponding adjustments and reporting status are separate matters. The UNFCCC publishes initial and regular information reports and technical-review status for participating Parties. [32]

A host country may have reasons to retain mitigation for its own nationally determined contribution rather than authorise export. The economic value of an authorised unit should therefore be assessed alongside the opportunity cost of adjusting the host-country account. The correct policy balance depends on national targets, marginal abatement costs and development priorities.

The buyer should examine the exact authorisation instrument, permitted use, vintages, quantities, transfer conditions, revocation provisions and corresponding-adjustment arrangements. A press announcement or memorandum of understanding is not a substitute for the required accounting and legal evidence.

The Seven-Ledger framework treats sovereign accounting as an independent ledger. A registry retirement records unit use. A national corresponding adjustment addresses double claiming between participating countries. Neither operation should be inferred from the other without evidence.

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10. Article 6.4 as an emerging operational mechanism

The UNFCCC approved the first issuance under the Paris Agreement Crediting Mechanism in February 2026 for a clean-cooking activity, subject to an appeal period. In July it announced a grid-connected renewable electricity methodology. The official methodology list includes landfill gas, nitrous oxide abatement and eligible grid-connected renewable electricity. These milestones show operational development, not universal eligibility for all projects. [03][04][05]

Article 6.4 has a Supervisory Body responsible for methodology approval, registration, accreditation and registry arrangements. The approval of a methodology does not mean a particular project is

registered. Registration does not itself mean credits have been issued. Issuance does not itself establish a buyer claim or corresponding adjustment.

For investors, this creates a sequence of regulatory and execution gates. Projects need a methodology, host-country participation conditions, registration, monitoring, verification, issuance and any required authorisation for intended use. Timelines and project risk differ at each stage.

The analysis therefore treats Article 6.4 as a developing institutional architecture. Claims about market scale, credit volume or future finance flows should be described as forecasts or aspirations unless supported by actual issued and transacted units.

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11. Registry infrastructure and chain of title

A registry records units, serial numbers, project identities, issuance, transfers, cancellations and retirement status according to programme rules. A registry is essential for traceability, but a unique serial number alone does not prove environmental additionality or legal suitability for every purpose. [19][20][24]

Buyers should reconcile project identifier, methodology version, vintage, unit serial range, issuance date, ownership, authorisation, cancellation or retirement and permitted use. Contractual title and registry control should align. Custodial arrangements and intermediary chains can create operational risk even when the underlying project is credible.

An immutable transaction history helps prevent double use inside one registry. Cross-registry migration, tokenisation and interoperability require additional controls to prevent a unit from being represented twice. A digital token is a representation of rights, not independent proof of mitigation.

The proposed control is a unit passport containing provenance, measurement, methodology, legal status, national adjustment, custody, retirement and claims metadata. Missing fields should restrict claims rather than being silently assumed.

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12. Corporate claims and the meaning of contribution

A company can finance mitigation outside its value chain without reducing its reported physical inventory by the same amount. The distinction between an emissions-reduction claim, a carbon-neutrality claim and a contribution claim is central to credible communication. VCMI updated its Claims Code to version 3.2 in September 2026, while ISO 14068:2026 established a hierarchy prioritising reductions and removals within the value chain before offsetting residual footprints. [18][22][23]

A defensible claim should state the boundary, period, standard, emissions trend, credits used, project type, unit status and whether the claim concerns compensation, contribution or achievement of a target. The marketing language should not exceed what the accounting evidence supports.

The risk is especially acute for product labels. Consumers may interpret carbon neutral as meaning a product has negligible lifecycle emissions when the claim depends on external credits. EU Directive 2024/825 specifically addresses product claims based on greenhouse-gas offsetting, with application from September 2026. [11][12]

A claims committee should include legal, technical, sustainability and commercial representation. Approval should be linked to a controlled claims register. Marketing revisions require the same evidence checks as the original statement.

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13. Carbon border adjustment and embedded emissions

The EU CBAM definitive regime began on 1 January 2026. It concerns embedded emissions in covered imported goods and the associated reporting, authorisation and certificate obligations. It is linked to the EU Emissions Trading System and its carbon-leakage architecture. A CBAM certificate is not a project carbon credit. [10][38]

Exporters should distinguish actual measured embedded emissions from default values, and direct from indirect emissions where applicable under the relevant product rules. Data lineage should reach the installation, production route, electricity and input materials. A corporate net-zero statement cannot substitute for product-specific emissions data.

The commercial consequences include contract allocation of data duties, verification costs, reporting deadlines, price exposure and liability for incorrect information. A supplier may face customer demands for emissions data even when it is not itself the regulated importer.

The practical response is a product-carbon data room. It should contain production volumes, emission factors, measurement methods, facility boundaries, verification evidence and change controls. Carbon-credit procurement should be managed separately from CBAM reporting unless a specific legal rule explicitly permits a relevant treatment.

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14. Target setting and implementation under SBTi V2.0

The Science Based Targets initiative published its Corporate Net-Zero Standard Version 2.0 in June 2026. The organisation stated that validation against V2.0 would open in February 2027, with transition provisions for existing targets. The new framework includes an implementation hierarchy and ongoing emissions responsibility concepts. [16][17]

A target standard answers a different question from an inventory standard or credit programme. It defines the pathway and criteria against which corporate commitments are assessed. Inventory standards quantify emissions. Crediting programmes issue units. Claims standards govern communication. A company must reconcile all four without treating one approval as proof of the others.

For management, the critical distinction is between operational abatement, value-chain action, market instruments and contributions beyond the value chain. Capital allocation should prioritise measures with clear physical emissions impact and business resilience benefits while keeping separate records of external climate finance.

Future guidance may change the recognition of instruments. The investment policy should therefore include standard-change clauses, document retention and the ability to restate claims when accepted methodologies evolve.

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15. The GHG Protocol-ISO convergence

In July 2026 the GHG Protocol announced a joint corporate standard-development programme with ISO. The published target is a consolidated public consultation in the second quarter of 2027 and a joint standard in the fourth quarter of 2028. This is a development timetable, not a currently effective replacement for all existing reporting requirements. [14][15]

The convergence responds to a persistent reporting problem: different frameworks may use different boundaries, terminology and recognition rules. Harmonisation can reduce duplicated work, but it also requires organisations to maintain clear version control during transition.

Companies should preserve raw activity data and method assumptions rather than storing only annual totals. This makes recalculation possible if consolidation approaches, emission factors or Scope 2 treatment change. A transition plan should specify the owner of each standard and the date on which reporting policies are updated.

The Seven-Ledger architecture is designed to be standard-neutral. It does not assert that a future standard will adopt its structure. Its purpose is to prevent premature netting and to keep different evidence types recoverable.

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16. ISO 14068:2026 and carbon-neutrality claims

ISO published ISO 14068:2026 in September 2026, replacing ISO 14068-1:2023. The new standard addresses carbon neutrality for organisations and products, prioritises direct and indirect emission reductions and removal enhancements, and treats offsetting as a means to counterbalance remaining footprint. ISO distinguishes carbon neutrality from requirements for net-zero greenhouse-gas emissions. [18]

This hierarchy changes the due-diligence question. A buyer should not ask only how many credits were retired. It should examine the underlying footprint, reduction plan, residual emissions, instrument quality, timing and evidence supporting the claim.

The same label can conceal different system boundaries. Organisation-wide neutrality, a product-specific claim and a facility-level statement each require their own footprint and treatment of

upstream and downstream activity. A verified company inventory does not automatically establish a verified product footprint.

Procurement and communications should adopt a claims matrix specifying the permitted wording for each evidence package. Claims that cannot be traced to a defined boundary and reporting period should remain unpublished.

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17. Voluntary-market quality and the ICVCM threshold

The Integrity Council for the Voluntary Carbon Market established ten Core Carbon Principles and an assessment framework for programmes and credit categories. Its 2026 progress update reported nine CCP-eligible programmes and 38 approved methodologies among 59 assessed, with an estimated 108 million credits eligible for CCP labelling under the assessed categories as of the cited assessment. These are institutional counts and estimates, not proof that every credit in those programmes meets every buyer requirement. [19][20][21]

A programme assessment tests governance and methodology requirements. A project-level review tests implementation and monitoring. A unit-level review tests serial numbers, vintage, issuance, ownership and retirement. A claims review tests whether the buyer has represented the outcome accurately. The four tests are cumulative.

Quality differentiation is economically relevant. Credits with stronger evidence, lower reversal risk and clear use eligibility may command different prices. Price premiums are signals of buyer preferences, not direct measures of atmospheric benefit.

The paper proposes a buyer diligence file organised around methodology, project, unit and claim. The absence of one layer should not be hidden by a rating from another layer.

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Author interpretation: the issue is best treated as a system of linked controls rather than a single carbon price or credit-quality rating. The next chapters apply this discipline to seven independent ledgers and to sector-specific decisions.

18. Aviation, CORSIA and purpose-specific eligibility

ICAO maintains criteria and lists of emissions-unit programmes eligible for use under CORSIA. Programme approval is tied to specific compliance periods, vintages and conditions. ICAO reported eight approved programmes for the 2024-2026 first phase in a November 2025 update, while later assessment cycles continue. [24][25][39]

CORSIA eligibility is not equivalent to generic voluntary-market eligibility. An airline needs units meeting the relevant compliance-period conditions and must cancel the required quantity. Host-country authorisation and avoidance of double claiming are material in specified cases.

A procurement contract should specify the CORSIA phase, eligible programme, project type, vintage, authorisation evidence, corresponding-adjustment status, delivery deadline and remedy for ineligibility. Buying a low-priced credit without these controls can create a compliance shortfall.

The broader lesson is that carbon-unit value is purpose-specific. A credit suited to a voluntary contribution claim may not be eligible for aviation compliance, a domestic scheme or an international transfer.

Analytical test	Required evidence	Failure condition
Boundary	Entity, facility, product, project or sovereign definition	Unit and inventory treated as identical
Timing	Reporting period, vintage, methodology version	Periods mixed without reconciliation
Rights	Contract, registry status, authorisation where relevant	Ownership or use inferred without evidence
Claim	Exact permitted statement and approval record	Public wording exceeds supported use

Author interpretation: the issue is best treated as a system of linked controls rather than a single carbon price or credit-quality rating. The next chapters apply this discipline to seven independent ledgers and to sector-specific decisions.

19. Disclosure standards, investors and decision usefulness

IFRS S2 addresses climate-related disclosures useful to users of general-purpose financial reports. The ISSB issued targeted amendments in December 2025, effective for reporting periods beginning on or after 1 January 2027 with early application permitted. The EU adopted revised ESRS in July 2026, subject to the applicable scrutiny process at the time of adoption. [13][26][27]

Disclosure quality depends on the relationship between metrics and enterprise risk. An emissions number is informative when linked to assets, capital expenditure, transition plans, regulation, supply-chain exposure and financial assumptions. A credit purchase alone is not evidence that an industrial asset has become less emissions-intensive.

Assurance requires reproducibility. Audit trails should connect source meters and invoices to calculation workbooks, reporting systems, governance approvals and published disclosures. Method changes and restatements should be visible.

Boards should require climate data governance equivalent in discipline to other material management information. Different reporting frameworks may remain in force across jurisdictions, so mapping and reconciliation are necessary even where standards converge.

Analytical test	Required evidence	Failure condition
Boundary	Entity, facility, product, project or sovereign definition	Unit and inventory treated as identical
Timing	Reporting period, vintage, methodology version	Periods mixed without reconciliation
Rights	Contract, registry status, authorisation where relevant	Ownership or use inferred without evidence
Claim	Exact permitted statement and approval record	Public wording exceeds supported use

Author interpretation: the issue is best treated as a system of linked controls rather than a single carbon price or credit-quality rating. The next chapters apply this discipline to seven independent ledgers and to sector-specific decisions.

20. The physical emissions constraint

The IEA estimated global energy-related CO2 emissions at nearly 38.4 gigatonnes in 2025, an increase of about 0.4 percent from 2024. The IPCC and UNEP continue to document a gap between current trajectories and Paris-aligned mitigation pathways. These figures describe physical emissions and modelled pathways, not the volume or effectiveness of carbon-credit issuance. [28][29][30]

A credible carbon-market strategy must be evaluated against this physical context. Carbon credits can finance mitigation, but their issuance does not automatically prove that aggregate emissions are falling. Demand growth, rebound effects, project baselines and double counting can weaken the link between units and global outcomes.

For corporations, the strongest information set contains both absolute physical emissions and separate records of mitigation finance and credits. Intensity reductions may coexist with absolute increases if output grows. Absolute reductions may reflect production declines rather than improved technology. Both dimensions require explanation.

The final policy and corporate question is how market mechanisms complement direct abatement, infrastructure investment and technology deployment. A tonne-level accounting system is necessary but insufficient for a credible transition strategy.

Analytical test	Required evidence	Failure condition
Boundary	Entity, facility, product, project or sovereign definition	Unit and inventory treated as identical
Timing	Reporting period, vintage, methodology version	Periods mixed without reconciliation
Rights	Contract, registry status, authorisation where relevant	Ownership or use inferred without evidence
Claim	Exact permitted statement and approval record	Public wording exceeds supported use

Author interpretation: the issue is best treated as a system of linked controls rather than a single carbon price or credit-quality rating. The next chapters apply this discipline to seven independent ledgers and to sector-specific decisions.

PART II | THE SEVEN-LEDGER INTEGRITY ARCHITECTURE

L1 | Physical emissions inventory

This ledger governs measured Scope 1, Scope 2 and Scope 3 quantities. Its primary evidence consists of meters, fuel records, process data, organisational boundaries. The accountable function is data owner and emissions accounting lead. The decision-useful output is physical emissions and intensity trend. The core failure mode is netting credits against the physical total. [14][27]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	physical emissions and intensity trend	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L2 | Contractual environmental attributes

This ledger governs contractual allocation of specified attributes. Its primary evidence consists of energy certificates, power purchase agreements, product attributes. The accountable function is

energy procurement and accounting lead. The decision-useful output is market-based and contractual disclosures. The core failure mode is presenting annual certificates as hourly physical supply. [14][15]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	market-based and contractual disclosures	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L3 | Project mitigation and counterfactual

This ledger governs verified project-level reductions or removals. Its primary evidence consists of baseline model, monitoring plan, additionality, leakage. The accountable function is project developer and independent validator. The decision-useful output is project performance and uncertainty interval. The core failure mode is claiming counterfactual savings as direct inventory reductions. [06][07][19]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the

calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	project performance and uncertainty interval	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L4 | Unit registry and ownership

This ledger governs unit existence and status under programme rules. Its primary evidence consists of serial number, vintage, issuance, transfers, retirement. The accountable function is registry operator and buyer custodian. The decision-useful output is unit passport and transaction chain. The core failure mode is double sale, duplicate representation or missing retirement. [19][20][24]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications

teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	unit passport and transaction chain	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L5 | National accounting and authorisation

This ledger governs internationally transferred mitigation outcomes where applicable. Its primary evidence consists of host-country authorisation, first transfer, corresponding adjustment. The accountable function is host-country authority and reporting focal point. The decision-useful output is Article 6 reporting and use status. The core failure mode is assuming registry retirement equals national adjustment. [03][32]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment

can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	Article 6 reporting and use status	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L6 | Product footprint and border treatment

This ledger governs embedded emissions and product-level intensity. Its primary evidence consists of bill of materials, plant emissions, production volumes, verification. The accountable function is manufacturer, exporter and importer. The decision-useful output is product carbon footprint and CBAM evidence. The core failure mode is substituting corporate credit purchases for embedded-emissions data. [10][13]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive

audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register
Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	product carbon footprint and CBAM evidence	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

L7 | Claims and representation

This ledger governs what an organisation communicates externally. Its primary evidence consists of approved wording, boundaries, targets, credit use, disclosures. The accountable function is legal, sustainability, marketing and board oversight. The decision-useful output is public claims register and substantiation file. The core failure mode is conflating compensation, contribution and reductions. [11][12][18][22]

The ledger must be independently intelligible before reconciliation. A reviewer should be able to trace a reported quantity back to the underlying source, identify the period and boundary, reproduce the calculation and determine the legal or methodological basis for use. When a field is unknown, the system should record an explicit unknown value instead of assuming equivalence with another ledger.

A robust control design separates data production from approval. Operating teams generate primary data. Technical specialists calculate and interpret. Legal teams validate rights and permitted uses. Finance assesses materiality and commitments. Assurance providers test the record. Communications teams translate the approved conclusion into language without extending its scope. This separation is especially important when commercial incentives reward a larger claim.

Reconciliation should proceed by links, not arithmetic subtraction. A project unit can be linked to a corporate contribution statement without being deducted from Scope 1 emissions. A product footprint can be linked to a facility inventory while using a different allocation boundary. A national adjustment can be linked to a transferred unit without becoming evidence of the project baseline. Each link should have a stated rule and a dated approval.

The control architecture should also preserve history. When methodology versions change, earlier records should remain available with their original assumptions. Restatements should be additive

audit events rather than silent overwrites. The system must preserve both the reported value and the reason for a later correction.

Control object	Minimum field	Assurance evidence
Identity	Unique facility, project, unit or claim ID	Master-data register

Time	Measurement period, vintage, issuance or use date	Timestamped records
Method	Standard, version, assumptions and calculations	Method file and calculation log
Rights	Owner, authorised use, transfer restrictions	Contract or official authorisation
Review	Approver, date, exception status	Signed approval and exception log
Output	public claims register and substantiation file	Published record and reconciliation map

Author proposition: a seven-ledger architecture reduces category errors by forcing each carbon statement to identify its evidence class and permitted use. The architecture is a management design, not a new legal standard. Organisations should adapt the control depth to materiality and applicable regulation.

PART III | SECTOR AND TECHNOLOGY DOSSIERS

Sector dossier | Cement and clinker

The material climate boundary in cement and clinker includes process emissions from limestone calcination plus kiln fuel. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include clinker ratio, thermal efficiency, supplementary cementitious materials, alternative fuels, capture and storage. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [10][28]

Measurement, reporting and verification should focus on plant-level clinker output, calcination factors, kiln fuel, electricity, product allocation. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves CBAM exposure for covered cement goods, buyer embodied-carbon demands. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is over-crediting fuel substitution while excluding process emissions. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	process emissions from limestone calcination plus kiln fuel	Is the emissions exposure material?
Abatement pathway	clinker ratio, thermal efficiency, supplementary cementitious materials, alternative fuels, capture and storage	What capital and operational risks arise?
Monitoring	plant-level clinker output, calcination factors, kiln fuel, electricity, product allocation	Can the result be assured?
Market interface	CBAM exposure for covered cement goods, buyer embodied-carbon demands	What customer or regulatory obligation applies?
Claims risk	over-crediting fuel substitution while excluding process emissions	What wording is supportable?

Sector dossier | Primary steel

The material climate boundary in primary steel includes ore reduction chemistry, coke and blast-furnace emissions, electricity. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include scrap-based EAF, direct reduced iron, hydrogen routes, process efficiency. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [10][13]

Measurement, reporting and verification should focus on crude-steel output, route-specific fuel, electricity, scrap content. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves embedded-emissions verification and product grade qualification. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is claiming green steel from purchased credits without route-specific data. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile

them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	ore reduction chemistry, coke and blast-furnace emissions, electricity	Is the emissions exposure material?
Abatement pathway	scrap-based EAF, direct reduced iron, hydrogen routes, process efficiency	What capital and operational risks arise?
Monitoring	crude-steel output, route-specific fuel, electricity, scrap content	Can the result be assured?
Market interface	embedded-emissions verification and product grade qualification	What customer or regulatory obligation applies?
Claims risk	claiming green steel from purchased credits without route-specific data	What wording is supportable?

Sector dossier | Aluminium

The material climate boundary in aluminium includes electricity-intensive smelting and anode-related process emissions. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include low-emission electricity, efficiency, anode changes, recycled content. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [10][14]

Measurement, reporting and verification should focus on smelter electricity, anode consumption, primary/recycled material balance. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves product footprint and supply-contract specifications. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is annual renewable certificate presented as zero physical grid emissions. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	electricity-intensive smelting and anode-related process emissions	Is the emissions exposure material?
Abatement pathway	low-emission electricity, efficiency, anode changes, recycled content	What capital and operational risks arise?
Monitoring	smelter electricity, anode consumption, primary/recycled material balance	Can the result be assured?
Market interface	product footprint and supply-contract specifications	What customer or regulatory obligation applies?
Claims risk	annual renewable certificate presented as zero physical grid emissions	What wording is supportable?

Sector dossier | Fertiliser and ammonia

The material climate boundary in fertiliser and ammonia includes hydrogen feedstock, process heat, nitrous oxide for relevant production. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include renewable hydrogen, capture, process controls, N2O destruction. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [05][10]

Measurement, reporting and verification should focus on feedstock, production output, abatement efficiency, leakage. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves industrial trade and procurement standards. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is mixing nitric-acid abatement credits with ammonia product footprint. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	hydrogen feedstock, process heat, nitrous oxide for relevant production	Is the emissions exposure material?
Abatement pathway	renewable hydrogen, capture, process controls, N2O destruction	What capital and operational risks arise?
Monitoring	feedstock, production output, abatement efficiency, leakage	Can the result be assured?
Market interface	industrial trade and procurement standards	What customer or regulatory obligation applies?
Claims risk	mixing nitric-acid abatement credits with ammonia product footprint	What wording is supportable?

Sector dossier | Hydrogen and derivatives

The material climate boundary in hydrogen and derivatives includes upstream electricity or fossil feedstock, conversion losses. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include electrolysis, capture with storage, methane control, efficient conversion. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [14][28]

Measurement, reporting and verification should focus on hourly power supply, methane emissions, process yield, lifecycle boundary. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions

remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves origin and emissions-intensity rules for industrial buyers. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is calling all hydrogen zero-carbon based on one production attribute. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	upstream electricity or fossil feedstock, conversion losses	Is the emissions exposure material?
Abatement pathway	electrolysis, capture with storage, methane control, efficient conversion	What capital and operational risks arise?
Monitoring	hourly power supply, methane emissions, process yield, lifecycle boundary	Can the result be assured?
Market interface	origin and emissions-intensity rules for industrial buyers	What customer or regulatory obligation applies?
Claims risk	calling all hydrogen zero-carbon based on one production attribute	What wording is supportable?

Sector dossier | Mining and mineral processing

The material climate boundary in mining and mineral processing includes diesel fleets, comminution, smelting, purchased power, explosives. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include electrification, renewable supply, heat recovery, ore sorting, efficiency. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [14][27]

Measurement, reporting and verification should focus on equipment fuel, ore throughput, grade, recovery, grid electricity. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves customer Scope 3 and product traceability requests. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is equating carbon-neutral mine marketing with zero Scope 1 emissions. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	diesel fleets, comminution, smelting, purchased power, explosives	Is the emissions exposure material?
Abatement pathway	electrification, renewable supply, heat recovery, ore sorting, efficiency	What capital and operational risks arise?
Monitoring	equipment fuel, ore throughput, grade, recovery, grid electricity	Can the result be assured?
Market interface	customer Scope 3 and product traceability requests	What customer or regulatory obligation applies?
Claims risk	equating carbon-neutral mine marketing with zero Scope 1 emissions	What wording is supportable?

Sector dossier | Oil and gas methane

The material climate boundary in oil and gas methane includes fugitive methane, venting, flaring and combustion. A credible strategy should first identify physical emissions and production output before

considering certificates or credits. The technical options include leak detection, repair, equipment replacement, methane capture. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [06][28]

Measurement, reporting and verification should focus on component measurements, flare efficiency, gas composition. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves supply-chain emissions requirements and methane-specific claims. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is crediting reductions that are already legally required. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	fugitive methane, venting, flaring and combustion	Is the emissions exposure material?
Abatement pathway	leak detection, repair, equipment replacement, methane capture	What capital and operational risks arise?
Monitoring	component measurements, flare efficiency, gas composition	Can the result be assured?
Market interface	supply-chain emissions requirements and methane-specific claims	What customer or regulatory obligation applies?
Claims risk	crediting reductions that are already legally required	What wording is supportable?

Sector dossier | Electricity generation

The material climate boundary in electricity generation includes combustion mix, dispatch, grid losses and marginal generation. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include renewables, storage, efficiency, nuclear, demand response. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [04][14]

Measurement, reporting and verification should focus on plant generation, fuel use, hourly grid intensity, certificates. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves Scope 2 procurement and renewable-credit methodologies. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is annual attribute matching represented as hourly zero-emission power. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	combustion mix, dispatch, grid losses and marginal generation	Is the emissions exposure material?
Abatement pathway	renewables, storage, efficiency, nuclear, demand response	What capital and operational risks arise?
Monitoring	plant generation, fuel use, hourly grid intensity, certificates	Can the result be assured?
Market interface	Scope 2 procurement and renewable-credit methodologies	What customer or regulatory obligation applies?

Claims risk	annual attribute matching represented as hourly zero-emission power	What wording is supportable?

Sector dossier | Data centres and AI infrastructure

The material climate boundary in data centres and ai infrastructure includes electricity, backup generators, cooling and hardware supply chain. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include efficiency, load flexibility, low-emission supply, heat reuse. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [14][28]

Measurement, reporting and verification should focus on IT load, PUE, hourly electricity, backup generation, embodied hardware. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves large-load procurement and corporate reporting. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is net-zero operations claim based only on annual offsets. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	electricity, backup generators, cooling and hardware supply chain	Is the emissions exposure material?

Abatement pathway	efficiency, load flexibility, low-emission supply, heat reuse	What capital and operational risks arise?
Monitoring	IT load, PUE, hourly electricity, backup generation, embodied hardware	Can the result be assured?
Market interface	large-load procurement and corporate reporting	What customer or regulatory obligation applies?
Claims risk	net-zero operations claim based only on annual offsets	What wording is supportable?

Sector dossier | International aviation

The material climate boundary in international aviation includes jet fuel combustion, operational efficiency, eligible CORSIA units. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include fleet renewal, sustainable fuels, operational measures, eligible unit cancellation. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [24][25]

Measurement, reporting and verification should focus on fuel use, eligible programme, unit vintage and cancellation. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves CORSIA compliance period and eligibility. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is substituting generic credits for CORSIA-eligible units. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	jet fuel combustion, operational efficiency, eligible CORSIA units	Is the emissions exposure material?
Abatement pathway	fleet renewal, sustainable fuels, operational measures, eligible unit cancellation	What capital and operational risks arise?
Monitoring	fuel use, eligible programme, unit vintage and cancellation	Can the result be assured?
Market interface	CORSIA compliance period and eligibility	What customer or regulatory obligation applies?
Claims risk	substituting generic credits for CORSIA-eligible units	What wording is supportable?

Sector dossier | Maritime shipping

The material climate boundary in maritime shipping includes marine fuels, voyage efficiency and upstream fuel emissions. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include fleet efficiency, alternative fuels, route optimisation. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [27][30]

Measurement, reporting and verification should focus on voyage fuel, cargo allocation, fuel lifecycle factors. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves freight customer Scope 3 and evolving sector rules. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is assuming port-level reductions equal full voyage reductions. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

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Evidence item	Question for technical reviewer	Question for board
Physical baseline	marine fuels, voyage efficiency and upstream fuel emissions	Is the emissions exposure material?
Abatement pathway	fleet efficiency, alternative fuels, route optimisation	What capital and operational risks arise?
Monitoring	voyage fuel, cargo allocation, fuel lifecycle factors	Can the result be assured?
Market interface	freight customer Scope 3 and evolving sector rules	What customer or regulatory obligation applies?
Claims risk	assuming port-level reductions equal full voyage reductions	What wording is supportable?

Sector dossier | Forest conservation

The material climate boundary in forest conservation includes land-use change, carbon stock, leakage and fire exposure. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include protection, management, restoration, community tenure. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [08][09][31]

Measurement, reporting and verification should focus on remote sensing, field plots, jurisdictional reference levels. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves crediting and national accounting interaction. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is baseline inflation and reversal risk masked by a single unit count. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should

explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	land-use change, carbon stock, leakage and fire exposure	Is the emissions exposure material?
Abatement pathway	protection, management, restoration, community tenure	What capital and operational risks arise?
Monitoring	remote sensing, field plots, jurisdictional reference levels	Can the result be assured?
Market interface	crediting and national accounting interaction	What customer or regulatory obligation applies?
Claims risk	baseline inflation and reversal risk masked by a single unit count	What wording is supportable?

Sector dossier | Afforestation and reforestation

The material climate boundary in afforestation and reforestation includes carbon growth, land-use history, soil and biomass stocks. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include site selection, species mix, long-term stewardship. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [08][09]

Measurement, reporting and verification should focus on survival, growth, carbon pools, permanence arrangements. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves removal claims and land-rights safeguards. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is counting projected sequestration as already achieved. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each

metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	carbon growth, land-use history, soil and biomass stocks	Is the emissions exposure material?
Abatement pathway	site selection, species mix, long-term stewardship	What capital and operational risks arise?
Monitoring	survival, growth, carbon pools, permanence arrangements	Can the result be assured?
Market interface	removal claims and land-rights safeguards	What customer or regulatory obligation applies?
Claims risk	counting projected sequestration as already achieved	What wording is supportable?

Sector dossier | Soil carbon

The material climate boundary in soil carbon includes soil organic carbon variability and management effects. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include cover crops, tillage changes, rotations, grazing practices. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [19][30]

Measurement, reporting and verification should focus on sampling design, depth, bulk density, uncertainty. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves agricultural supply-chain and credit programme claims. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is small noisy measurements treated as precise annual tonnes. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	soil organic carbon variability and management effects	Is the emissions exposure material?
Abatement pathway	cover crops, tillage changes, rotations, grazing practices	What capital and operational risks arise?
Monitoring	sampling design, depth, bulk density, uncertainty	Can the result be assured?
Market interface	agricultural supply-chain and credit programme claims	What customer or regulatory obligation applies?
Claims risk	small noisy measurements treated as precise annual tonnes	What wording is supportable?

Sector dossier | Biochar

The material climate boundary in biochar includes feedstock carbon, pyrolysis, storage and energy co-products. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include durable carbon production from suitable biomass. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [08][19]

Measurement, reporting and verification should focus on feedstock origin, carbon content, stability, lifecycle emissions. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves removal procurement and product safety. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is crediting avoided disposal and stored carbon twice. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost

per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	feedstock carbon, pyrolysis, storage and energy co-products	Is the emissions exposure material?
Abatement pathway	durable carbon production from suitable biomass	What capital and operational risks arise?
Monitoring	feedstock origin, carbon content, stability, lifecycle emissions	Can the result be assured?
Market interface	removal procurement and product safety	What customer or regulatory obligation applies?
Claims risk	crediting avoided disposal and stored carbon twice	What wording is supportable?

Sector dossier | Direct air capture

The material climate boundary in direct air capture includes atmospheric CO2 separation, energy demand and storage. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include process optimisation, low-emission energy, geological storage. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [08][09]

Measurement, reporting and verification should focus on capture mass, energy use, transport losses, storage monitoring. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves durable removal contracting and long-term liability. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is gross capture presented as net removal. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	atmospheric CO2 separation, energy demand and storage	Is the emissions exposure material?
Abatement pathway	process optimisation, low-emission energy, geological storage	What capital and operational risks arise?
Monitoring	capture mass, energy use, transport losses, storage monitoring	Can the result be assured?
Market interface	durable removal contracting and long-term liability	What customer or regulatory obligation applies?
Claims risk	gross capture presented as net removal	What wording is supportable?

Sector dossier | Landfill methane

The material climate boundary in landfill methane includes methane generation, capture, flaring or beneficial use. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include gas collection, flare efficiency, monitoring. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [05][06]

Measurement, reporting and verification should focus on methane flow, destruction efficiency, baseline conditions. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves Article 6.4 landfill-gas methodology. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is assuming captured methane equals destroyed methane. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through

a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	methane generation, capture, flaring or beneficial use	Is the emissions exposure material?
Abatement pathway	gas collection, flare efficiency, monitoring	What capital and operational risks arise?
Monitoring	methane flow, destruction efficiency, baseline conditions	Can the result be assured?
Market interface	Article 6.4 landfill-gas methodology	What customer or regulatory obligation applies?
Claims risk	assuming captured methane equals destroyed methane	What wording is supportable?

Sector dossier | Nitric acid N2O

The material climate boundary in nitric acid n2o includes nitrous oxide generated in chemical production. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include secondary and tertiary catalyst abatement. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [05][07]

Measurement, reporting and verification should focus on production volume, abatement efficiency, N2O monitoring. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves Article 6.4 nitric-acid methodology. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is project crediting without monitoring operational performance. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The

practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	nitrous oxide generated in chemical production	Is the emissions exposure material?
Abatement pathway	secondary and tertiary catalyst abatement	What capital and operational risks arise?
Monitoring	production volume, abatement efficiency, N2O monitoring	Can the result be assured?
Market interface	Article 6.4 nitric-acid methodology	What customer or regulatory obligation applies?
Claims risk	project crediting without monitoring operational performance	What wording is supportable?

Sector dossier | Agricultural methane

The material climate boundary in agricultural methane includes livestock, rice cultivation and manure management. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include feed changes, water management, manure capture. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [19][30]

Measurement, reporting and verification should focus on animal or field activity, methane factors, monitoring. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves food-supply-chain claims and programme rules. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is assuming one practice yields uniform savings across geographies. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	livestock, rice cultivation and manure management	Is the emissions exposure material?
Abatement pathway	feed changes, water management, manure capture	What capital and operational risks arise?
Monitoring	animal or field activity, methane factors, monitoring	Can the result be assured?
Market interface	food-supply-chain claims and programme rules	What customer or regulatory obligation applies?
Claims risk	assuming one practice yields uniform savings across geographies	What wording is supportable?

Sector dossier | Waste and circular materials

The material climate boundary in waste and circular materials includes waste treatment, landfill methane, embodied production. A credible strategy should first identify physical emissions and production output before considering certificates or credits. The technical options include reuse, recycling, landfill diversion, process efficiency. The choice among these measures depends on cost, asset age, operating conditions and infrastructure rather than on a generic carbon price. [19][30]

Measurement, reporting and verification should focus on material flows, avoided production assumptions, waste treatment. The data model must distinguish measured activity from emission factors and engineering estimates. Where continuous monitoring is unavailable, the organisation should document sampling frequency, calibration, uncertainty and the period over which assumptions remain valid. An assurance provider should be able to reconstruct the reported result without relying on management narrative.

The commercial setting involves recycled-content and avoided-emission claims. Contract terms should identify which party provides primary data, which party owns environmental attributes, whether a

credit is transferred or retired, and which claims each party is permitted to make. Product-level claims should not be inferred from a corporate inventory or from the acquisition of external credits.

The principal claims risk is double counting avoided production and waste-project units. This is a failure of boundary control rather than necessarily a failure of the underlying technology. The practical response is to maintain separate physical, contractual and credit records, then reconcile them through a documented approval process. A buyer should refuse wording that implies a stronger causal effect than the monitoring and accounting support.

An investment appraisal should compare a direct abatement project with external mitigation finance. Direct measures may reduce fuel purchases, improve equipment performance or lower future compliance exposure. Credits may finance additional mitigation outside the asset boundary. Their cost per nominal tonne is not a like-for-like measure of enterprise value because permanence, additionality, operating benefits and legal eligibility differ.

The operational scorecard should contain absolute emissions, emissions intensity, data completeness, energy or feedstock efficiency, verification exceptions, project progress and claim approvals. Each metric should have a named owner and a source system. When output grows, management should explain why intensity and absolute emissions diverge rather than selecting whichever metric appears more favourable.

Author proposition: the sector should adopt a carbon decision file for every material investment or credit purchase. The file should contain the physical baseline, alternative options, marginal cost, technical uncertainty, rights treatment, intended claim, counterfactual and review trigger. This requirement turns climate strategy into capital-allocation discipline.

Evidence item	Question for technical reviewer	Question for board
Physical baseline	waste treatment, landfill methane, embodied production	Is the emissions exposure material?
Abatement pathway	reuse, recycling, landfill diversion, process efficiency	What capital and operational risks arise?
Monitoring	material flows, avoided production assumptions, waste treatment	Can the result be assured?
Market interface	recycled-content and avoided-emission claims	What customer or regulatory obligation applies?
Claims risk	double counting avoided production and waste-project units	What wording is supportable?

PART IV | COMPARATIVE REGULATORY AND MARKET SYSTEMS

Comparative system | European Union CBAM

The governing architecture concerns border adjustment for embedded emissions in covered goods. Its core evidence is verified product and installation data, and the principal accountable actors include EU importer and non-EU supplier. A material interpretive caution is that do not treat CBAM certificates as offsets. The description here concerns the framework and its published status, not an assessment of any government or institution. [10][38]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	border adjustment for embedded emissions in covered goods
Core evidence	verified product and installation data
Accountable actor	EU importer and non-EU supplier
Interpretive boundary	do not treat CBAM certificates as offsets
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | EU consumer green-transition rules

The governing architecture concerns controls on misleading environmental product claims. Its core evidence is substantiation of lifecycle impact and precise wording, and the principal accountable actors include brand owner, retailer and legal counsel. A material interpretive caution is that offset-based neutral product claims are specifically restricted. The description here concerns the framework and its published status, not an assessment of any government or institution. [11][12]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	controls on misleading environmental product claims
Core evidence	substantiation of lifecycle impact and precise wording
Accountable actor	brand owner, retailer and legal counsel
Interpretive boundary	offset-based neutral product claims are specifically restricted
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | EU sustainability reporting

The governing architecture concerns revised ESRS and corporate reporting architecture. Its core evidence is disclosure mapping and value-chain data, and the principal accountable actors include reporting company and assurance function. A material interpretive caution is that adoption, scrutiny and applicability dates must be checked. The description here concerns the framework and its published status, not an assessment of any government or institution. [13][33]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	revised ESRS and corporate reporting architecture
Core evidence	disclosure mapping and value-chain data
Accountable actor	reporting company and assurance function
Interpretive boundary	adoption, scrutiny and applicability dates must be checked
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | IFRS S2 and ISSB

The governing architecture concerns investor-oriented climate-related disclosures. Its core evidence is financially relevant risks, metrics and targets, and the principal accountable actors include reporting entity and board audit committee. A material interpretive caution is that 2027 effective date for targeted GHG amendments. The description here concerns the framework and its published status, not an assessment of any government or institution. [26][27]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	investor-oriented climate-related disclosures
Core evidence	financially relevant risks, metrics and targets
Accountable actor	reporting entity and board audit committee
Interpretive boundary	2027 effective date for targeted GHG amendments
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | Paris Agreement Article 6.2

The governing architecture concerns cooperative approaches and national accounting. Its core evidence is authorisation and corresponding-adjustment evidence, and the principal accountable actors include host and acquiring Parties. A material interpretive caution is that a bilateral announcement is not proof of completed adjustment. The description here concerns the framework and its published status, not an assessment of any government or institution. [32]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract

terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	cooperative approaches and national accounting
Core evidence	authorisation and corresponding-adjustment evidence
Accountable actor	host and acquiring Parties
Interpretive boundary	a bilateral announcement is not proof of completed adjustment
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | Paris Agreement Article 6.4

The governing architecture concerns centralised crediting mechanism under UNFCCC supervision. Its core evidence is methodology, registration, verification and issuance, and the principal accountable actors include project participants, host Party and Supervisory Body. A material interpretive caution is that methodology approval is not issuance. The description here concerns the framework and its published status, not an assessment of any government or institution. [03][04][05]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	centralised crediting mechanism under UNFCCC supervision
Core evidence	methodology, registration, verification and issuance
Accountable actor	project participants, host Party and Supervisory Body
Interpretive boundary	methodology approval is not issuance
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | CORSIA

The governing architecture concerns aviation-specific eligibility and cancellation. Its core evidence is eligible units by compliance phase and vintage, and the principal accountable actors include aircraft operator and administering State. A material interpretive caution is that generic credit status does not establish CORSIA eligibility. The description here concerns the framework and its published status, not an assessment of any government or institution. [24][25]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	aviation-specific eligibility and cancellation
Core evidence	eligible units by compliance phase and vintage
Accountable actor	aircraft operator and administering State
Interpretive boundary	generic credit status does not establish CORSIA eligibility
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | ICVCM Core Carbon Principles

The governing architecture concerns voluntary credit programme and methodology quality threshold. Its core evidence is programme, category and unit checks, and the principal accountable actors include programme, project developer and buyer. A material interpretive caution is that CCP programme approval does not replace unit-level diligence. The description here concerns the framework and its published status, not an assessment of any government or institution. [19][20][21]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	voluntary credit programme and methodology quality threshold
Core evidence	programme, category and unit checks
Accountable actor	programme, project developer and buyer
Interpretive boundary	CCP programme approval does not replace unit-level diligence
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | VCMI Claims Code

The governing architecture concerns corporate communication and credit-use claims. Its core evidence is foundational criteria, monitoring and assurance, and the principal accountable actors include corporate claimant. A material interpretive caution is that claims code compliance is separate from inventory measurement. The description here concerns the framework and its published status, not an assessment of any government or institution. [22][23]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	corporate communication and credit-use claims
Core evidence	foundational criteria, monitoring and assurance
Accountable actor	corporate claimant
Interpretive boundary	claims code compliance is separate from inventory measurement
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | ISO 14068:2026

The governing architecture concerns carbon neutrality standard for organisations and products. Its core evidence is footprint, reductions, residual treatment and claims, and the principal accountable actors include organisation or product owner. A material interpretive caution is that carbon neutrality and net zero are not identical constructs. The description here concerns the framework and its published status, not an assessment of any government or institution. [18]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	carbon neutrality standard for organisations and products
Core evidence	footprint, reductions, residual treatment and claims
Accountable actor	organisation or product owner
Interpretive boundary	carbon neutrality and net zero are not identical constructs
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | SBTi Corporate Net-Zero V2.0

The governing architecture concerns target setting and implementation hierarchy. Its core evidence is target validation and implementation evidence, and the principal accountable actors include company and validation provider. A material interpretive caution is that publication in 2026 is distinct from validation opening in 2027. The description here concerns the framework and its published status, not an assessment of any government or institution. [16][17]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	target setting and implementation hierarchy
Core evidence	target validation and implementation evidence
Accountable actor	company and validation provider
Interpretive boundary	publication in 2026 is distinct from validation opening in 2027
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | GHG Protocol-ISO convergence

The governing architecture concerns planned consolidated corporate GHG standard. Its core evidence is preservation of raw data and version control, and the principal accountable actors include standard setters and reporting companies. A material interpretive caution is that Q4 2028 is a target publication date, not an operative standard. The description here concerns the framework and its published status, not an assessment of any government or institution. [14][15]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	planned consolidated corporate GHG standard
Core evidence	preservation of raw data and version control
Accountable actor	standard setters and reporting companies
Interpretive boundary	Q4 2028 is a target publication date, not an operative standard
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | World Bank carbon pricing instruments

The governing architecture concerns direct carbon taxes and trading systems. Its core evidence is coverage, effective price, revenue and policy design, and the principal accountable actors include national and subnational authorities. A material interpretive caution is that global average price does not describe every sector exposure. The description here concerns the framework and its published status, not an assessment of any government or institution. [01][02]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	direct carbon taxes and trading systems
Core evidence	coverage, effective price, revenue and policy design
Accountable actor	national and subnational authorities
Interpretive boundary	global average price does not describe every sector exposure
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | Article 6.4 removals rules

The governing architecture concerns crediting requirements for removal activities. Its core evidence is storage, reversal, monitoring and net accounting, and the principal accountable actors include project developer and methodology body. A material interpretive caution is that gross capture is not necessarily net removal. The description here concerns the framework and its published status, not an assessment of any government or institution. [08][09]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	crediting requirements for removal activities
Core evidence	storage, reversal, monitoring and net accounting
Accountable actor	project developer and methodology body
Interpretive boundary	gross capture is not necessarily net removal
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | UNFCCC methodology revisions

The governing architecture concerns additionality and baseline-setting standards. Its core evidence is version history and methodology applicability, and the principal accountable actors include project and verification bodies. A material interpretive caution is that new standards require project-specific applicability review. The description here concerns the framework and its published status, not an assessment of any government or institution. [06][07]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	additionality and baseline-setting standards
Core evidence	version history and methodology applicability
Accountable actor	project and verification bodies
Interpretive boundary	new standards require project-specific applicability review
Evidence class	Published rule or institutional guidance, not author endorsement

Comparative system | Global emissions assessment

The governing architecture concerns IEA physical emissions and UNEP scenario evidence. Its core evidence is consistent periods and scenario labels, and the principal accountable actors include analysts and decision makers. A material interpretive caution is that emissions trajectory is not a credit market volume. The description here concerns the framework and its published status, not an assessment of any government or institution. [28][29][30]

A compliance map should begin with jurisdiction, sector, regulated activity, legal entity, effective date, reporting period and required evidence. The map must then distinguish a binding legal requirement from a voluntary standard or programme rule. Failure to separate these categories creates over-compliance in some areas and exposure in others.

The second step is to identify the instrument. A tax liability, allowance, border certificate, project credit, energy attribute, national authorisation and corporate target are different objects. Contract terms should state whether the obligation is to deliver data, surrender a unit, obtain a verification opinion or substantiate a public claim.

The third step is to assess interoperability. Some datasets may support several frameworks, but reporting outputs may require different boundaries, emission factors or allocation methods. Reusing the same primary data is efficient. Reusing a conclusion without checking the relevant method is not.

The fourth step is to plan for change. Standards and legislation evolve on different calendars. Contracts should allocate change-in-law risk, permit updated data requirements and specify the treatment of earlier vintages or reporting periods. A version register should preserve the rule in force when a transaction occurred.

The fifth step is public accountability. The responsible institution should document why the system applies, what it requires, how compliance is verified and which statements are supported. An independent reviewer should be able to trace the conclusion to a dated authoritative document.

Comparative dimension	Assessment
Primary object	IEA physical emissions and UNEP scenario evidence
Core evidence	consistent periods and scenario labels
Accountable actor	analysts and decision makers
Interpretive boundary	emissions trajectory is not a credit market volume
Evidence class	Published rule or institutional guidance, not author endorsement

PART V | THE 42-CONTROL ASSURANCE LIBRARY

C01 | Organisational boundary

Control objective. Establish a reliable basis for organisational boundary using entities and operational-control decisions. The material failure mode is acquisitions, disposals and joint ventures. The primary record is legal entity map. The required response is to restate or explain discontinuities. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version,

unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	legal entity map
Evidence test	entities and operational-control decisions
Known failure	acquisitions, disposals and joint ventures
Response	restate or explain discontinuities
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C02 | Facility register

Control objective. Establish a reliable basis for facility register using site identifiers and operational dates. The material failure mode is duplicate or omitted sources. The primary record is asset master. The required response is to reconcile with finance and permits. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions

affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	asset master
Evidence test	site identifiers and operational dates
Known failure	duplicate or omitted sources
Response	reconcile with finance and permits
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C03 | Fuel activity data

Control objective. Establish a reliable basis for fuel activity data using purchase, storage and consumption records. The material failure mode is estimated fuel use presented as metered. The primary record is invoice and tank reconciliation. The required response is to quantify uncertainty. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	invoice and tank reconciliation
Evidence test	purchase, storage and consumption records
Known failure	estimated fuel use presented as metered
Response	quantify uncertainty
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C04 | Electricity activity data

Control objective. Establish a reliable basis for electricity activity data using metered imports, exports and onsite generation. The material failure mode is double counting self-generation. The primary record is meter and billing data. The required response is to reconcile to grid invoices. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	meter and billing data
Evidence test	metered imports, exports and onsite generation
Known failure	double counting self-generation
Response	reconcile to grid invoices
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C05 | Emission-factor provenance

Control objective. Establish a reliable basis for emission-factor provenance using factor year, geography and method. The material failure mode is obsolete or mismatched factors. The primary record is factor catalogue. The required response is to version control. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with

the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	factor catalogue
Evidence test	factor year, geography and method
Known failure	obsolete or mismatched factors
Response	version control
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C06 | Process-emissions chemistry

Control objective. Establish a reliable basis for process-emissions chemistry using material balance and process stoichiometry. The material failure mode is process emissions omitted. The primary record is laboratory and process logs. The required response is to technical sign-off. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	laboratory and process logs

Evidence test	material balance and process stoichiometry
Known failure	process emissions omitted
Response	technical sign-off
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C07 | Scope 3 category mapping

Control objective. Establish a reliable basis for scope 3 category mapping using value-chain category and supplier boundary. The material failure mode is category omissions or overlap. The primary record is supplier map. The required response is to materiality and gap analysis. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	supplier map
Evidence test	value-chain category and supplier boundary
Known failure	category omissions or overlap
Response	materiality and gap analysis
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C08 | Inventory recalculation

Control objective. Establish a reliable basis for inventory recalculation using base-year and structural changes. The material failure mode is false trend from changing boundaries. The primary record is recalculation log. The required response is to disclose restatements. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	recalculation log
Evidence test	base-year and structural changes
Known failure	false trend from changing boundaries
Response	disclose restatements
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C09 | Location-based Scope 2

Control objective. Establish a reliable basis for location-based scope 2 using grid factor and purchased electricity. The material failure mode is contractual claim substituted for physical grid estimate. The primary record is utility and grid source. The required response is to dual reporting where required. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims.

The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	utility and grid source
Evidence test	grid factor and purchased electricity
Known failure	contractual claim substituted for physical grid estimate
Response	dual reporting where required
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C10 | Market-based Scope 2

Control objective. Establish a reliable basis for market-based scope 2 using certificate quality and retirement. The material failure mode is unretired or mismatched attributes. The primary record is certificate registry. The required response is to validate geography and period. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	certificate registry
Evidence test	certificate quality and retirement
Known failure	unretired or mismatched attributes
Response	validate geography and period
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C11 | Hourly matching

Control objective. Establish a reliable basis for hourly matching using load and generation intervals. The material failure mode is annual total described as hourly matched. The primary record is interval meter data. The required response is to state matching granularity. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	interval meter data
Evidence test	load and generation intervals
Known failure	annual total described as hourly matched
Response	state matching granularity
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C12 | PPA additional impact

Control objective. Establish a reliable basis for ppa additional impact using contracted project and counterfactual. The material failure mode is contracting equated with causation. The primary record is investment and contract file. The required response is to report impact separately. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	investment and contract file
Evidence test	contracted project and counterfactual
Known failure	contracting equated with causation
Response	report impact separately
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C13 | Project baseline

Control objective. Establish a reliable basis for project baseline using baseline scenario and assumptions. The material failure mode is inflated counterfactual. The primary record is approved methodology and model. The required response is to independent sensitivity review. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	approved methodology and model
Evidence test	baseline scenario and assumptions
Known failure	inflated counterfactual
Response	independent sensitivity review
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C14 | Additionality evidence

Control objective. Establish a reliable basis for additionality evidence using investment timing and alternatives. The material failure mode is post hoc claims. The primary record is investment decision records. The required response is to test regulatory and common practice. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	investment decision records
Evidence test	investment timing and alternatives
Known failure	post hoc claims
Response	test regulatory and common practice
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C15 | Common-practice screen

Control objective. Establish a reliable basis for common-practice screen using market adoption and prevailing law. The material failure mode is routine activity credited as additional. The primary record is sector benchmark. The required response is to update periodically. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	sector benchmark
Evidence test	market adoption and prevailing law
Known failure	routine activity credited as additional
Response	update periodically
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C16 | Leakage analysis

Control objective. Establish a reliable basis for leakage analysis using displacement outside project boundary. The material failure mode is shifting emissions ignored. The primary record is geographic or market model. The required response is to monitor indirect effects. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	geographic or market model
Evidence test	displacement outside project boundary
Known failure	shifting emissions ignored
Response	monitor indirect effects
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C17 | Monitoring-plan integrity

Control objective. Establish a reliable basis for monitoring-plan integrity using sensors, frequency and calibration. The material failure mode is measurement bias. The primary record is calibration certificates. The required response is to independent field review. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	calibration certificates
Evidence test	sensors, frequency and calibration
Known failure	measurement bias
Response	independent field review
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C18 | Uncertainty quantification

Control objective. Establish a reliable basis for uncertainty quantification using sampling and model error. The material failure mode is false precision. The primary record is uncertainty workbook. The required response is to conservative adjustment. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	uncertainty workbook
Evidence test	sampling and model error
Known failure	false precision
Response	conservative adjustment
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C19 | Permanence horizon

Control objective. Establish a reliable basis for permanence horizon using storage duration and reversal pathways. The material failure mode is short storage equated with permanent. The primary record is risk and monitoring plan. The required response is to match claim durability. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with

the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	risk and monitoring plan
Evidence test	storage duration and reversal pathways
Known failure	short storage equated with permanent
Response	match claim durability
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C20 | Reversal response

Control objective. Establish a reliable basis for reversal response using buffer, insurance and replacement. The material failure mode is unfunded future liability. The primary record is contract and buffer rules. The required response is to stress correlated loss. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	contract and buffer rules
Evidence test	buffer, insurance and replacement

Known failure	unfunded future liability
Response	stress correlated loss
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C21 | Land rights and tenure

Control objective. Establish a reliable basis for land rights and tenure using documented lawful authority and consent. The material failure mode is carbon rights separated from land rights. The primary record is title and consultation file. The required response is to legal and social review. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	title and consultation file
Evidence test	documented lawful authority and consent
Known failure	carbon rights separated from land rights
Response	legal and social review
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C22 | Community benefit sharing

Control objective. Establish a reliable basis for community benefit sharing using allocation formula and payment evidence. The material failure mode is promised benefit not delivered. The primary record is benefit register. The required response is to independent grievance access. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	benefit register
Evidence test	allocation formula and payment evidence
Known failure	promised benefit not delivered
Response	independent grievance access
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C23 | Biodiversity safeguards

Control objective. Establish a reliable basis for biodiversity safeguards using habitat baseline and impacts. The material failure mode is carbon benefit masking nature harm. The primary record is ecology monitoring. The required response is to mitigation hierarchy. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	ecology monitoring
Evidence test	habitat baseline and impacts
Known failure	carbon benefit masking nature harm
Response	mitigation hierarchy
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C24 | Project registry identity

Control objective. Establish a reliable basis for project registry identity using project ID and methodology version. The material failure mode is project confusion. The primary record is registry entry. The required response is to serial reconciliation. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	registry entry
Evidence test	project ID and methodology version
Known failure	project confusion
Response	serial reconciliation
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C25 | Unit serial integrity

Control objective. Establish a reliable basis for unit serial integrity using issuance, transfer and retirement. The material failure mode is duplicate representation. The primary record is registry transaction log. The required response is to unit-level audit. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	registry transaction log
Evidence test	issuance, transfer and retirement
Known failure	duplicate representation
Response	unit-level audit
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C26 | Ownership and custody

Control objective. Establish a reliable basis for ownership and custody using legal title and account control. The material failure mode is unresolved intermediary rights. The primary record is contracts and registry accounts. The required response is to legal chain-of-title review. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with

the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	contracts and registry accounts
Evidence test	legal title and account control
Known failure	unresolved intermediary rights
Response	legal chain-of-title review
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C27 | Host authorisation

Control objective. Establish a reliable basis for host authorisation using permitted international use. The material failure mode is unapproved export claim. The primary record is official authorisation. The required response is to check conditions and vintages. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	official authorisation
Evidence test	permitted international use

Known failure	unapproved export claim
Response	check conditions and vintages
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C28 | Corresponding adjustment

Control objective. Establish a reliable basis for corresponding adjustment using national accounting treatment. The material failure mode is retirement assumed to equal adjustment. The primary record is Article 6 reporting. The required response is to review official status. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	Article 6 reporting
Evidence test	national accounting treatment
Known failure	retirement assumed to equal adjustment
Response	review official status
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C29 | CORSIA eligibility

Control objective. Establish a reliable basis for corsia eligibility using phase, vintage and programme. The material failure mode is noneligible unit bought for compliance. The primary record is ICAO eligibility list. The required response is to pre-delivery eligibility check. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version,

unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	ICAO eligibility list
Evidence test	phase, vintage and programme
Known failure	noneligible unit bought for compliance
Response	pre-delivery eligibility check
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C30 | Product boundary

Control objective. Establish a reliable basis for product boundary using functional unit and production allocation. The material failure mode is corporate data used as product footprint. The primary record is product LCA file. The required response is to boundary assurance. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions

affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	product LCA file
Evidence test	functional unit and production allocation
Known failure	corporate data used as product footprint
Response	boundary assurance
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C31 | CBAM data lineage

Control objective. Establish a reliable basis for cbam data lineage using installation, process and embedded emissions. The material failure mode is offset purchase treated as CBAM deduction. The primary record is importer-exporter data room. The required response is to verify legal calculation. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	importer-exporter data room
Evidence test	installation, process and embedded emissions
Known failure	offset purchase treated as CBAM deduction
Response	verify legal calculation
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C32 | Supplier data quality

Control objective. Establish a reliable basis for supplier data quality using primary data and estimates. The material failure mode is unqualified supplier assertions. The primary record is supplier audit trail. The required response is to tiered evidence requirements. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	supplier audit trail
Evidence test	primary data and estimates
Known failure	unqualified supplier assertions
Response	tiered evidence requirements
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C33 | Carbon price exposure

Control objective. Establish a reliable basis for carbon price exposure using allowance, tax and border price assumptions. The material failure mode is single global price assumption. The primary record is jurisdiction exposure model. The required response is to scenario analysis. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling

and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	jurisdiction exposure model
Evidence test	allowance, tax and border price assumptions
Known failure	single global price assumption
Response	scenario analysis
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C34 | Credit procurement eligibility

Control objective. Establish a reliable basis for credit procurement eligibility using intended use and programme status. The material failure mode is unit bought without defined purpose. The primary record is purchase specification. The required response is to legal and technical sign-off. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	purchase specification
Evidence test	intended use and programme status

Known failure	unit bought without defined purpose
Response	legal and technical sign-off
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C35 | Delivery and replacement terms

Control objective. Establish a reliable basis for delivery and replacement terms using unit failure and ineligibility remedies. The material failure mode is unsecured forward delivery. The primary record is contract security. The required response is to replacement waterfall. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	contract security
Evidence test	unit failure and ineligibility remedies
Known failure	unsecured forward delivery
Response	replacement waterfall
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C36 | Retirement instructions

Control objective. Establish a reliable basis for retirement instructions using beneficiary and use statement. The material failure mode is retirement for wrong entity. The primary record is registry confirmation. The required response is to dual approval. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version,

unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	registry confirmation
Evidence test	beneficiary and use statement
Known failure	retirement for wrong entity
Response	dual approval
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C37 | Claims wording

Control objective. Establish a reliable basis for claims wording using scope, period and basis. The material failure mode is ambiguous neutrality language. The primary record is claims register. The required response is to legal and technical approval. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions

affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	claims register
Evidence test	scope, period and basis
Known failure	ambiguous neutrality language
Response	legal and technical approval
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C38 | Product consumer claims

Control objective. Establish a reliable basis for product consumer claims using lifecycle substantiation and applicable rules. The material failure mode is offset-based neutral label where prohibited. The primary record is marketing review. The required response is to jurisdiction screening. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	marketing review
Evidence test	lifecycle substantiation and applicable rules
Known failure	offset-based neutral label where prohibited
Response	jurisdiction screening
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C39 | Target-standard version

Control objective. Establish a reliable basis for target-standard version using SBTi or other target rules. The material failure mode is obsolete version presented as current. The primary record is target validation file. The required response is to transition calendar. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	target validation file
Evidence test	SBTi or other target rules
Known failure	obsolete version presented as current
Response	transition calendar
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C40 | Disclosure reconciliation

Control objective. Establish a reliable basis for disclosure reconciliation using IFRS, ESRS and voluntary disclosures. The material failure mode is conflicting totals without explanation. The primary record is crosswalk table. The required response is to audit committee review. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with

the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	crosswalk table
Evidence test	IFRS, ESRS and voluntary disclosures
Known failure	conflicting totals without explanation
Response	audit committee review
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C41 | Assurance independence

Control objective. Establish a reliable basis for assurance independence using verifier competence and conflicts. The material failure mode is management self-certification. The primary record is engagement and accreditation. The required response is to independence check. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	engagement and accreditation

Evidence test	verifier competence and conflicts
Known failure	management self-certification
Response	independence check
Escalation	Technical lead, legal, finance and claims approver as materiality requires

C42 | Board governance and escalation

Control objective. Establish a reliable basis for board governance and escalation using risk appetite, owners and exceptions. The material failure mode is material claims bypass oversight. The primary record is committee minutes. The required response is to escalate exceptions before publication. This control belongs to the author-developed assurance library and should be adapted to the governing standard and jurisdiction.

Design logic. Assign a first-line owner who produces the evidence, a second-line reviewer who tests completeness and methodology, and an independent assurance route where materiality warrants it. The approval record should identify the reporting period, unit or project identifier, method version, unresolved exceptions and permitted use. Where evidence is incomplete, the system should restrict the conclusion rather than silently extrapolate.

Operating test. Select a sample from the reported population, trace the item backward to source records, independently reproduce the calculation or legal-status check, and compare the result with the published statement. For automated systems, inspect access rights, edit history, exception handling and reconciliation rules. A pass requires both numerical consistency and a valid interpretation of the underlying object.

Commercial significance. A weak control can create a compliance shortfall, overpayment for ineligible units, inaccurate supplier declarations, misallocated carbon cost or unsupported marketing claims. The loss is not confined to a disputed tonne. Remediation may require restatement, customer notification, contract replacement, additional assurance and changes to internal governance.

Management response. Maintain an exception log with severity, financial exposure, claim exposure, responsible executive, target closure date and independent validation of remediation. Exceptions affecting legal compliance or public claims should block publication or surrender until resolved. Lower-risk data gaps may be disclosed with uncertainty and a dated correction plan.

Assurance step	Required output
Source record	committee minutes
Evidence test	risk appetite, owners and exceptions
Known failure	material claims bypass oversight
Response	escalate exceptions before publication
Escalation	Technical lead, legal, finance and claims approver as materiality requires

PART VI | INDUSTRIAL AND MARKET SCENARIOS

S1 | High carbon price, weak physical data

This is an illustrative stress scenario, not a forecast. The assumed shock is that compliance cost increases but the organisation cannot trace emissions to individual assets. The analytical implication is that measurement investment precedes trading optimisation. The proposed response is to prioritise

primary activity data, factor governance and verified facility baselines. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	prioritise primary activity data, factor governance and verified facility baselines

S2 | Low credit price, high claims scrutiny

This is an illustrative stress scenario, not a forecast. The assumed shock is that nominally cheap units attract buyers despite uncertain additionality. The analytical implication is that claims risk dominates acquisition cost. The proposed response is to require project and unit diligence before price comparison. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	require project and unit diligence before price comparison

S3 | Export demand with CBAM data gaps

This is an illustrative stress scenario, not a forecast. The assumed shock is that industrial supplier loses commercial flexibility despite production competitiveness. The analytical implication is that data becomes a market-access constraint. The proposed response is to build product-level embedded-emissions records and importer contracts. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory

Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	build product-level embedded-emissions records and importer contracts

S4 | Article 6 authorisation delayed

This is an illustrative stress scenario, not a forecast. The assumed shock is that forward credit delivery becomes exposed to sovereign accounting processes. The analytical implication is that legal status and environmental delivery diverge. The proposed response is to contract conditional delivery and replacement rights. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	contract conditional delivery and replacement rights

S5 | Forest reversal shock

This is an illustrative stress scenario, not a forecast. The assumed shock is that wildfire or land-use change undermines storage assumptions. The analytical implication is that correlated risk defeats naive diversification. The proposed response is to stress buffer sufficiency and long-term liability. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	stress buffer sufficiency and long-term liability

S6 | Electricity attribute standard changes

This is an illustrative stress scenario, not a forecast. The assumed shock is that reported Scope 2 result changes without physical load change. The analytical implication is that methodological transition affects comparability. The proposed response is to preserve hourly data and original certificate history. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a

unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	preserve hourly data and original certificate history

S7 | Industrial production doubles

This is an illustrative stress scenario, not a forecast. The assumed shock is that emissions intensity falls while absolute emissions rise. The analytical implication is that a single progress metric misleads. The proposed response is to report both absolute and intensity outcomes. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response

Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	report both absolute and intensity outcomes

S8 | CORSIA eligibility narrows

This is an illustrative stress scenario, not a forecast. The assumed shock is that previously available unit category loses use eligibility. The analytical implication is that procurement risk becomes compliance risk. The proposed response is to maintain eligibility surveillance and substitute supply. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	maintain eligibility surveillance and substitute supply

S9 | SBTi transition requirements evolve

This is an illustrative stress scenario, not a forecast. The assumed shock is that targets and implementation claims require new evidence. The analytical implication is that standard risk affects communications and capital plans. The proposed response is to track validation timetable and preserve versioned evidence. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	track validation timetable and preserve versioned evidence

S10 | Low-emission technology becomes common practice

This is an illustrative stress scenario, not a forecast. The assumed shock is that project additionality declines as costs fall. The analytical implication is that static baseline overstates future benefit. The proposed response is to apply periodic baseline and common-practice review. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	apply periodic baseline and common-practice review

S11 | Carbon capture with high energy demand

This is an illustrative stress scenario, not a forecast. The assumed shock is that gross capture exceeds net removal after lifecycle emissions. The analytical implication is that process boundary changes unit economics. The proposed response is to calculate net removals and storage risk. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	calculate net removals and storage risk

S12 | Cross-border credit chain multiplies

This is an illustrative stress scenario, not a forecast. The assumed shock is that intermediaries create complex custody and title. The analytical implication is that transaction risk rises without environmental change. The proposed response is to require serial-level chain-of-title controls. The scenario does not assign a probability and does not represent an observed transaction.

The first test is to establish the baseline position before the shock. Record physical emissions, contractual attributes, outstanding credit obligations, inventory and registry status, legal authorisations, product exposures and public claims. A scenario with no reliable opening balance cannot produce a meaningful sensitivity result.

The second test is to separate cash flow from claims. Carbon prices affect purchase cost and compliance liability. Project performance affects physical mitigation. Eligibility rules affect whether a unit can satisfy a specified use. Marketing standards affect permissible language. These channels can move in different directions, and a single net exposure number will conceal the mechanism.

The third test is governance response. Assign an owner to each affected ledger, establish a decision deadline, and identify which transactions or public statements should pause pending evidence. A board should receive the range of outcomes and the assumptions driving the range, not a point estimate without uncertainty.

The fourth test is reversibility. Some responses, such as correcting a claim or changing a contract clause, are relatively fast. Capital-intensive abatement projects and supply-chain changes take longer. Scenario analysis should identify near-term protective actions and long-term investment options separately.

Scenario dimension	Decision input	Illustrative response
Physical	Measured emissions and project output	Preserve independent inventory
Legal	Eligibility and authorisation status	Block unsupported use
Financial	Price and replacement cost sensitivity	Reserve and contract options
Commercial	Customer and product data obligations	Disclose and renegotiate where needed
Claims	Approved wording and retirement status	Suspend or revise claim
Governance	Exception severity and board threshold	require serial-level chain-of-title controls

PART VII | IMPLEMENTATION AND DECISION SYSTEM

A twelve-month implementation sequence

Month 1 | Scope and governance

The implementation focus is scope and governance. The operating work is to appoint data owners, legal reviewer and claims committee. The required deliverable is approved responsibility matrix. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 2 | Physical inventory

The implementation focus is physical inventory. The operating work is to reconcile sites, meters, factors and boundaries. The required deliverable is baseline with exceptions. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 3 | Contractual attributes

The implementation focus is contractual attributes. The operating work is to inventory certificates and energy contracts. The required deliverable is attribute ledger. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 4 | Projects and credits

The implementation focus is projects and credits. The operating work is to map methodologies, projects, units and ownership. The required deliverable is project and unit passport. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 5 | National and legal status

The implementation focus is national and legal status. The operating work is to review Article 6 and other authorisations. The required deliverable is legal-use matrix. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 6 | Product footprint

The implementation focus is product footprint. The operating work is to pilot high-exposure products and supply chains. The required deliverable is product data room. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 7 | Claims inventory

The implementation focus is claims inventory. The operating work is to collect all public climate statements. The required deliverable is claims register. Progress should be assessed through

completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 8 | Assurance controls

The implementation focus is assurance controls. The operating work is to test C01-C42 against materiality. The required deliverable is assurance exceptions. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 9 | Commercial contracts

The implementation focus is commercial contracts. The operating work is to update offtake, procurement and replacement clauses. The required deliverable is contract remediation plan. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 10 | Capital allocation

The implementation focus is capital allocation. The operating work is to compare direct abatement and external finance. The required deliverable is abatement investment portfolio. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary

commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 11 | Board review

The implementation focus is board review. The operating work is to stress scenarios and sign off risk appetite. The required deliverable is board decision paper. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Month 12 | Public disclosure

The implementation focus is public disclosure. The operating work is to release reconciled statements and limitations. The required deliverable is auditable publication package. Progress should be assessed through completeness, reproducibility, exception closure and decision usefulness rather than the number of documents produced.

The project sponsor should appoint one accountable executive and preserve technical independence for verification. The workstream should maintain a register of legal obligations, voluntary commitments, material exposures and dependencies on external parties. Any public claim awaiting evidence should remain under approval control.

The implementation gate should require a clear definition of completion. A completed data upload is not the same as an assured dataset. A signed contract is not the same as an eligible unit. A board presentation is not the same as an adopted operating control. The gate must record evidence and responsible approval.

Seven-ledger reconciliation protocol

Protocol step 1: L1 | Physical emissions inventory

Reconcile meters, fuel records, process data, organisational boundaries to the target statement physical emissions and intensity trend. Assign data owner and emissions accounting lead as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is netting credits against the physical total.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data,

methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 2: L2 | Contractual environmental attributes

Reconcile energy certificates, power purchase agreements, product attributes to the target statement market-based and contractual disclosures. Assign energy procurement and accounting lead as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is presenting annual certificates as hourly physical supply.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data, methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 3: L3 | Project mitigation and counterfactual

Reconcile baseline model, monitoring plan, additionality, leakage to the target statement project performance and uncertainty interval. Assign project developer and independent validator as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is claiming counterfactual savings as direct inventory reductions.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data, methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 4: L4 | Unit registry and ownership

Reconcile serial number, vintage, issuance, transfers, retirement to the target statement unit passport and transaction chain. Assign registry operator and buyer custodian as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is double sale, duplicate representation or missing retirement.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data,

methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 5: L5 | National accounting and authorisation

Reconcile host-country authorisation, first transfer, corresponding adjustment to the target statement Article 6 reporting and use status. Assign host-country authority and reporting focal point as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is assuming registry retirement equals national adjustment.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data, methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 6: L6 | Product footprint and border treatment

Reconcile bill of materials, plant emissions, production volumes, verification to the target statement product carbon footprint and CBAM evidence. Assign manufacturer, exporter and importer as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is substituting corporate credit purchases for embedded-emissions data.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data, methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Protocol step 7: L7 | Claims and representation

Reconcile approved wording, boundaries, targets, credit use, disclosures to the target statement public claims register and substantiation file. Assign legal, sustainability, marketing and board oversight as the primary custodian. The protocol should identify unique identifiers, accounting period, methodology version, quality status and the permitted relation to adjacent ledgers. The specific prohibited inference is conflating compensation, contribution and reductions.

Document the source of each field and the method used to transform it. Retain the original record, the calculated value and the approved reported value. Exceptions should be categorised as missing data,

methodological uncertainty, legal uncertainty, system failure or claims overreach. Each category has a different remediation route.

A reconciliation sign-off should record the reviewer, date, sampling approach, unresolved exceptions and the consequences for disclosure. If the control is not material, management should document why. If it is material, the relevant statement should not be published until the evidence threshold is met or the limitation is clearly disclosed.

Illustrative financial and emissions sensitivity model

The following calculations are hypothetical demonstrations. They are not forecasts, observed company data or evidence of credit-market prices. Their purpose is to show why an inventory, a credit, a carbon price and a claim must be modelled separately.

Illustration: an uncovered compliance exposure of 100,000 tCO2e at an assumed carbon price of US$20/tCO2e produces a gross annual price exposure of US$2,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 100,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 100,000 tCO2e at an assumed carbon price of US$50/tCO2e produces a gross annual price exposure of US$5,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 100,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 100,000 tCO2e at an assumed carbon price of US$100/tCO2e produces a gross annual price exposure of US$10,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 100,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 250,000 tCO2e at an assumed carbon price of US$20/tCO2e produces a gross annual price exposure of US$5,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 250,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 250,000 tCO2e at an assumed carbon price of US$50/tCO2e produces a gross annual price exposure of US$12,500,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 250,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 250,000 tCO2e at an assumed carbon price of US$100/tCO2e produces a gross annual price exposure of US$25,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 250,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 500,000 tCO2e at an assumed carbon price of US$20/tCO2e produces a gross annual price exposure of US$10,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity

calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 500,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 500,000 tCO2e at an assumed carbon price of US$50/tCO2e produces a gross annual price exposure of US$25,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 500,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 500,000 tCO2e at an assumed carbon price of US$100/tCO2e produces a gross annual price exposure of US$50,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 500,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 1,000,000 tCO2e at an assumed carbon price of US$20/tCO2e produces a gross annual price exposure of US$20,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 1,000,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 1,000,000 tCO2e at an assumed carbon price of US$50/tCO2e produces a gross annual price exposure of US$50,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 1,000,000 tCO2e unless physical operations change.

Illustration: an uncovered compliance exposure of 1,000,000 tCO2e at an assumed carbon price of US$100/tCO2e produces a gross annual price exposure of US$100,000,000 before exemptions, free allocation, border adjustments, credits, tax effects or abatement. This multiplication is a sensitivity calculation, not a forecast of a jurisdictional obligation. The corresponding emissions remain 1,000,000 tCO2e unless physical operations change.

The same arithmetic should not be used to value project credits without adjusting for delivery risk, eligibility, permanence, vintage, legal status and claim purpose. Nor should a company subtract purchased credits from its physical inventory to imply direct operational decarbonisation. A decision model should show physical emissions, compliance exposure, mitigation investment and voluntary credit use on separate lines.

PART VIII | EVIDENCE, LIMITATIONS AND REFERENCES

Evidence hierarchy and factual boundaries

Verified historical observations

World Bank 2026 carbon-pricing counts and 2025 revenue, IEA 2025 emissions estimates, and official 2026 publication dates are attributed to their sources. A verified publication is not proof that every reported statistic is free of uncertainty.

Institutional assessments

UNFCCC, ICVCM, VCMI, ISO, SBTi, IFRS and EU publications describe their own rules, programmes or assessments. Their positions are attributed. Institutional approval is not treated as a universal environmental guarantee.

Projections and planned dates

The GHG Protocol-ISO 2028 publication target and SBTi 2027 validation timetable are described as announced plans. Future events are not reported as completed outcomes.

Author analysis

The seven-ledger architecture, sector decision files, scenario logic and control library are original analytical structures. They have not been externally validated as a standard and do not replace legal or technical due diligence.

Quantitative illustrations

Price-exposure examples are explicitly hypothetical. They do not represent observed carbon prices, actual liabilities, project credit valuations or policy predictions.

Jurisdictional scope

Regulatory applicability varies by country, sector, entity size, reporting period and product. This paper compares systems without providing legal advice or recommending a political choice.

Limits of this review

Primary web pages were reviewed for current institutional status. Full paywalled standards and individual project files were not independently audited. This is a strategic synthesis, not certification of any carbon unit, project, national accounting report or corporate claim.

Closing proposition

The next phase of carbon markets will not be defined only by the price of a tonne. It will be defined by whether the tonne has a traceable physical basis, a credible counterfactual where applicable, a unique registry history, a defensible legal status and a claim that remains within the evidence. Industrial transition requires finance, technology and physical emissions reductions. Carbon accounting should make those decisions clearer, not obscure them.

A credible carbon system therefore requires multiple ledgers and one discipline: never represent an accounting attribute, a mitigation unit or a public statement as more than the evidence establishes. The real asset is not a headline tonne. It is the confidence that every reported tonne means exactly what the organisation says it means.

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