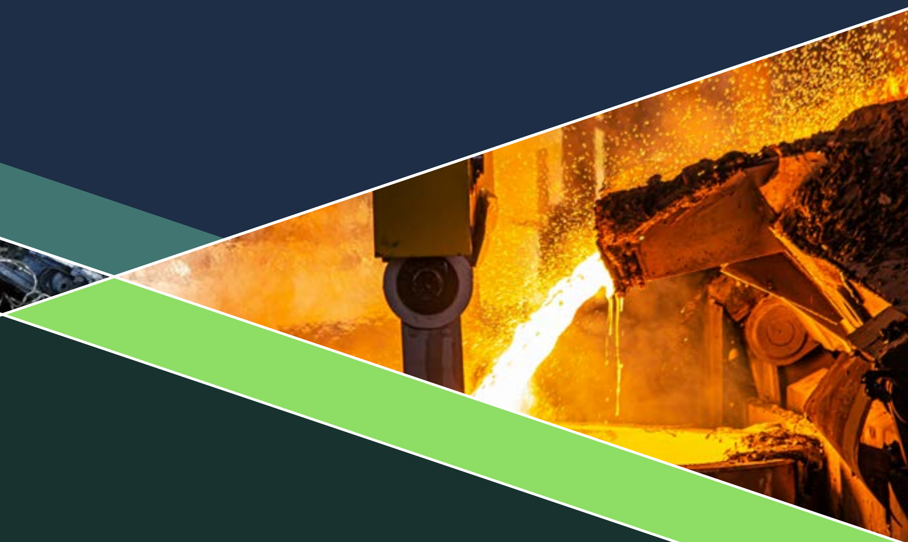
Principles and guardrails for credible mass balance claims

Mass Balance as a Tool for Decarbonising Heavy Industry



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Executive Summary

Clean industry is on the move. Nearly 1,000 clean industrial projects are now in development around the world, a sign of real momentum behind the industrial transition. Turning that project pipeline into operational plants, however, depends on something less certain: demand. Connecting buyers of low-emission fuels, chemicals and materials with suppliers is not straightforward for markets in transition, as physical products rarely travel from a single source directly to a single buyer. Clean fuels and materials today still share pipelines, ports, and processing plants making fossil-based products, and pass through multiple organisations before reaching their end user, whether automotive, construction or shipping. A critical challenge for clean industry is to make sense of that shared, complex infrastructure, so that a tonne of clean steel or clean fuel can be tracked, trusted, and rewarded.

In this context, the ability to make credible environmental claims about products depends on traceability frameworks. Mass balance is one such framework. It allows for certified and non-certified material to be mixed physically during processing, tracking each amount through to the final product so that the volume of certified output never exceeds the volume of certified input.

Well-designed mass balance systems can activate early demand for low-emission products, help suppliers monetise partial decarbonisation of existing infrastructure before fully segregated clean supply chains are developed and build the buyer confidence needed to catalyse further investment in truly decarbonised production. Poorly designed systems risk the opposite: loss of trust in low-emission product markets, enabling business-as-usual activity to be relabelled as climate progress, and ultimately slowing rather than accelerating the transition they are meant to support.

Different mass balance approaches are being trialled, developed, and adopted across energy intensive industries, including steel, cement, chemicals and fuels. Its flexibility makes it attractive to producers, but multiple applications and lack of singular definition mean it is difficult for buyers to understand what they are purchasing, slows adoption, and risks undermining trust in low-emission product markets more broadly.

System transparency and design element disclosure is critical for determining the credibility and associated emissions impacts of a product. Approaches that are less transparent or that give more flexibility in how they are designed - such as the “carbon bank” approach - risk being seen as less credible and having less impact on the market. This report explains how mass balance works, where it creates value, where it creates risk, and how it can be assessed and designed to support credible, scalable, and decision-useful climate markets. These design choices should be reviewed in a sector-specific context. What works for steel may not work for aluminium, cement and concrete, chemicals, or fuels. Differences in production configuration, technologies, emissions profiles, product varieties, market maturity, and buyer needs all affect what level of physical connectivity, attribution flexibility, and claim specificity is appropriate.

The value of a mass balance system depends entirely on how it is designed. A high-quality system must meet two related tests:

1. Supports additional decarbonisation by helping drive new or accelerated investment, rather than merely rewarding business-as-usual activity;
2. Balances accuracy and usability: the system should accurately represent what is being claimed, while still generating claims that buyers can use in procurement decisions, product differentiation, product carbon footprints, and environmental disclosures.

Questions to test a mass balance system:

- **Is mass balance needed?** The flexibility of mass balance makes it attractive, unlocking the green premium by connecting limited low-emission supply with limited demand for low-emission products. However, there must be clear and justifiable reasons why a mass balance approach has been adopted over and how the approach accelerates decarbonisation of supply chains.
- **What is being mass balanced?** It must be clear what low-emission input or intervention is being mass-balanced to support a credible claim about product. Third party verification and certification of inputs also improves system integrity and claim credibility. The impact of the inputs must appropriately correspond with the claims associated with the outputs, maximising both credibility and system impact. For example, if a system has no truly net-zero inputs, then a net-zero claim risks disincentivising additional, catalytic investment in net-zero technologies needed for the transition, whilst undercutting truly net-zero products in the market.
- **Is the approach transparent?** The credibility of any claim is built on a transparent and easily accessible methodology that stakeholders can understand. Without a clear description of how a claim was formed, value chains cannot truly assess the decarbonisation impact of products, leading to increased confusion that limits demand for mass balance based products.
- **Can a group-level system be credible?** Mass balance by definition requires a physical link between inputs and outputs. Group-level or company-wide mass balance, across multiple sites, generally lacks a physical link, which can undermine the credibility of low-emission product claims. Strong justification of real world limitations, such as geographical scarcity of inputs, are needed to implement group level mass balancing. Time limiting group-level systems while site specific infrastructure is built could be one approach to improving system credibility.
- **Are credit ledger approaches robust?** Systems that use a credit ledger approaches to track low-emission inputs can be robust providing appropriate tracking systems are in place that are transparent and auditable. Which inputs generate credits and whether different credit types are stacked or pooled is critical to the net-zero alignment of a mass balance approach. Importantly, these credits cannot be transferred outside of an organisation's internal system and should not be confused with market traded carbon credits or renewable energy certificates.
- **Which design feature is most important?** A system must be viewed holistically, with no one design feature carrying more inherent risk than others. The range of optionality in design choices provide flexibility for producers seeking to demonstrate demand for low emission products and recoup investment. Flexibility must be balanced with the accuracy of claims about a product and how the system supports additional investment in decarbonising production and the wider supply chain.

Recommendations

- **Buyers:** use this report and its accompanying due-diligence assessment tool; these offer a structured way to evaluate a mass balance claim before relying on it for procurement, product carbon footprints, or environmental disclosures.
- **Producers:** clearly communicate the system boundary, eligible inputs, attribution method, balancing period, and claim-use limitations, building your mass balance system on transparency and integrity; this will increase product and producer trust
- **Standard setters and industry bodies:** align on transparent, shared definitions that align with emerging cross-sector guidance from the Science Based Targets Initiative and the Greenhouse Gas Protocol while incorporating sector-specific nuance needed to drive each sector towards realising true near-zero production. Serve as third-party verifiers where appropriate and critically assess the system design balance between accuracy and usability.

1. Introduction

Decarbonising heavy industry is one of the defining challenges of the energy transition. In many sectors, near-zero emission production technologies are ready for deployment, but are capital-intensive, commercially unproven at scale, or require significant and sustained demand to justify investment.

Buyers have a critical role to play in sending that demand signal. However, it is difficult for producers with complex supply chains and shared infrastructure to separate fossil and low-emission production lines to produce fully traceable low-emission materials at the volumes, locations, or specifications requested by limited demand in the near term. This gap between demand and physical supply is one of the main obstacles to low-emission market formation in energy intensive sectors.

Mass balance approaches have emerged as a potential bridge. By allowing conventional and low-emission inputs to be physically mixed within a defined production system, their respective fossil and low-emission attributes are tracked and attributed to outputs through defined rules.

Well-designed mass balance systems can help activate early demand, support buyer access to lower-emission production, and enable suppliers to monetise partial transitions as new low-carbon production comes online alongside conventional infrastructure that has not yet been fully depreciated. This in turn demonstrates demand for low-emission products, enabling further investment, and accelerating early market formation.

Despite this potential, mass balance remains loosely defined and inconsistently applied across markets. The same “mass balance” label may be used to describe materially different systems, including physical blending of lower-emission inputs, attributing emissions across outputs, or pooling emission reductions across multiple production sites via a credit bank to production lines that are not physically connected. This variety and ambiguity has created market confusion that can slow buyer adoption, weaken claim credibility, and undermine trust.

This report aims to help reduce market confusion by equipping stakeholders with the fundamentals needed to interrogate a low-emission product claim that is underpinned by a mass balance system. It has four objectives:

- Distinguishing between mass balance as a chain-of-custody method and a crediting approach used to make near or net-zero product claims.
- Identifying the core system design elements that determine whether a given mass balance approach supports high-quality claims.
- Providing a practical assessment tool for assessing the integrity, additionality, and usability of mass-balance-based claims.
- Using sector-specific applications to show how design priorities must reflect differences in production systems, value chains, decarbonisation pathways, and market structures.

By starting with a product claim and breaking down the mass balance system behind it, buyers should be empowered to make better procurement decisions, ensuring that producers develop systems that result in catalytic investments in truly decarbonised low-emissions production systems.

Figure 1: Recycled plastic content claims using mass balance approaches are becoming common place on food packaging

2. What is Mass Balance and Why Does it Matter?

2.1 What is Mass Balance?

Mass balance **is the system and process of assigning inputs, attributes, and emissions across multi-output production systems.** The system helps track important input characteristics or “attributes”, such as renewable, biological, or recycled content, as they are mixed with conventional inputs through complex production processes. The system then determines how these attributes are distributed to the final product outputs.

Mass balance is applied in two related but distinct ways:

1. A **chain-of-custody method** to track and transfer specific attributes through value chains where materials or products with specified attributes are mixed or co-processed with materials or products without those attributes.
2. In **product-level market claims** to assign eligible low-emissions attributes to outputs, or parts of outputs, under defined accounting and attribution rules.

Both applications share the same basic balancing principle: the attributes assigned to outputs cannot exceed verified attributes introduced into or generated within the defined system. However, they serve different market purposes and create different claim quality risks which are explored below.

Mass balance as a chain-of-custody (CoC) method

Mass balance as a chain of Custody (CoC) method is used to track sustainability attributes through complex production and supply systems. It sits between physical segregation, where materials with different attributes are kept entirely separate throughout the supply chain, and book-and-claim, where attributes are fully decoupled from physical products and traded as certificates.

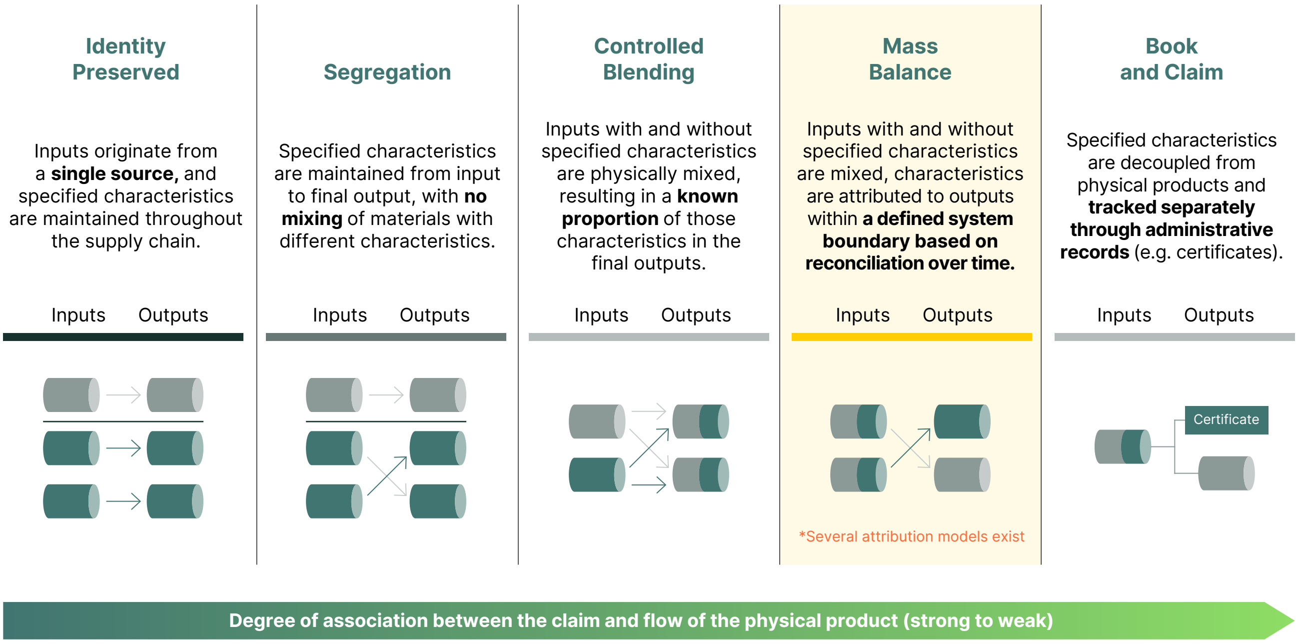


Figure 2: Mass balance within the chain-of-custody model landscape (ISO 22095:2020)

Mass balance's defining feature as a CoC method is that it maintains an overall system-level link between the physical flow of material and energy mixing from inputs to outputs, without requiring individual product-level traceability of the physical attributes. Rather than proving that a specific molecule, metal unit, or product component physically contains a certified sustainable attribute, the system verifies that the volume of certified output matches an equivalent volume of eligible input within the defined production chain.

Mass balance as a CoC method is most applicable when full physical traceability is not feasible, but system-level tracking and controlled accounting is possible. For example, in biodiesel production, a range of biobased waste feedstocks are tracked as sustainable attributes through processing and production. The resulting biodiesel is then tracked through blending with fossil fuels before being utilised in a vessel, aircraft, or vehicle. The exact amount of biodiesel in each litre cannot be determined due to the fossil diesel and biodiesel mixing, but an average percentage based on the total volume of biodiesel input can be calculated e.g. 7% biodiesel in road transport fuels.

In this role, mass balance is primarily an attribute-transfer mechanism within a physically connected value chain. Its credibility depends on the strength of the chain-of-custody controls: which entities are included, how eligible and non-eligible materials are measured, how co-processing and mixing are treated, how attribution to outputs is permitted, how often balances are reconciled, and how documentation is verified.

Mass balance in product-level accounting and market-claim context

This application operates with a different emphasis and is increasingly relevant when only a part of a production system has transitioned to lower-emission inputs or processes. Rather than functioning as a traceability tool, mass balance principles are applied to link, or "attribute", eligible low-emission inputs to specific products outputs. These lower-emission inputs may come from certified recycled content, renewable energy, process changes, or verified emissions reductions within a defined system.

The central question is not only whether a low-emission input can be tracked and traced through a value chain, but how it is attributed to the end product claim.

Systems are emerging that allow proportional attribution across all outputs from a site, or selectively assign attributes to specific products or volumes (over a defined time period). Each approach carries different implications for accuracy, additionality, and credibility.

From left to right: decreasing physical linkage and increasing flexibility in attribution

Site-Level Proportional (Uniform)	**Site-Level Proportional (Physically constrained)**	**Site-Level Selective Product**	**Site-Level Non-Proportional**	**Group-Level Non-Proportional**
Attribute evenly across all eligible output based on the input share.	Proportional attribution within the limits of physical input mix, e.g., share of ore vs scrap.	Attributed to selected product lines within the same site.	Attributed in aggregation within a site to a portion of output.	Stack characteristics across multiple sites and attribute them all into one product line.
Steelmaker blends 50% green iron input + 50% conventional iron input → **All steel output** from the site marketed as green steel made with 50% green iron	With 20% green iron, 30% conventional iron, and 50% scrap → **Steel output may be claimed as 40% green and 60% conventional,** both with 50% scrap content.	Steelmaker using 25% green iron and 75% conventional to produce equal volume of cold rolled and hot rolled steel→ **may attribute all green iron to cold rolled products**	Steelmaker using 50% green iron input and 50% conventional iron input → **50% of steel output are 100% green.**	One site switches to NG DRI, another increases scrap content, another sources green iron and pooling of those **three interventions show in one final product**

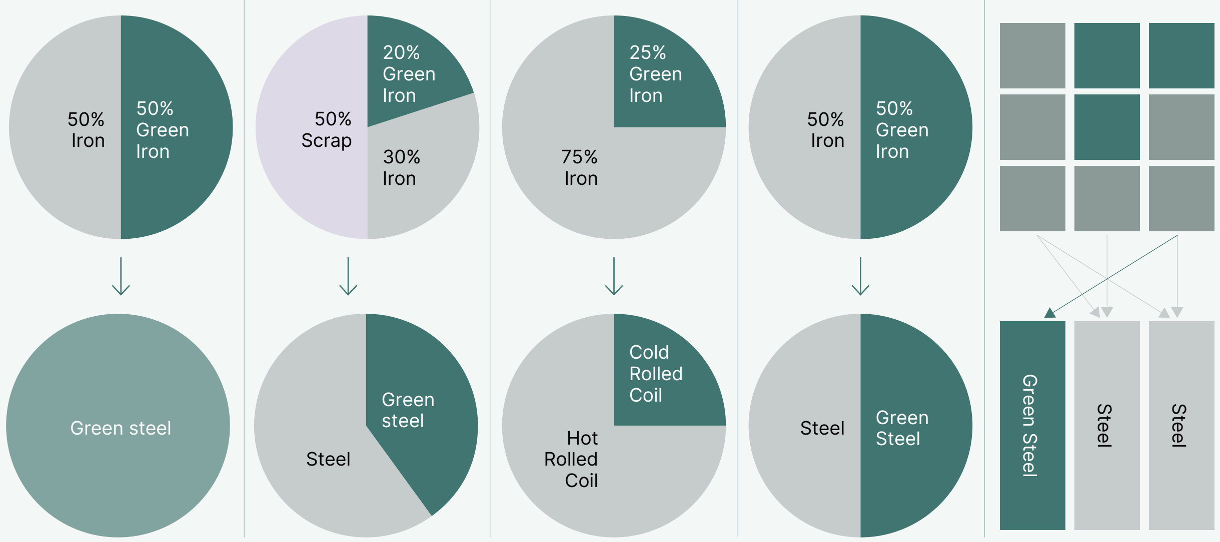


Figure 3: Mass balance archetypes in the steel sector

Because this application directly interfaces with market-facing claims, it carries distinct integrity considerations and risks. The credibility of the claim depends on how the system boundary is defined, what qualifies as an eligible attribute, how attribution is handled, how double counting is prevented, and whether the attributed volumes reflect real decarbonisation rather than a redistribution (or *"reattribution"*) of existing performance. 3rd party verification and certification of both inputs, outputs and system management can help provide transparency and confidence in true impact of decarbonisation claims.

Without clear rules, product-level mass balance can blur the difference between a lower-emissions product, a lower-emissions production system, and a transferred environmental attribute.

Table 1. Comparison of mass balance for chain-of-custody vs product market claim

	Mass Balance as Chain of Custody (CoC)	Mass Balance as product market claim
Primary function	Attribute transfer and CoC control	Constructing a low emission product claim construction and differentiation between final products
Physical connection	Maintains a system-level link to physical flows within a defined boundary, but does not require a segregated production line or physical presence of attributes in outputs	May be linked to a production system, facility, line, or input stream, but the focus is on attribution to a specific product volume, rather than tracing the physical movement of certified material
Typical context for use	Supply chains where full segregation is infeasible, but inputs and outputs can be measured	Producers investing in incremental decarbonisation of production and early-stage, low-emissions markets
Attribute source	Certified inputs entering the system (e.g., recycled content, certified lower-emission input)	Emissions reductions from technologies, process improvements, or the use of lower-emissions inputs, fuels, power within the system
Integrity risks	High integrity if the system boundary is well-defined and inputs are independently verified	Lower integrity without proper governance and transparency due to risk of weak additionality, double counting, or over-attribution.
Downstream use	Responsible sourcing, supply chain transparency, procurement requirements	Scope 3 accounting and lower-emissions product procurement. Potentially product carbon footprints and environmental product declarations in future.[1]

2.2 Why Does Mass Balance Matter for Low-Emission Market Formation?

The rising use of and exposure to mass balanced products via both the CoC and market-claim methods reflects a practical market need. In practice, mass balance typically serves one or more of the following market functions:

- **Demand signalling during staged transitions:** suppliers apply mass balance to create differentiated product offerings and test buyer willingness to pay before full-site transition is complete. This is especially important in sectors where decarbonisation is costly and happens gradually.

Example: *A steel producer may take a phased decarbonisation strategy to retire one blast furnace reaching its end-of-life and replace it with hydrogen-ready direct reduced iron and electric arc furnace steelmaking technology, while other BF-BOF lines remain in operation until the next relining cycle. Mass balance can attribute the lower-emission attribute from the retrofitted line to a defined volume of steel sold to early buyers, helping monetise the first retrofit and build demand for broader site transition.*

- **Attribution of scarce low-emission supply:** In early markets, low-emission inputs or production volumes are often limited. Mass balance provides a mechanism to match this scarce supply with buyers that are willing to pay a premium, without requiring the entire production system to be physically segregated.

Example: *Recycled feedstocks from chemical recycling, such as plastic-waste-derived pyrolysis oil, are often scarce low-emission inputs. Chemically recycled plastics account for only around 0.1% of global plastic production, while customer demand for circular plastics is growing. Mass balance provides a practical way to attribute this limited recycled input to selected circular polyethylene or polypropylene products for buyers willing to pay a premium, without requiring full physical segregation across crackers and polymer assets.*

1 As of August 2026, product category rules (PCRs), which govern the life cycle assessment (LCA) rules used in EPDs, generally do not allow mass balance approaches to be incorporated into global warming potential (GWP) calculations. It is important to note that multiple PCR standards providers exist, and requirements can vary significantly across geographies, including how PCRs are developed and amended.

- **Certified asset-linked sourcing:** where full physical traceability is not feasible, value chain mass balance can link products to certified mines, sites, or facilities. This can help buyers meet responsible sourcing requirements while recognising that commodity materials are often blended, processed, and traded through shared infrastructure.

Example: *The Aluminium Stewardship Initiative (ASI) Chain of Custody Standard uses a mass balance approach that allows ASI and non-ASI material to be mixed under material accounting controls, with the focus on connecting certified supply chain practices rather than tracing specific atoms in the material. The system can link a defined product volume to certified entities or facilities, including upstream smelters, through an unbroken chain of ASI CoC-certified actors, but it is not designed to prove that the specific physical atoms in the final product came from that smelter.*

- **Attributed emissions intensity claims for products:** Mass balance can support product-level emissions claims that are used in procurement decisions. In future, this could include product carbon footprints or EPDs, although mass balancing of emissions or emissions reductions is not currently permitted under most internationally recognised methodologies.

Example: *A construction company may prefer to procure cement from site with CCUS that uses a mass balance approach, to support deployment of a deep decarbonisation technology, rather than purchasing a partially decarbonised cement product that uses a substitute material (SCM).*

These market functions show why mass balance is increasingly attractive. It gives producers a way to monetise early decarbonisation investments before a full-site transition becomes feasible and provides buyers with a structured pathway to access low-emission supply before physically segregated supply is available. Its effectiveness, however, depends on disciplined system design.

3. Principles

While all mass balance systems share the same underlying mechanics, the design choices that govern their configuration vary significantly and have material consequences for the credibility and flexibility of the resulting claims. This section outlines the two system minimum requirements and five flexible system design elements.

3.1 System Requirements for Credibility

3.1.1 System Requirement #1: Verified Inputs

Are the emissions-reducing inputs verified on the product and market-impact level?

Mass balance systems are designed to maintain certain product or production attributes within a defined operational boundary and time window. When mass balance is applied to sustainable product market claims, attributes may be defined by an input's material composition (e.g. bio-based content, recycled content, green hydrogen, renewable electricity), or production process (e.g. fairtrade coffee or organic cotton), or an environmental performance compared to a historic benchmark. Verifying these inputs are additional and net-zero aligned by third party auditors supports a high integrity product claim.

The nature of the attribute itself also varies in ways that have significant integrity implications. System attributes can be measured as absolute emission values, or as emissions reduction measured against a historic baseline.[2] Both can both be reconciled under mass balance methods, but have different credibility and comparability implications. Independently verified emissions value offers higher credibility compared with emissions reductions as it avoids the risk of inflating benefits by comparing against an misleading baseline.

Reduction-based claims are inherently more integrity-sensitive because they depend not only on measured emissions, but also on assumptions about a historic baseline and what would have happened under business-as-usual conditions. These claims are being proposed through "carbon bank" style instruments, where a producer generates a pool of reductions from multiple small projects or process improvements at the site, multi-site, or corporate level. The actual emissions from those projects are then compared against a baseline, deposited as reductions into a virtual bank, and then attributed to selected products, customers, or reporting periods.

This approach can weaken the link between the claim and the physical product or production process, create risks of generous baselines and over-crediting, and allow reductions to be used for products or time periods disconnected from where and when they occurred.

This weak link between the physical decarbonisation activities and the final product likely reflect why a carbon bank approach is not seen as a credible. Without using low-emission interventions that are net-zero aligned, and using a system that fails to retain some physical connection between the inputs and outputs, carbon bank approaches result in a very weak final product claim.

Determining which material or product inputs attributes are eligible in a mass balance system, using high-integrity audit and certifications to verify the sustainability of those attributes is critical to provide confidence in any product claim made.

2 Emissions reductions or savings (t CO_2e reduced per ton product or material) are not explicitly or clearly qualified under ISO's definition of specified characteristics, which are tied to material flows. This is an important distinction between mass balance and carbon banking systems.

3.1.2 System Requirement #2: Traceability

Are the attributes tracked in a transparent, verifiable system?

Traceability of how the claimed attributes are transferred is important to provide assurance that claimed attributes are real and are not double counted through attribution and re-assignment in mass balance systems. How and to what extent attributes and their associated entitlements to claim are permitted to move across sites or legal entities determines how well they can be traced, managed, and tracked.

Transparency of claims and the infrastructure to support them is critical for guaranteeing product trust and for mitigating fraudulent activity or clerical error. Transparently balanced products should disclose the system boundary, attribute source, attribution method, balancing period, and verification approach used to balance the product.

Without a common disclosure framework, it is difficult for buyers to compare mass balance products across different brands or determine whether a claim is suitable for procurement targets, EPDs, or other sustainability marketing communications.

Traceability of attributes and related claims is impacted by system boundaries, attribution methods, as well as the rules for the reassignment, transfer, and disclosure of attributes within and across value chains. Intra-company transfers, where characteristics move between facilities within the same organisation, are generally more traceable than inter-company transfers, where attributes are sold or assigned across organisational boundaries. As transferability increases, the system becomes more scalable, but the ability to trace characteristics to specific products or production lines weakens.

3.2 Core Design Features

The following core design features underpin the credibility of claims made through a mass balance system.

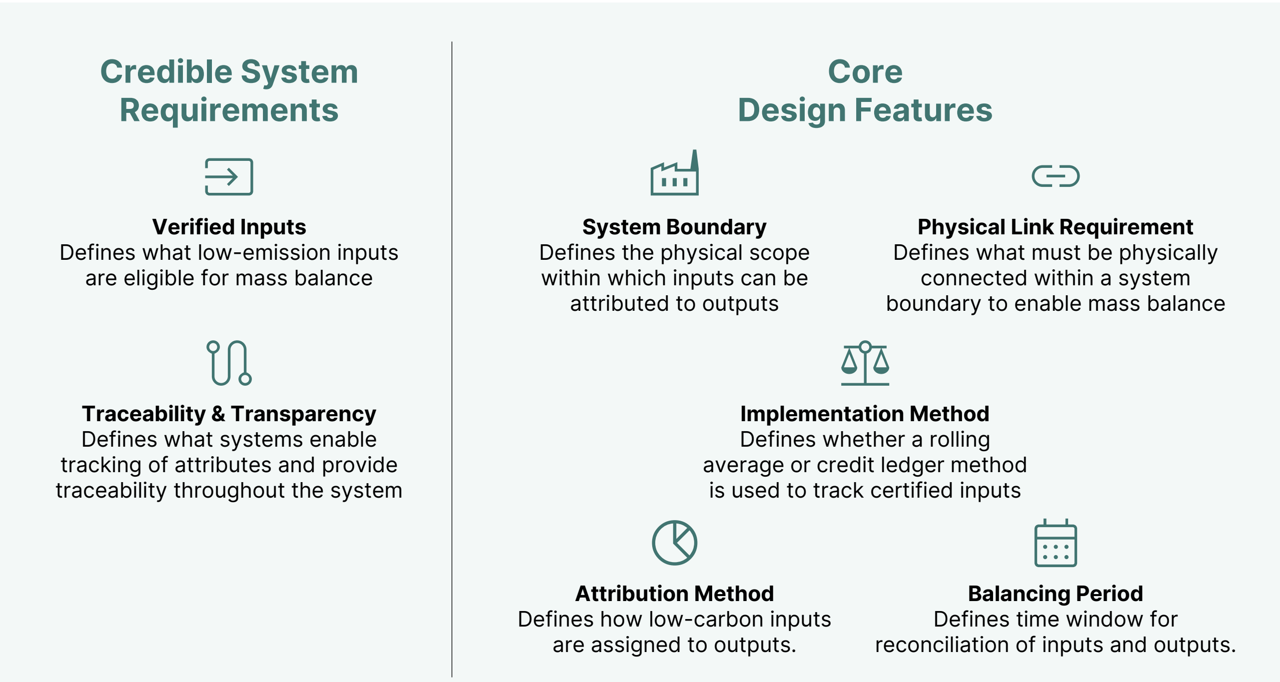


Figure 4: Core design features of mass balance systems

3.2.1 System Boundary – From which parts of a production system do attributes originate?

The **system boundary** defines the physical scope within which inputs and outputs are reconciled. This may range from a single process unit or facility to multiple sites or networked systems. Boundaries can be drawn around a geographic area, government or legal entity, or shared physical infrastructure. Expanding the boundary increases flexibility by allowing attributes to be attributed across a larger output base but can weaken the system-level connection between claimed attributes and the specific production processes that generated them.

Batch Level	Process Level	Site Level	Multi-Site / Group Level	Geographically Networked
Batch Boundary	**Production Boundary**	**Site Boundary**	**Corporate Boundary**	**Geographic Boundary**
Covers a specific production batch at a facility	Covers a specific production process	Covers a specific production facility	Covers a corporate cluster of production facilities	Covers regional balancing pools and pipeline-connected assets
• Single batch unit	• Single production unit	• Multiple production units within site boundary	• Multiple sites within corporate boundary • Multiple production units within each site	• Multiple corporate clusters within geographic boundary • Multiple sites within each corporate cluster • Multiple production units within each site

Example: Steel Sector

Multiple emissions reducing pathways exist within the steel sector, and oftentimes they cannot be combined in the same production process. For example, a company has two steel production facilities. At Facility A, the company operates a BF-BOF process and replaces coal-based coke inputs in the blast furnace with biochar in some of its production runs. At Facility B, the company operates an EAF which runs on renewable electricity. Each of these interventions incrementally reduce emissions. Using a batch-level system boundary, Facility A could account for the emissions reductions from biochar for a specific single batch. Using a site-level system boundary, Facility A could distribute the biochar usage across multiple batch outputs. Using a group-level system boundary, the company could combine the emissions reductions of using biochar at Facility A and with the emissions reductions of using the renewably powered EAF, attributing both emissions reductions to a product output.

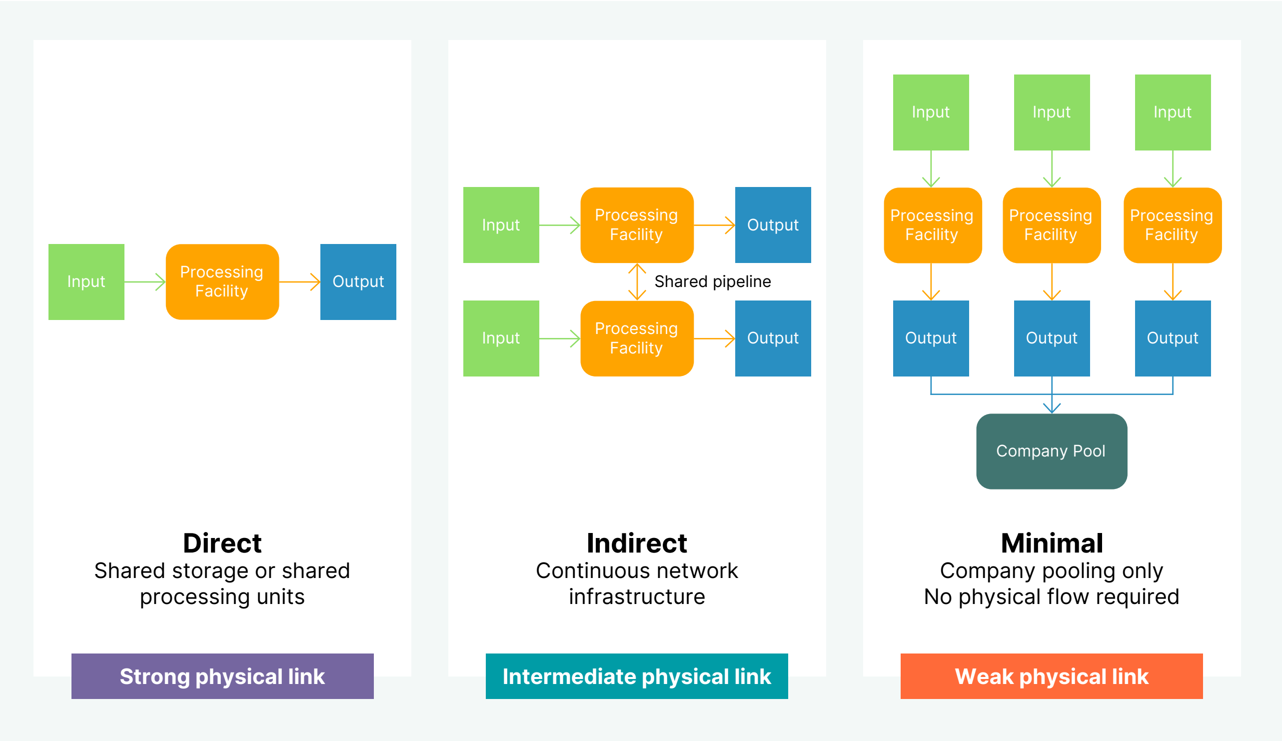
However, it is important to note that this group-level example increases risk by both weakening the physical connection and breaking technical feasibility as blast furnaces and electric arc furnaces cannot be used in the same production process. System boundaries are therefore worth careful attention including how they interact with other system design features.

The broader the system boundary (e.g. corporate group-level), the more likely attributes will be transferred across unrelated facilities and cause attributed claims to represent unrelated production processes and technology routes. How the line is drawn around a producer's operations is critical in understanding how attributes are attributed to products/outputs. By defining what production processes or technology routes are included, system boundaries set clear technological limitations for the volume and impact of low-emissions inputs in production pathways.

These parameters are critical to ensure that mass balanced claims from any given system are reflective of (or can be associated with) specific production processes and must be balanced against producers' need for operational flexibility when linking environmental attributes to their products to justify an investment.

3.2.2 Physical Link Requirement – How closely do the attributes and the physical inputs stay linked?

The **physical link**[3] specifies the degree of physical or system-level connection required between inputs carrying attributes and the outputs to which those attributes are assigned within a given system boundary. Strong physical links, such as shared processing infrastructure, support more credible claims. Weaker links increase the risk that claimed attributes are detached from real production processes. Some sectors set requirements for input attributes to be physically present in attributed outputs, which is not guaranteed for all outputs using mass balance methods.

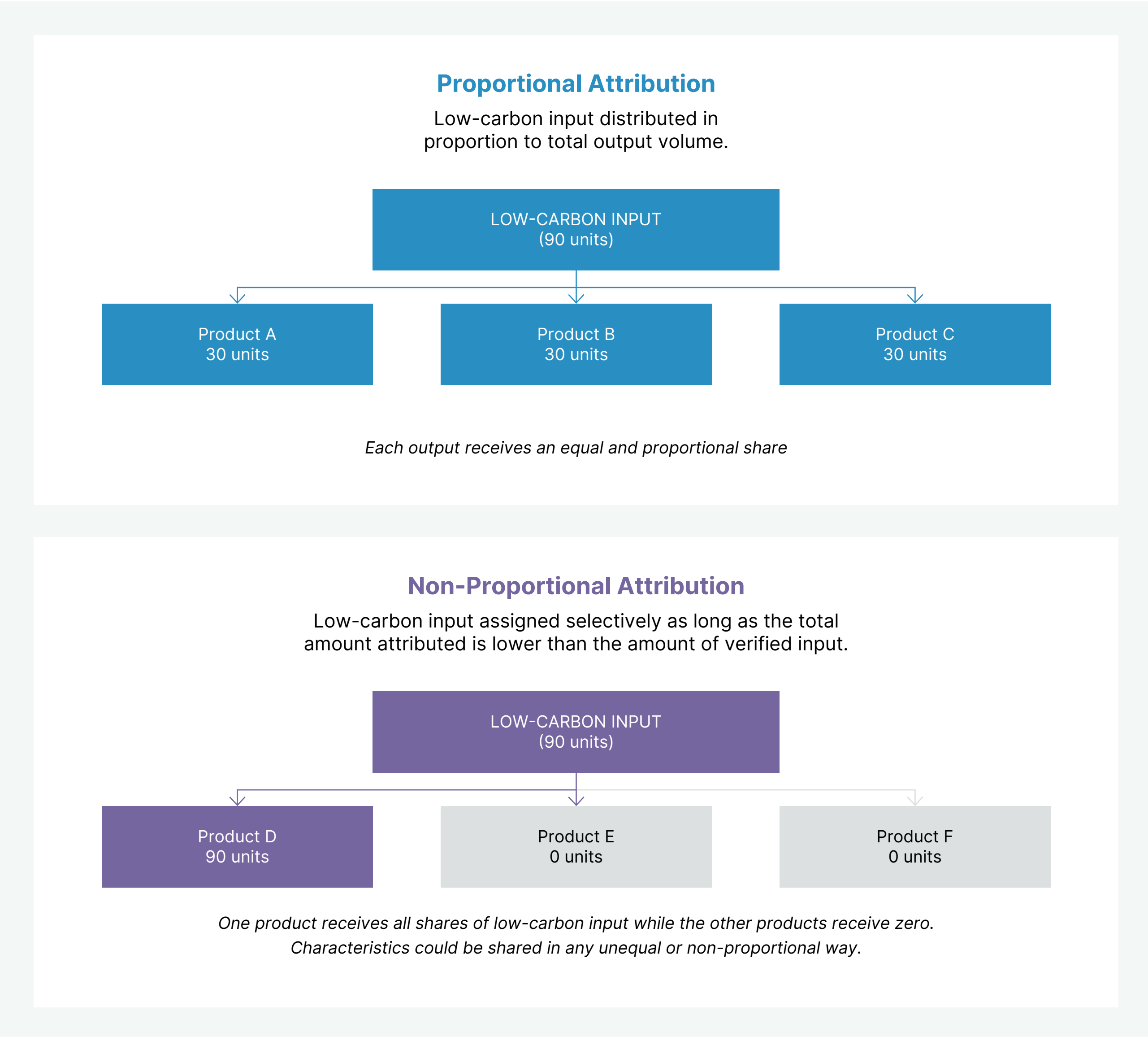


To ensure claims are connected to specific routes and processes, system boundaries should be drawn around a producer's unique operational set-up and asset configuration.

3 Within any mass balance system boundary, there is no guarantee that characteristics of inputs are physically present in all of the outputs; and nor is physical presence always a good metric to evaluate how well product claims are reflective of underlying production processes. Physical presence of attributes in mass balanced materials is currently rewarded by reporting standards like the Greenhouse Gas Protocol.

3.2.3 Attribution Method – How are attributes assigned or re-distributed across outputs?

The attribution method determines how attributes are distributed across outputs when inputs of different characteristics are mixed.



Under **proportional attribution,** attributes are distributed across all outputs in proportion to the share of low-emission inputs entering the system. This means that if 30% of inputs carry a low-emission attribute, then each unit of output carries 30% of that characteristic. This is the more conservative approach and most closely reflects the actual input mix.

Under **non-proportional attribution,** attributes can be concentrated in specific products or output streams rather than distributed evenly, allowing a producer to designate certain outputs as low-emission while others carry no attributes at all. This increases commercial flexibility but also increases the risk that claimed attributes diverge from the physical reality of any given unit of output.

To reduce risks associated with non-proportional attribution, attributes must be:

- linked to a decarbonised technology or input that does or will enable net-zero production,
- interventions stacked within a single production process or system
- systems must be transparent and provide clear traceability of attribute transfer.

Example: Steel Sector

Today, non-proportional attribution of emissions reductions are used in the steel sector to generate “zero-carbon” product claims. These claims are typically attributed to production processes and technology routes that cannot achieve low-emissions performance e.g. energy efficiency improvements, which only require modest investment. Such interventions, regardless of scale, cannot produce a net-zero steel, even at small volume. As a result these “net-zero products” are produced at much lower cost, undercutting truly decarbonised steel; creating inefficiencies in incentives and emissions-linked pricing structures, which threaten to delay investment in deep decarbonisation.

In future, non-proportional attribution could be used to support product claims which are linked to transitionary technologies that could produce net-zero steel, such blending renewable hydrogen into a natural gas DRI production facility. If a facility blends 10% renewable hydrogen with natural gas, then a small portion of the final crude steel produced could be claimed to be net-zero steel. Being able to sell a small volume of steel as net-zero will enable justification for investment in increased blending of renewable hydrogen in the long term. A similar example would be the use of renewable electricity in an EAF facility, via a power purchase agreement (PPA), where renewable electricity could be attributed to create a net-zero steel product.

To ensure that system-level connection is sufficient across mass balance applications and across sectors, attributed claims must be **technically feasible**[4] and only assigned to products within the **system boundary,** or follow **attribution methods** that are accounting for (or based on) physical and technical limitations within that system boundary. When either of these principles are violated, claims are at risk of overstating both intervention impact and additionality, thus potentially misleading product buyers.

Combining these two principles of technical feasibility and physical limitation yield the physically constrained mass balance model, which only allows the selective allocation of attributes onto a single, high-value product line if the physical manufacturing process allow a product to be made that way. For example, an EAF that procures carbon-free electricity to cover 50% of production would be able to attribute the carbon-free electricity attributes in full to 50% of the product because it is not beyond the physical limits of the system to operate using 100% carbon-free electricity, even though the given production run was only supplied with 50% carbon-free electricity.

Additionally, the attributes allocated to end products must be “similar in nature” to those of the original inputs, a concept also known as the ‘like-for-like’ principle. For example, attributing green iron to the iron portion of the output, not scrap, so as to ensure that the final product attributes represent the same charge mix required for those outputs. This is important given the impact of different metallic inputs (virgin iron vs scrap) on steel quality, functionality, and composition. Emissions attributed on the basis of iron/scrap ratios maintain product equivalence.

4 Technical feasibility refers to the possibility that an output could truly be composed of the materials claimed in the attributes. For example, if 25% HEFA SAF is blended into a blending tank with 75% Fossil Jet A, it is technically feasible that both a unit of 100% HEFA SAF or a unit of 25% HEFA SAF/75% Fossil Jet A could flow from that tank.

Example: Cement and Concrete Sector

In the cement sector, a similar issue could arise with carbon capture and storage (CCS) systems designed to capture only a portion of a facility's emissions. For example, a plant equipped with a CCS system that captures 60% of its emissions could use non-proportional allocation to market 60% of its output as "net-zero cement," despite the facility continuing to emit the remaining 40%. Because the capture rate is constrained by the physical capacity of the installed CCS system, achieving deeper emissions reductions would require additional capital investment and infrastructure upgrades. As a result, product-level net-zero claims may obscure the fact that further decarbonisation has not yet occurred and could reduce incentives for the investments needed to achieve it. However, because CCS is a overlayed technology rather than a system input, some argue its eligibility for Mass Balance criteria and suggest it should be assessed separately.

Example: Chemicals Sector

In the chemicals sector, selective product attribution is emerging as a potential approach aiming to boost financial viability while minimising traceability risk. ISCC PLUS reflects an approach they call "free attribution", which allows non-proportional attribution to selected eligible products, subject to guardrails such as chemical connectivity, physical output limits, site-specific mass-balance accounting, and documented operational data. In large chemicals facilities, incremental emissions reduction interventions can require significant capital investment but when the emissions reductions are spread across all end products proportionally, the percent reduction per product is too small to attract the willingness to pay needed to cover the intervention.

Selective product allocation permits the emissions attributes to be allocated into select end product(s), increasing the product's value and ability to cover the investment the intervention required.

For example, if a steam cracker produces ethylene and propylene in equal volumes as end products, and the input intervention allows for 10% emissions reduction when spread across both products, via selective product attribution, the ethylene could instead exhibit 20% emissions reduction while the propylene exhibits 0%. This attribution approach is non-proportional, but the flexibility increase the value of the ethylene allowing it to draw demand and cover the green premium.

3.2.4 Balancing Period – Under what time window are attributes measured and collected?

The implementation method defines how inputs and outputs are matched over time, as described in the next section. The **balancing period** sets the time window over which reconciliation occurs. Shorter periods align more closely with physical production cycles and reduce the risk that attributes generated in one period are claimed against outputs in another. Longer periods are more flexible but can create temporal inconsistencies.

The shorter the balancing period, the more likely a low-emission attribute will be present in a final product, increasing the physical accuracy of the claim. Systems typically operate on a quarterly or annual basis, however, there may be reasons for storing low-emission products over a longer time frame before use in production. A clear risk with multi-year balancing periods is further delays in transitioning to net-zero production, as well as increasing disconnect between physical attribute input and the final product.

As with all design features, clear reasoning for system design coupled with transparency and attribute traceability improves credibility and reduces the likelihood of inaccurate product claims.

Example: Steel Sector

A steel facility that uses a high share of green hydrogen during one production campaign could, under a long balancing period, spread those characteristics across output produced during periods when no green hydrogen was used. Some systems apply vintage restrictions to address this, requiring that characteristics be matched to outputs produced within the same defined window.

Example: Chemical Sector

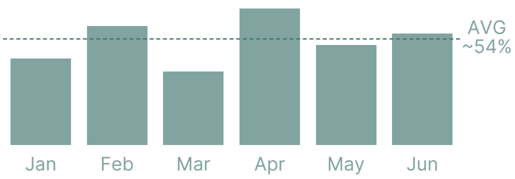
Chemical assets often run continuously or semi-batch, with inventories remaining in tanks for weeks or months, so temporal boundaries are important for linking alternative inputs to claimed outputs. If users choose the rolling average method, ISCC PLUS and SCS-115 require a maximum 3-month balancing period. In practice, the chemical sector commonly uses the more flexible credit method, especially for complex integrated production systems. Under ISCC PLUS, the credit method can still be rigorous when supported by a clearly defined mass balance period, site-specific bookkeeping and calculation, chemical connectivity, documented operational data, and clear rules for credit generation, allocation, attribution, and transfer.

3.2.5 Implementation Method – How are attributes combined and pooled?

The **implementation method** defines how pooled attributes are combined and attributed to outputs within the balancing period. Two implementation methods are commonly used: rolling average accounting and credit ledger accounting.

Rolling Average Method

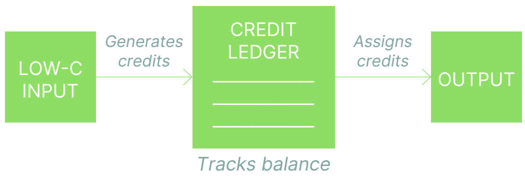
Low-carbon content averaged over period. Each output reflects the average share.



Every output assigned same characteristic regardless of when input arrived

Credit Ledger Method

Inputs generate 'credits.' Credits assigned to outputs. Ledger reconciled at period end.



Input characteristics are pooled and assigned to outputs

Under a **rolling average** method, the attributes associated with eligible inputs are pooled over the balancing period and averaged across all qualifying outputs. Every output produced during the period receives the same proportional share of the pooled attributes, regardless of when individual inputs entered the system.

This method is relatively simple to implement and verify, aligns well with continuous manufacturing processes where materials are physically mixed, and provides a consistent attributed profile across all outputs. From an integrity perspective, credibility depends largely on the length of the balancing period. Shorter averaging periods better reflect production conditions and strengthen the temporal connection between inputs and outputs, while longer periods provide greater operational flexibility but may weaken that connection.

Under a **credit ledger** method, eligible inputs generate a corresponding quantity of attributes that are recorded in an accounting ledger. Rather than averaging these attributes across all outputs, the resulting attributes are attributed to selected qualifying outputs while ensuring that the total quantity of attributed attributes never exceeds the quantity generated by eligible inputs during the balancing period.

This method provides greater commercial flexibility by allowing low-emissions attributes to be directed toward specific customers or products. However, because products may receive different attribute volumes despite being produced within the same system, the approach requires more robust accounting controls. Clear reconciliation rules, transparent recordkeeping, limits on attribute banking where applicable, and independent verification are essential to prevent over-attribution, double counting, or other accounting errors.

When these safeguards are in place, a credit ledger approach can achieve a credible system-level outcome while offering greater flexibility in how attributes are attributed to outputs. However, compared to rolling average methods, credit ledger methods generally present higher risks of misallocation or over-attribution if controls are weak, due to their selective attribution and reliance on detailed accounting.

As a result, they are often better suited to contexts where differentiated product claims or targeted customer demand justify this added complexity, whereas rolling average approaches may be more appropriate for applications prioritising simplicity, uniformity, and ease of verification.

4. System Infrastructure: Designing to Mitigate Trade-offs and Risks

Mass balance design is ultimately an exercise in managing the trade-off between market flexibility and claim accuracy. Flexibility helps producers commercialise partial transition and helps buyers access scarce lower-emission supply. Accuracy reflects ensures the claim remains technically grounded, transparent, and free from overstatement.

These objectives are not inherently conflicting, but they often pull system design in different directions. More flexible approaches can improve usability by expanding supply, reducing operational burden, and helping match nascent demand with limited lower-emission production. However, as flexibility increases, accuracy risks also increase. Claims may become less connected to the production system, less temporally aligned with the underlying intervention, or more dependent on attribution rules that are difficult for buyers to interpret.

The design task is therefore to make flexibility disciplined, which can be managed with the right guardrails. But this requires deliberate design choices, transparent disclosure, and sufficient governance to prevent flexibility from becoming a route to overstatement. The table below maps the most consequential trade-offs in mass balance system design, alongside the practical guardrails that can help manage each one.

Table 2. Trade-offs in mass balance system design

Design trade-off	Market value	Claim risk	Guardrail
Broad input eligibility vs. additionality	Expanded supply and market participation	May monetise business-as-usual activities or existing low-emission attributes.	Define eligible inputs and interventions clearly. Prioritise activities aligned with sectoral transition pathways and require evidence of incremental decarbonisation value.
Wider system boundary vs. physical linkage	Allows suppliers to match buyer demand with decarbonisation activity across sites or assets.	Weakens the link between the claimed product and the production system that generated the attribute.	Use the narrowest practical boundary. Allow multi-site transfer only where there is clear operational, technical, or supply-chain rationale.
Longer balancing period vs. temporal relevance	Accommodates production cycles, inventories, and contract timing.	Creates a mismatch between when attributes are generated and when claims are made.	Set a defined balancing period that reflects sector operations. Limit carryover and require retirement against specific claims.
Non-proportional attribution vs. claim accuracy	Concentrates efforts into premium products or early buyer contracts.	May make selected products appear lower emission than the actual production mix.	Require clear attribution rules, volume caps, no over-attribution, and disclosure that the attribute is re-assigned rather than physically present where applicable.
Product-claim usability vs. accounting conservativeness	Enables use in procurement, product footprints, EPDs, and customer-facing claims.	Higher-value claims create higher risk of double counting or misleading downstream use.	Match claim language to evidence transparency. Distinguish product-linked claims, market-development claims, and inventory claims.

Several observations emerge when these trade-offs are viewed together.

4.1 Trade-offs compound

Design choices should not be assessed in isolation. A system that combines broad input eligibility, group-level boundaries, long balancing periods, and non-proportional attribution is not simply "more flexible." It is operating at the high-usability, high-accuracy-risk end of the spectrum. Stakeholders using the assessment tool should therefore assess the full design package, because overall claim accuracy depends on how these system elements interact.

4.2 Claim ambition should match system design

Not all claims require the same level of discipline. A market-development claim, which signals that a purchase supports demand for an investment in lower-emission production rather than making a product-specific environmental claim, may not require the same design standard as a product-level claim used in a carbon footprint, EPD, or downstream Scope 3 inventory. Accuracy risk increases when claim ambition exceeds the strength of the underlying system design. Where near-zero or net-zero product-level claims are made, the system should be held to a correspondingly higher standard across all key design choices.

4.3 Undisclosed design choices are a red flag

A mass balance claim cannot be meaningfully assessed if the core design choices are not disclosed. At minimum, stakeholders need to understand the system boundary, eligible inputs or interventions, attribution method, balancing period, and claim-use limitations. Opacity should not be treated as a minor disclosure gap. It should be treated as an accuracy risk that warrants heightened scrutiny under the assessment framework.

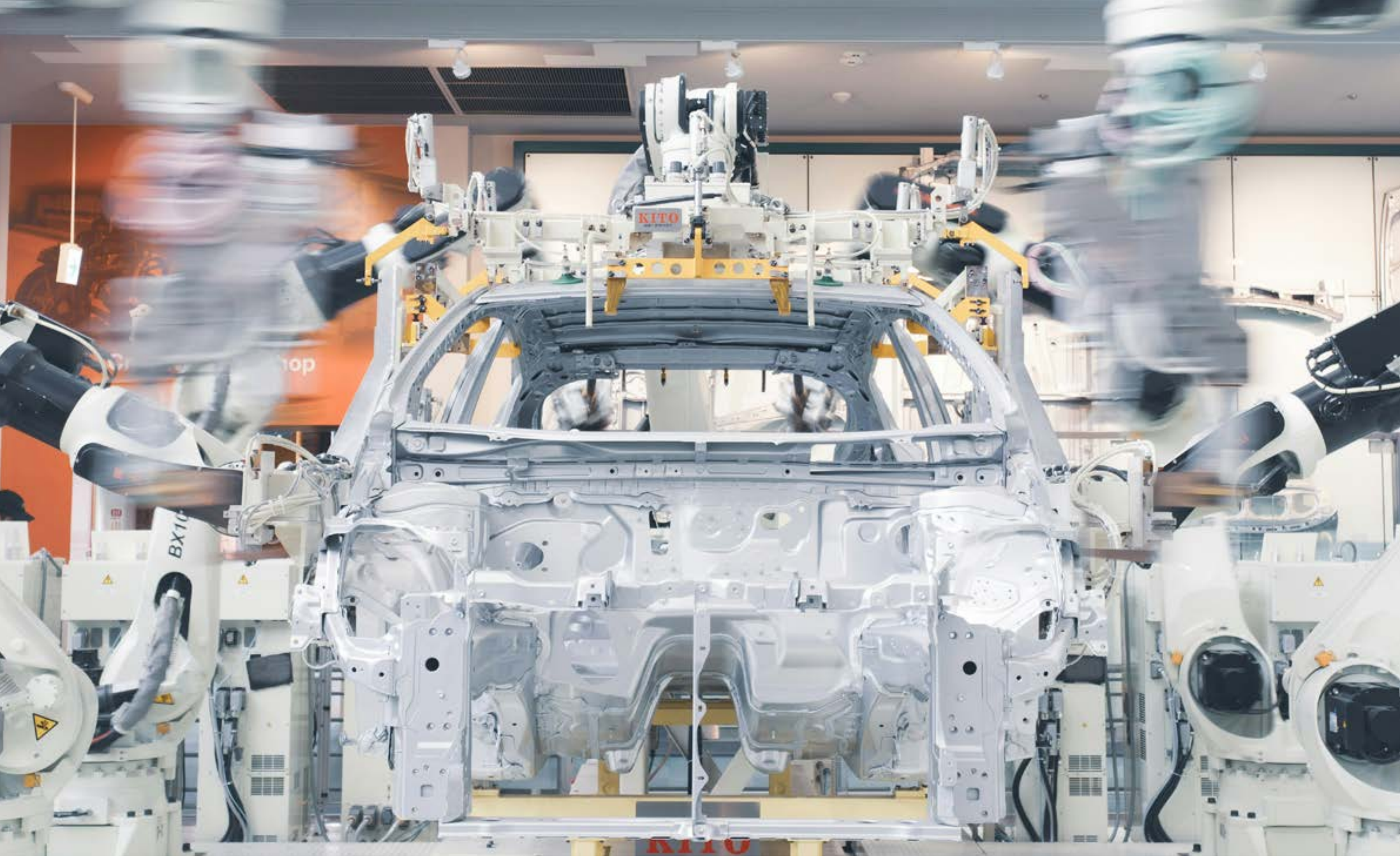
4.4 Structural guardrails outperform disclosure alone

Disclosure is necessary, but it is not sufficient. Strong systems build accuracy into the design itself through physical connectivity requirements, defined eligibility rules, maximum balancing periods, volume caps, stacking prohibitions, and clear retirement rules. Where governance depends mainly on producer disclosure after the fact, claim quality becomes vulnerable to inconsistent interpretation and weak implementation. Durable credibility comes from rules that prevent overclaiming before it occurs.

4.5 Accuracy and usability are more compatible than they appear

The tension between accuracy and usability is real, but it can be managed. Well-designed systems allow flexibility where it supports market formation and impose discipline where flexibility would otherwise weaken claim quality. The goal is not to maximise accuracy at the expense of adoption, or usability at the expense of trust, but design mass balance systems that produce claims buyers can both use and defend.

5. System Design Applied: Mass Balance Today



5.1 Market Confusions

The proliferation of mass balance-based product offerings has created several sources of market confusion. **Unclear definitions** of the term "mass balance" and many system design iterations have made it difficult for buyers to understand the composition of the product they are purchasing and the associated claims they can make via the purchase.

Some "mass balance" models maintain a **strong link to specific physical production** flows. Others pool attributes from a much broader system boundary or stack emissions reductions from multiple sources via a credit-based or carbon bank approach, producing claims that bear little resemblance to the real project composition. Buyers and market participants have no reliable way to know what a mass balance claim represents without detailed knowledge of the system that produced it.

Uncertainty around the link to real decarbonisation impact also weakens confidence in the market. Some mass balance systems are genuinely connected to new or accelerated decarbonisation investment, providing the demand signal and revenue that enables producers to make the transition from conventional to low-emission production. However, others may simply reattribute the impacts of existing interventions, certifying performance that would have occurred regardless, without driving any change in emissions outcomes. This question of additionality is consequential for the real-world impact of mass balance markets, and it is one that clear disclosure practices must adequately address.

Together, these confusions create a trust and adoption roadblock. As previously discussed, balance is not inherently credible or problematic; its value depends on how it is designed. However, today's market lacks a shared language, consistent disclosure norms, and a practical assessment lens that would allow buyers, investors, and policymakers to distinguish credible, impactful, and usable mass balance claims from weak or misleading ones. Without these systems in place, mass balance risks becoming a tool that generates market activity without delivering the decarbonisation outcomes it is intended to support.

5.2 Common "Mass Balance" Approaches

Using the system design terminology introduced in Section 3, this section will outline common mass balance approaches used across industrial sectors today, identify their strengths and risks, and introduce sector-specific applications of these archetypes.

Combinations of these system designs several commonly used mass balance archetypes:

5.2.1 Site-level proportional

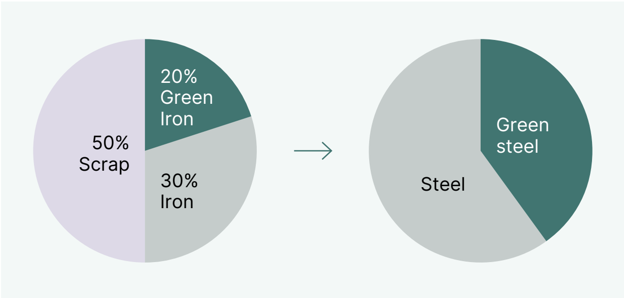
This model assigns attributes proportionally across output volumes within a single site. This archetype requires all the attributes to be spread evenly across outputs. For example, a site that uses 50% low-emission inputs will market all of its products as "50% low-emission" based on the proportion of low-emission inputs. This archetype, in practice, is not frequently used due to its limited claim flexibility as suppliers cannot concentrate verified low-emission attributes into specific products or customers that may be willing to pay a premium for stronger lower-emission claims.

This model is often confused with the controlled blending model, which also attributes attributes proportionally based on verified inputs. The key distinction is that controlled blending maintains a stronger physical relationship between input and output: the claimed attribute is expected to be physically present in each output at the stated proportion. By contrast, mass balance allows materials with different characteristics to be physically mixed while claimed attributes are assigned through auditable bookkeeping, provided that total attributed outputs do not exceed verified inputs over the defined accounting period. This makes proportional mass balance more practical for sectors where inputs are mixed, transformed, or fluctuate over time, and where it is not technically feasible to verify the exact share of the attribute physically present in each final product.

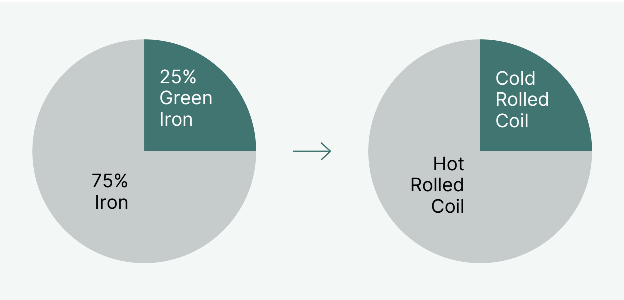
5.2.2 Site-level non-proportional

This model is widely leveraged and tailored by suppliers to capture its site-specific decarbonisation activities and customer needs. Generally, it allows verified attributes generated or introduced within a site to be concentrated into selected product volumes, product lines, or customer contracts rather than distributed evenly across all output. This archetype can take different forms:

- Under a ***physically constrained model,*** attribution is limited to what is physically plausible given the actual input mix used in production. Rather than non-proportionally concentrating attributes to some outputs, claims must reflect the physical reality requirement on the composition and ratio of different input streams entering the production process (e.g., an ore/scrap ratio). Because different feedstocks or production pathways have inherently different physical attributes, a facility cannot claim a higher low-emission attribute percentage than its actual input mix could have theoretically yielded. This model is particularly relevant where a production process draws from multiple input streams with meaningfully different physical properties and where those properties constrain how attributes can flow through outputs. The result is that low-emission attribute claims are bounded not just by the share of verified low-emission inputs but also by what underlying production processes allow.



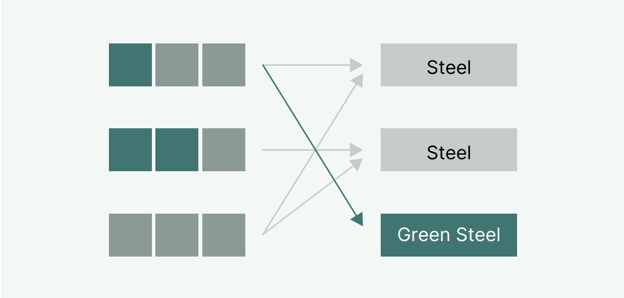
- Under a ***selective product model,*** a producer concentrates all low-emission attributes into a specific, designated product line or customer contract within the same site rather than spreading attributes evenly. This leaves the remaining output with only conventional attributes. The total low-emission attributes claimed across all products cannot exceed verified low-emission inputs, but they are attributed asymmetrically. This allows producers to offer a "fully green" or "zero emission" certified product to customers while simultaneously selling conventional product from the same facility.



- Under a ***selective volume model,*** the principle is similar to selective product attribution; however, attributes are attributed to a portion of total output volume rather than to a named product category. A defined quantity of product output is designated as "fully green" or "zero emission" (up to the limit of verified low-emission inputs) while the remaining output is designated as conventional product. This gives producers flexibility to fulfill contracts by volume without being constrained to specific product types.

5.2.3 Group-level non-proportional

This model pools verified attributes across multiple facilities attribute them selectively to specific product lines, contracts, or production volumes. Individual sites within the group may contribute different types of interventions, such as low-emission inputs, process improvements, renewable energy procurement, or emissions reduction projects, while other sites may contribute no intervention at all. The aggregated attributes are then managed through a centralised accounting pool, sometimes described as a "carbon bank", and assigned to selected final products that may carry an inflated low-emission claim than would be supported by their site-specific production pathway alone. This model offers the greatest flexibility for companies with diversified production portfolios, but it also creates the highest integrity risk.



Across these archetypes, the underlying interventions that give rise to these attributes may also differ substantially. Some are tied directly to a certified physical input (e.g., recycled content, bio-based feedstock, or certified low-emission raw material). Others may be linked to a specific near-zero production technology, a process improvement (e.g., energy efficiency improvement, fuel switching), or an intervention project (e.g., a CCUS project). Some systems may go further still by incorporating offset-like attributes or carbon credits, which can significantly weaken the link between the claimed attributes and actual production activity. The choice of attribute type therefore affects not only what the claim means but how it can be verified and what it can legitimately be used for in downstream accounting.

Deep dive example of mass balance archetypes in the steel sector:

From left to right: decreasing physical linkage and increasing flexibility in attribution

Site-Level Proportional (Uniform)	Site-Level Proportional (Physically constrained)	Site-Level Selective Product	Site-Level Non-Proportional	Group-Level Non-Proportional
Attribute evenly across all eligible output based on the input share.	Proportional attribution within the limits of physical input mix, e.g., share of ore vs scrap.	Attributed to selected product lines within the same site.	Attributed in aggregation within a site to a portion of output.	Stack characteristics across multiple sites and attribute them all into one product line.
Steelmaker blends 50% green iron input + 50% conventional iron input → **All steel output** from the site marketed as green steel made with 50% green iron	With 20% green iron, 30% conventional iron, and 50% scrap → **Steel output may be claimed as 40% green and 60% conventional,** both with 50% scrap content.	Steelmaker using 25% green iron and 75% conventional to produce equal volume of cold rolled and hot rolled steel→ **may attribute all green iron to cold rolled products**	Steelmaker using 50% green iron input and 50% conventional iron input → **50% of steel output are 100% green.**	One site switches to NG DRI, another increases scrap content, another sources green iron and pooling of those **three interventions show in one final product**

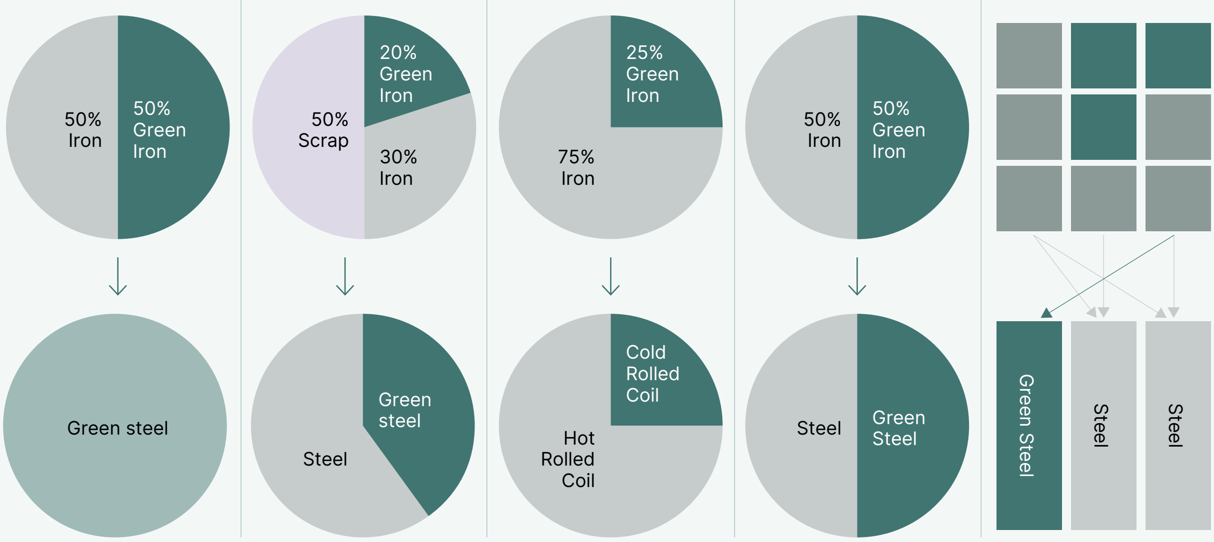


Figure 3: Mass balance archetypes in the steel sector

Site-level proportional model keeps the closest connection to physical production and is often used by the steel facilities that have achieved full-site transition. A close commercial example is ArcelorMittal's XCarb® produced with recycled scrap renewables, which is linked to EAF production using scrap and 100% renewable electricity and averaged to all the steel outputs from a site.

Site-level physically constrained model limits low-emission attribute claims to what the physical input mix can plausibly support. Although there is no close commercial example in the steel sector at this time, a representative example would be a steelmaker operating with a mix of green iron, conventional iron, and scrap where the scrap, as a physically distinct input, cannot be credited with green iron attribute. Low-emission claims are therefore capped at the share of output attributable to green iron inputs, with scrap content preserved as a fixed characteristic across all products.

Site-level selective product model concentrates low-emission attributes into a specific designated product line within a site, leaving remaining output with only conventional attributes. POSCO Greenate certified steel is an example of this application, which pooled carbon emissions reductions from increased use of pellets (higher-quality iron ore) in blast furnaces and increased use of scrap in basic-oxygen furnaces to selected Greenate-certified steel product, while other output from the same site carries no low-emission claim.

Site-level selective volume model attributes low-emission attributes to a defined tonnage of output rather than a named product type, allowing producers to fulfil low-emission contracts by volume. A close commercial example is Tata Steel Zeremis® Recycled, which concentrates increased scrap content attributes (up to 30%) into a designated volume of steel, with the remainder of the site output carrying no recycled content claim.

Group-level non-proportional model pools low-emission attributes across multiple facilities or interventions and attributes them selectively to a specific product or contract. Nippon Steel's NSCarbolex Neutral, which pools CO2 emissions savings across a Nippon Steel's own manufacturing process improvements and decarbonisation projects and save them in a virtual bank and then attributes them to specific products, in accordance with the Japan Iron and Steel Federation (JISF) guidelines for group-level mass balance accounting.

Across these archetypes for application in the steel sector, the composition of attributes itself varies in ways that have integrity implications. They may represent a lower-emission physical input, such as scrap, hydrogen-based direct reduced iron (H2-DRI) or hot briquetted iron (HBI), emissions performance of a near-zero production route, such as EAF production using renewable power, or a verified emissions reduction from a project or process change, such as process efficiency improvements, and carbon captures. These differences determine whether the buyer is receiving a product linked to supporting actual near-zero ironmaking and steelmaking or risking reshuffling existing incremental improvements.

6. Assessment Tool

6.1 Objective and Overarching Design

To help buyers and suppliers navigate market confusions and distinguish credible claims from weaker ones, this section introduces an assessment tool for evaluating different mass balance applications in a streamlined and structured manner. The tool is designed to identify what a specific mass balance-based product system is used in a product claim, where its risks and benefits are concentrated, and what evidence is needed before a claim can be relied upon.

The tool is intended to function as a due diligence instrument. It helps stakeholders engaging with mass balance approaches ask investigative questions systematically, surface the key risks and benefits of a given system, and make more informed procurement, investment, or policy decisions. It is organised around a single overarching question:

Does this mass balance approach support the long-term decarbonisation of this sector?

This question is especially important because mass balance is not a single model. Different variants and design modifications carry very different implications for physical connectivity, emissions attribution, buyers' claims and market integrity. To answer this, the assessment begins with a pre-assessment stage that gathers contextual information about the nature of the claim and the intervention associated with the attributes. It then applies to two core assessment criteria: **Accuracy and Usability.**

6.2 Pre-Assessment

Before applying the two core criteria, users should gather and screen basic information about the mass balance application under review. This stage is diagnostic and not intended to provide a pass/fail judgement. It does not determine whether a system is credible or not, rather it defines what type of system is being assessed, what claim it enables, and where the main integrity risks are likely to sit, establishing the context needed to apply the two criteria appropriately and to identify where closer scrutiny may be warranted.

The pre-assessment should clarify four areas by asking the following questions:

Use case
Whether the mass balance approach is used as a chain-of-custody method to track sustainability attributes through mixed physical supply chains, or as a crediting method in product-level GHG accounting to assign low-emission attributes to selected product volumes in support of low-emission product claims can imply a different level of scrutiny for assessment.

Where the approach is being used as a crediting mechanism, users should apply greater scrutiny under the Accuracy criterion. Crediting-based approaches generally tend to carry higher claim-quality risks because the focus shifts from tracking product flows to assigning attributes, making the robustness of the underlying accounting more consequential.

Key question: *Is mass balance being used to track attributes through mixed physical supply chains, or to assign GHG emission reductions to selected product volumes?*

System boundary
Where the mass balance production system is drawn is a critical indicator as it may be defined at batch, production process, site, multi-site or even corporate group level. This indicates how closely the claim remains connected to actual production flows.

Key question: *Is the mass balance approach operating at the batch, site, or group level?*

Attribution method
How low-emission attributes assigned to outputs within the system significantly indicates the level of claim risk. Proportional attribution generally produces more intuitive and defensible product claims. While selective or non-proportional approaches can support early market demand and partial transition, they also involve stacking and concentrating reductions into a narrow

product volume, risking representing misleading impressions of actual production conditions.

Key question: *Are low-emission attributes distributed proportionally across all outputs, selectively assigned to defined product volumes, or attributed through another methodology?*

Net zero alignment

Most importantly, whether the underlying intervention for generating low-emission attributes is consistent with a credible transition pathway is a critical indicator to distinguish between interventions that represent structural decarbonisation progress and those that deliver incremental efficiency or substitution benefits.

Key question:

- *Is the intervention associated with this mass balance approach aligned to a credible net-zero pathway for the sector?*
- *Is a near-zero or net-zero product-level claim being made on the basis of this mass balance approach?*[5]
- *Is the technology at the site level capable of reducing all of the site's emissions, or only a portion of them?*

6.3 Assessment Criteria

Accuracy: the claims accurately reflect real production, supply, or emissions-reduction activity, are free from overstatement, and are supported by robust underlying data, accounting, and verification.

This criterion examines whether the claims enabled by a mass balance approach are technically grounded and honestly represented. Key questions to guide the assessment on accuracy include:

- Are near-zero or net-zero emissions claims only made possible through the mass balance approach, or would they exist regardless?
- Does the attribution method reflect emissions reductions that are technically feasible given the intervention?
- Is the claim technically feasible at the site level, given actual production conditions and technological capabilities?

These questions matter because the flexibility inherent in mass balance systems, particularly those using non-proportional attribution or broad system boundaries, may enable claims that overstate the emissions benefit actually delivered. Where these broad claims are being made, scrutiny of accuracy should be proportionally more rigorous.

Usability: the involved mass balance approach of the claim is clearly disclosed, consistently applied across products and time, while remaining practical for producers and informative for buyers.

This criterion assesses whether the approach can be understood and applied consistently by market participants. Key questions to guide the assessment on usability include:

- Is the mass balance approach clearly enough disclosed that buyers can understand how the claim was derived?
- Is the approach consistent and easy to replicate over time and across different producers?
- Can it be implemented practically by all parties in the value chain?

Usability matters because even a technically rigorous mass balance system fails in practice if it cannot be communicated clearly, verified independently, or applied consistently. Poor usability also creates conditions for inconsistent market claims that erode buyer trust over time.

5 Where there is a significant gap between what is being claimed at the product level and what the site is actually capable of achieving in emissions terms, users should apply greater due diligence when reviewing both the Accuracy and Usability of the approach. The wider this difference, the more important it becomes to understand the intervention in detail and to scrutinize how the mass balance approach has been used to generate the claim.

6.4 Tool for Decision Making

To facilitate translation of qualitative due diligence checking into a practical decision pathway, this work develops a decision tree tool illustrating how buyers and producers should navigate the framework. They are intended as rough guidance rather than prescriptive instruction. An unclear or negative answer at any stage should prompt further investigation into that dimension, not a definitive conclusion about the overall quality of the approach.

When reviewing a mass balance claim, buyers should begin with the pre-assessment stage to understand the claim architecture: system boundary, attribution method, and the net zero alignment of the underlying intervention. Where there is a significant gap between what is being claimed at the product level and what the site can physically and technically achieve, buyers should apply greater scrutiny throughout the assessment.

Under accuracy, buyers should test whether the claim is technically grounded in what the production system can actually deliver. For near-zero or net-zero claims, buyers should ask whether the claims reflect site-level reality or are primarily created through attribution. They should also assess whether the attribution method, emissions data, and baseline for reduction-based claims would withstand independent scrutiny. Where the accounting basis is unclear or undisclosed, buyers should request additional information before relying on the claim for procurement decisions and downstream reporting.

Under usability, buyers should assess whether the approach is disclosed clearly enough to support their own procurement decision-making, product footprints reporting, environmental product declarations, or customer-facing communications. Where the methodology is opaque, inconsistently applied, or difficult to compare across producers, buyers should seek third-party independent verification or require clearer disclosure before the claim can be used with confidence.

When designing or disclosing a mass balance approach, producers should approach the pre-assessment stage as a disclosure discipline. They should be prepared to clearly communicate the system boundary, attribution method, and the net zero alignment of their intervention, as this information will be foundational for buyer due diligence process and determines whether the claim can be trusted and used in the market.

Under accuracy, producers should satisfy themselves that the claims being made are technically achievable at the site level and that the attribution methodology would withstand independent scrutiny. Where there is a gap between the product-level claim and what the site can physically deliver, producers should be prepared to explain in detail how the mass balance approach was used to generate the claim, what reduction pool or eligible input pool supports it, and what evidence supports it.

Under usability, producers should assess whether their methodology can be communicated clearly explained to buyers and replicated consistently over time. Where it can, publishing the system design including attribution rules supports market trust. Where it cannot be, producers should consider simplifying or more clearly documenting the approach before entering the market with claims.

6.5 From Due Diligence to System Design

The assessment tool described in this section is designed to help stakeholders navigate existing mass balance approaches, identifying where the risks lie, what questions to ask, and what information to require. But due diligence on an existing system is only one part of the picture. The findings from applying this tool across a range of approaches also point toward a set of system design features that consistently distinguish high-accuracy approaches from weaker ones.

Buyer due diligence — mass balance assessment tool

Pre-Assessment: Net Zero Alignment

Use of mass balance
Is this approach being used as a chain-of-custody method or a crediting method to assign low-carbon attributes to products?

System boundary
Is the approach operating at the batch, site, or group level?

Attribution method
How are low-carbon attributes assigned to outputs — proportionally, selectively, or via another defined methodology?

Net zero alignment
Is the intervention aligned to a credible net-zero pathway for the sector?

Product-level claim
Is a near-zero or net-zero product-level claim being made on the basis of this approach?

Site capability
Is the site technology capable of reducing all of the site's emissions, or only a portion?

***Note:** Where a product-level claim significantly exceeds site-level capability, apply heightened scrutiny under both Accuracy and Usability.*

Criterion 1: Accuracy

Claims accurately reflect real production or supply, are free from overstatement, and are supported by robust underlying data and accounting.

- Are the claims technically feasible at the site level given actual production conditions?
- Is the attribution method free from over-crediting — i.e. are no more attributes claimed than are generated by the intervention?
- Where non-proportional attribution is used, is there a clear and justified rationale?
- Is there a risk of double counting within the system or with upstream/downstream claims?
- Is the emissions intensity or reduction based on verified or third-party certified data?
- Is the approach governed by a recognised certification scheme, or is it a proprietary methodology?

Based on the above: are the accuracy-related questions sufficiently answered?

Yes / Likely
Stronger accuracy basis
Proceed — claim can support downstream reporting

Unclear / No
Further investigation recommended
Request further disclosure on attribution and data basis

Criterion 2: Usability

The approach is clearly disclosed, consistently applied across products and time, and practical for all parties in the value chain.

- Is the approach clearly enough disclosed to understand how the claim was derived?
- Is the approach applied consistently across products and producers, or does it vary significantly?
- Can the approach be independently verified or audited?

Based on the above: are the usability-related questions sufficiently answered?

Yes / Likely
Stronger usability basis
Claim is suitable for use in procurement or downstream reporting

Unclear / No
Further investigation recommended
Request clearer disclosure or independent verification before relying on claim

Producer due diligence — mass balance assessment tool

Pre-Assessment: Net Zero Alignment

Use of mass balance
Are you using mass balance as a chain-of-custody method or a crediting method to support green product claims?

System boundary
Is the approach operating at the batch, site, or group level?

Attribution method
How are low-carbon attributes assigned to outputs — proportionally, selectively, or via another defined methodology?

Net zero alignment
Is the intervention aligned to a credible net-zero pathway for the sector?

Product-level claim
Are you making a near-zero or net-zero product-level claim on the basis of this approach?

Site capability
Is the site technology capable of reducing all of the site's emissions, or only a portion?

Note: *Where a product-level claim significantly exceeds site-level capability, apply heightened scrutiny under both Accuracy and Usability.*

↓

Criterion 1: Accuracy

Claims accurately reflect real production or supply, are free from overstatement, and are supported by robust underlying data and accounting.

Are the emissions reductions attributed through this approach technically feasible at the site level?

Is the attribution method free from over-crediting — i.e. are no more attributes claimed than are generated by the intervention?

Where non-proportional attribution is used, is there a clear and justified rationale?

Is there a risk of double counting within the system or with upstream/downstream claims?

Is the emissions data underlying the claim verified or certified by a third party?

Is the approach governed by a recognised certification scheme, or is it a proprietary methodology?

Based on the above: are the accuracy-related questions sufficiently answered?

Yes / Likely
Stronger accuracy basis
Proceed — document evidence and disclose methodology

Unclear / No
Further investigation recommended
Review attribution method and accounting rules before making claims

↓

Criterion 2: Usability

The approach is clearly disclosed, consistently applied across products and time, and practical for all parties in the value chain.

Is your methodology clearly documented and disclosed so buyers can understand how the claim was derived?

Can the methodology be consistently replicated over time and by different producers or sites?

Can the approach be practically implemented by all parties in your value chain?

Based on the above: are the usability-related questions sufficiently answered?

Yes / Likely
Stronger usability basis
Approach is ready for market — seek third-party verification

Unclear / No
Further investigation recommended
Simplify or better document methodology before going to market

7. Conclusion

Mass balance is in the early stages of acting as a decarbonisation tool. Scope 3 reporting is pushing buyers to seek verifiable low-emissions attributes now, but fully segregated supply chains are far from reaching commercial scale. This makes mass balance a practical bridge and outlines the importance of the system design considerations, especially while procurement decisions and disclosure norms are being established.

Mass balance is not a single system, and it is not inherently credible or problematic; its value depends entirely on how it is designed. As both a chain-of-custody method and, increasingly, a mechanism for constructing product-level market claims, mass balance can play a valuable role in accelerating early demand for low-emissions materials in sectors where full physical segregation is not commercially or technically feasible.

At the same time, treating any mass balance label as automatically credible risks legitimising claims that do little more than relabel business-as-usual activity. The assessment tool set out in Section 5 equips buyers, producers, and policymakers with the questions needed to judge whether a specific claim drives tangible decarbonisation and is traceable and defensible.

The market needs clearer, common language to resolve the confusion around what “mass balance” means to allow its use to scale with confidence. A due diligence lens must consider all system design elements and how they interact to assess the accuracy risks that emerge from their combination. The strongest systems are the ones that balance accuracy and usability, and the assessment tool offers a structured way to scrutinise that balance for any given claim.

Where this leaves us today

Buyers are already building mass balance-based claims into procurement, product footprints, and Scope 3 disclosures before the market has agreed on consistent definitions and guardrails. Today, this often means buyers are dependent on supplier claims to inform which products to procure. Therefore, mass balance systems transparency is not only a procurement or disclosure question, but a question of whether climate-linked capital reaches the right projects via targeted procurement efforts. Mass balance can help fund new or accelerated decarbonisation or simply reattribute existing performance. The two are observationally similar to a buyer unless the underlying system design is disclosed and scrutinised. Real-world impact should therefore remain central to evaluating any mass-balance-based claim, as mass balance is a market-enabling tool, not a credibility guarantee.

What is left to do

As standard setters like ISO, SBTi, and GHGp and policy makers work to develop universal and sector-specific standards for mass balance use, suppliers and buyers can send early market signals and pilot system design criteria.

As we’ve seen emerge in other market mechanism systems like book and claim, early purchasing before formal standard publication can serve as proof-of-concept and test market hypotheses before their codification in a formal standard. Buyers can drive market quality and accountability through their purchasing choices. Suppliers have the responsibility of maintaining market trust and enabling success by offering transparent, credible, and catalytic product offerings. Standards setters should observe the impacts of early market purchases to inform standard design decisions and criteria with a critical lens on the balance between accuracy and usability.

Mass balance has the potential to mature considerably without sacrificing the flexibility that makes it useful. Clearer disclosure norms, structural guardrails embedded in system design, and consistent use of a shared assessment framework would allow buyers, producers, and policymakers distinguish credible, catalytic mass balance claims from weaker ones, and let the market scale on the strength of that distinction.

Appendix A: Sector-Specific Mass Balance Analysis

This appendix provides sector-specific analyses of mass balance system design across three key industrial sectors: Fuels (aviation and shipping), Steel, and Cement & Concrete. Each section summarises the sector context, typical design choices, and a comparative table of observed approaches ranging from strongest to weakest physical linkage.

A.1 Fuels (Aviation & Shipping)

Sector Overview

The fuels sector is characterised by highly interconnected infrastructure (pipelines, terminals, and shared storage) that makes physical blending across the system largely unavoidable. Supply chains are geographically distributed and networked, with technical blending constraints for Sustainable Aviation Fuel (SAF) typically in the range of 5–50% depending on pathway and certification scheme.

Typical Mass Balance Design Choices

- System boundary: multi-site / networked (refinery → pipeline → terminal / port)
- Physical link: indirect but continuous
- Attribution method: often non-proportional
- Reconciliation: credit ledger
- Balancing period: monthly to annual
- Transferability: across assets within boundary

As system boundaries expand and transferability increases, fuel mass balance systems tend to migrate from physical mass balance toward partial or full attribute decoupling (book & claim). This spectrum has important implications for the credibility of emissions reduction claims associated with specific flights or voyages.

Fuel Mass Balance Examples

The table below summarises the main chain-of-custody approaches in the fuels sector, from strongest to weakest physical linkage.

Case	System Boundary	Physical Link	Attribution	Reconciliation	Balancing Period	Transferability	Risk Level
Direct physical (Aircraft/ vessel filled with SAF/ SMF)	Aircraft / vessel (point of fuel burn)	Direct	None	Not needed	Immediate	None	Very Low
Site MB (Low-emission fuel into shared tank)	Airport fuel system / port bunkering	Direct	Proportional	Rolling average	Short (monthly)	Within boundary	Low
Network MB (Fuel into pipeline network)	Pipeline / regional fuel network	Indirect	Non-proportional (within boundary)	Credit ledger	Short–medium	Within boundary	Medium
Company-level MB (SAF at one airport, counted for all flights)	Multiple sites under one company	None	Non-proportional (pooled across boundary)	Credit ledger	Medium (quarterly–annually)	Within boundary	High
Selective attribution ('100% SAF/ SMF' flight/ voyage)	Company	None	Non-proportional (extreme selective)	Credit ledger	Medium (quarterly–annually)	Limited	Very High

A.2 Steel

Sector Overview

Steel production routes vary widely in emissions intensity. Emissions depend on scrap content, energy source, and process pathway, with multiple intervention points across the value chain (raw materials, processing, energy inputs). Industry adoption of mass balance is fragmented, and sector-specific chain of custody frameworks remain under development.

Typical Mass Balance Design Choices

- System boundary: mostly site-level or multi-site level
- Attribution: mixed approaches in practice
- Transferability: typically linked to product flows, but increasingly tested beyond them

Steel Mass Balance Examples

The following table maps the main chain-of-custody approaches in the steel sector, from strongest to weakest physical linkage.

Approach	System Boundary	Physical Link	Attribution	Reconciliation	Balancing Period	Transferability	Risk Level
Segregated CoC with formal certification	Site (with verified downstream CoC)	Strong: direct, verified at every stage	None	Physical batch tracking at every stage	Immediate (physical)	None	Minimal: strongest verification regime
Segregated physical production	Product	Strong: low-emission attribute is a physical property of the steel	None	None	Immediate (physical)	None	Minimal: measurement error only
Insetting MB with carbon bank	Site	Strong at site level; varies at product level	Proportional or non-proportional (customer choice)	Carbon bank drawdown (tracked against specific orders)	Short–medium (DNV validates quarterly)	None (site-level credits cannot be independently transferred)	Low to moderate: product claims depend on attribution method rigor
Insetting MB with project-based attribution	Organisational	Strong at project level; weakens at application	Non-proportional (savings attributed to any nominated product)	Project-by-project at origin; credit method at application	Short–medium (third-party assurance required)	None (credits cannot be transferred or sold outside of the organisation)	Moderate: non-proportional attribution creates greenwashing risk
Site-level attribution	Site	Strong where intervention occurred, not guaranteed at product level	Proportional or non-proportional	Rolling average or credit method	Short–medium (audited regularly)	None	Moderate: physical steel delivered is not different from conventional steel
Cross-site pooling / corporate MB	Multi-site / corporate	Weak to none, product receiving certificate may differ from where saving occurred	Non-proportional (pooled, no methodological constraint)	Credit ledger across sites	Medium to long	Internal	High: no physical linkage, disproportionate attribution creates greenwashing risk

A.3 Cement and Concrete

Sector Overview

The cement and concrete sector involves multiple potential intervention points at which mass balance may apply: clinker production, cement blending, or concrete manufacturing. Materials are blended in practice and emissions are closely tied to clinker content, while performance requirements constrain allowable composition changes.

Typical Mass Balance Design Choices

- System boundary: site- or multi-site level
- Attribution: non-proportional or proportional
- Transferability: across sites

Mass balance in this sector tends to remain closely linked to physical material flows. However, where non-proportional attribution is used without constraints tied to technical feasibility, reduction claims may exceed what is physically achievable at a site or technology level.

Cement Mass Balance Examples

The table below maps the main chain-of-custody approaches in the cement and concrete sector, from strongest to weakest physical linkage.

Approach	System Boundary	Physical Link	Attribution	Reconciliation	Balancing Period	Transferability	Risk Level
Direct physical (e.g., CCS stored emissions, SCM clinker-to-cement ratio)	Site or product-level	Strong	None	Not needed	Immediate / batch (can be short–medium in practice)	None	Minimal, measurement error only
Proportional MB (e.g., CCS: annual production emissions ÷ annual CO2 stored, applied to product-level)	Site	Strong	Proportional	Rolling average	Short (monthly–annual)	None	Low, product composition estimated
Selective attribution within site (non-proportional up to technology's decarbonisation potential — e.g., actual capture rate or SCM replacement rate)	Site	Moderate	Non-proportional	Rolling average or credit	Short–medium	None	Moderate, attribution subjectivity; risk of exceeding site-level feasibility
Cross-site pooling / corporate MB (e.g., carbon capture at one plant applied to other facilities; SCM usage pools avoided clinker emissions across multiple plants)	Multi-site / corporate	Weak / none across sites	Non-proportional (pooled)	Credit ledger across sites	Medium–long (corporate optimisation)	Internal (sometimes extended)	High, no physical linkage; high greenwashing risk; may exceed decarbonisation potential

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