MAKING WASTE VISIBLE: MATERIAL FLOW COST ACCOUNTING UNDER ISO 14051 AS THE COSTING SPINE OF CIRCULAR PRODUCTION

Abstract

Conventional cost accounting is designed to establish whether period costs are recovered from sales, not to isolate the cost of material that never becomes a product; material losses are therefore absorbed into production overhead and waste remains financially invisible where it is created. Material Flow Cost Accounting (MFCA), standardised under ISO 14051:2011, extends the cost accounting system by tracing inputs through each quantity centre and separating the cost of positive products from that of negative products. This article sets out the computational structure of MFCA, illustrates it through a quantity-centre matrix, and draws on the documented Nitto Denko implementation to show how visibility of loss cost drives capital allocation. It links MFCA output to BRSR disclosure obligations, examines why adoption has stalled internationally despite positive case evidence, and argues that Cost and Management Accountants are uniquely placed to institutionalise the framework in Indian industry.

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Introduction: Where Waste Hides in the Cost Sheet

Conventional cost accounting was designed to answer a particular question: whether the costs incurred in a period are recovered from sales. It answers that question reliably. It was not designed to establish how much of that cost was spent on material which never became a product, and so it does not (APO, 2014). Materials consumed are recorded, conversion costs absorbed, scrap realisation credited, and a sound cost per unit emerges. Yet the rejected casting, the machining turning, the trimmed edge and the evaporated solvent each carried a full share of purchase price, freight, duty, electricity, labour and depreciation up to the moment of discard, and that expenditure is absorbed into the cost of good output, indistinguishable from value-adding expenditure.

The gap widens where the loss is recyclable. Because such material is reused internally or sold to recyclers, it appears as a credit rather than a loss, and the conversion effort already embedded in it is not separately recognised. Auxiliary materials — solvents, detergents, cleaning water — are commonly managed at equipment level rather than accounted for by product. This is a limitation of the method, not of the practitioner, and it is observed wherever conventional costing is applied.

The distinction matters more now than it once did. Industry 5.0 asks enterprises to build production systems that are sustainable and circular by design, and a circular model cannot be justified to a board

on environmental sentiment alone; it must be justified on cost, which requires the cost of linearity to be measured first. Material Flow Cost Accounting (MFCA) supplies that measurement.

What ISO 14051 Prescribes

MFCA is an environmental management accounting tool developed in Germany in the late 1990s and refined in Japan, where the Ministry of Economy, Trade and Industry supported the first corporate pilots. Japan proposed its standardisation, and ISO/TC 207 developed ISO 14051, published in 2011 (ISO, 2011). ISO 14052:2017 extends the framework across the supply chain; ISO 14053:2021 gives phased implementation guidance for small and medium enterprises.

The framework rests on four fundamental elements: the quantity centre, the material balance, cost calculation, and the material flow model (APO, 2014). A quantity centre is a process, group of processes or storage point at which inputs and outputs are quantified, so that losses are located, not merely totalled. The material balance requires that mass entering a quantity centre equal mass leaving it, adjusted for inventory change; physical reconciliation precedes monetary analysis. Output is then divided into positive products and negative products — losses in every form: scrap, rejects, effluent, emissions and evaporation. The term "negative product" rather than "waste" is deliberate: it requires losses to be costed in exactly the manner products are costed.

Four cost categories are traced: material, energy, system (labour, depreciation, maintenance, transport) and waste management. The first three are allocated across both positive and negative products; waste management cost attaches wholly to the negative product.

The Computational Core

For each quantity centre, the material balance is stated as:

$$\Sigma \text{ Material Inputs} = \Sigma \text{ Positive Products} + \Sigma \text{ Negative Products} \pm \Delta \text{ Inventory}$$

The allocation basis is the material distribution percentage — the share of input mass emerging as intended output, taken here as a ratio:

$$\alpha = \text{Mass of positive product} \div \text{Total mass of material input}$$

The cost carried by material losses at a quantity centre is then:

$$\text{Negative product cost} = (MC + EC + SC) \times (1 - \alpha) + WMC$$

where MC, EC, SC and WMC denote material, energy, system and waste management cost. Where these are captured only facility-wide, they are first apportioned to quantity centres on a defensible driver — machine hours, operating time or man-hours — then allocated to outputs (APO, 2014).

An Illustrative Quantity-Centre Analysis

Consider a precision auto-component machining unit consuming 100 MT of alloy steel bar in a month at ₹65,000 per MT. Output is 78 MT of finished components; 22 MT leaves as turnings, offcuts and rejects. Energy cost is ₹8.00 lakh, system cost ₹22.00 lakh and waste handling ₹1.50 lakh. Scrap realises ₹18,000 per MT. ISO 14051 presents the outcome as a material flow cost matrix.

Table 1: Material Flow Cost Matrix for the Quantity Centre (one month, ₹)

Cost	Material	Energy	System	Waste mgmt.	Total
Positive product (78 MT)	50,70,000	6,24,000	17,16,000	—	74,10,000
Negative product (22 MT)	14,30,000	1,76,000	4,84,000	1,50,000	22,40,000
Total	**65,00,000**	**8,00,000**	**22,00,000**	**1,50,000**	**96,50,000**
Negative product share	**22.0%**	**22.0%**	**22.0%**	**100.0%**	**23.2%**

Note: Material, energy and system costs allocated on the material distribution percentage (α = 0.78); waste management cost assigned wholly to the negative product, per ISO 14051. Figures are indicative and constructed for illustration.

The unit's costing system correctly reports a cost of production of ₹1,18,641 per MT after crediting scrap realisation. MFCA offers a second reading of the same data: ₹22.40 lakh — 23.2 per cent of period

cost — was spent on material that did not become a product, against a scrap recovery of ₹3.96 lakh. The unrecovered element is ₹18.44 lakh a month, or ₹2.21 crore a year, presently absorbed within the cost per tonne rather than presented as a figure to be managed. The cost attributable to the positive product alone is ₹95,000 per MT. Neither number is wrong; they answer different questions.

From Loss Visibility to Capital Allocation

Industry 5.0 treats sustainability as a design parameter rather than a compliance overlay. The difficulty is that circular interventions — near-net-shape forming, closed-loop scrap recovery, remanufacturing, design for disassembly — require capital and compete against conventional projects at the same hurdle rate. They lose that contest when benefits are stated in tonnes of waste avoided while costs are stated in rupees.

The documented implementation at Nitto Denko Corporation, Japan's first ministry-supported MFCA adopter, shows how the asymmetry is resolved. Examining an adhesive-tape line at its Toyohashi plant across five quantity centres, Nitto found positive products accounted for 67.17 per cent of period cost and negative products for 32.83 per cent. Its conventional accounts reported a single cost of sales; the material flow profit-and-loss statement showed an identical operating profit but carried the cost of negative products separately. Nothing in the financial statements changed — everything in the management statement did. On the strength of that visibility, the company committed a further ¥700 million of capital investment and lifted the positive-product share from 67 to 78 per cent within three years (APO, 2014).

The same discipline applies to the illustration above, provided the ₹22.40 lakh is read correctly. Material cost and waste handling of ₹15.80 lakh are directly avoidable, though eliminating the loss also forgoes ₹3.96 lakh of scrap realisation, leaving ₹11.84 lakh of net cash benefit. The remaining ₹6.60 lakh of energy and system cost does not disappear when yield improves; it reattaches to the positive product and is recovered only to the extent that released capacity produces saleable output.

The Indian Regulatory Pull

Until recently MFCA in India lacked an external driver. That has changed. SEBI's Business Responsibility and Sustainability Reporting framework (SEBI, 2021), mandatory for the top 1,000 listed entities from FY 2022-23, requires quantified disclosure of waste generated by category, waste recovered through recycling and reuse, and waste disposed, under Principle 6 of the National Guidelines on Responsible Business Conduct. BRSR Core extends assurance to a defined subset of these indicators (SEBI, 2023). Extended Producer Responsibility obligations under the plastic, e-waste and battery waste rules separately require producers to trace material flows to the recycler.

Each demands precisely what MFCA generates: a reconciled physical material balance at process level. In many entities these figures are assembled from environment and safety records kept for another purpose, so the disclosure is satisfied but the data is not tied to the cost records. An MFCA system built once serves both ends, yielding the physical quantities BRSR demands and the monetary analysis the board needs from one reconciled dataset.

Why MFCA Has Stalled — and How Not to Repeat It

The international record carries a warning. Christ and Burritt (2016) assess MFCA against Rogers' diffusion of innovation framework and find it well placed on the attributes that ordinarily drive adoption — relative advantage, compatibility, low complexity and trialability — yet take-up has remained slow. A Japanese survey they cite found that while roughly three-quarters of responding companies knew of MFCA, only about one in fifteen had implemented it even partially. Knowledge is not adoption, and a later survey of 27 adopting Japanese firms found a significant number discontinued after a short period (Kitada et al., 2022).

Two failure modes emerge, both avoidable. The first is positioning. MFCA is frequently run as a one-off diagnostic, produces a report, and is never embedded in the routine reporting cycle; when the project team disperses, so does the practice. The remedy is to place MFCA output in the monthly cost report operating management is accountable for, and to assign ownership to the costing function.

The second is pilot selection. ISO 14051 advises beginning with processes carrying significant environmental and economic impact, but presumes

the organisation can identify them — a presumption research has shown to be unreliable (Christ and Burritt, 2016). A pilot placed on a low-loss process returns an unimpressive result and can prompt abandonment of a technique that would work well elsewhere. Selection should follow a preliminary material balance rather than intuition.

The CMA's Mandate

Little of this is unfamiliar territory. Quantity centres are cost centres reconstructed around material flow; material balance is yield and rejection analysis raised to a reconciliation standard; cost allocation is the daily work of the profession. MFCA is best understood as an extension of the cost accounting system rather than a replacement for it (Christ and Burritt, 2016), and here Indian industry begins from an unusually strong position. The statutory cost records maintained under the Companies (Cost Records and Audit) Rules, 2014 already capture consumption, yields and rejections at process level — data enterprises in most jurisdictions would have to build from nothing. What remains to be added is the quantity-centre architecture and the allocation to negative products.

Implementation is transdisciplinary, drawing on operational, technical, quality-control, environmental and accounting expertise (APO, 2014). The Cost and Management Accountant is the natural convenor — the one member holding process-level data, allocation discipline and standing with operating management.

The professional opportunity is largely unclaimed. Published MFCA work remains dominated by Japanese, European and South-East Asian cases; Indian evidence is confined largely to enterprise-level studies such as the application documented in a steel pipes and tubes SME (Sahu et al., 2021). For members in practice, MFCA is a definable advisory service with a measurable deliverable; for members in industry, it converts a sustainability commitment into a capital allocation argument that survives scrutiny.

Conclusion

Circular production will not be achieved through targets. It will be achieved when the cost of not being circular appears, in rupees, in a statement for which operating management is accountable. ISO 14051 supplies the framework, ISO 14052 and ISO 14053 the routes to supply-chain and SME application, and none demands certification. The technique is disciplined material accounting, applied to the flows conventional costing was never built to see.

For Indian manufacturing, entering an Industry 5.0 decade under tightening disclosure obligations, the question is no longer whether waste carries a cost. It is how that cost is to be measured, and by whom. The profession best placed to answer already holds the cost sheet. MA

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