ADDING VALUE THROUGH SOLVENT RECOVERY REPORTING: THE EXPANDING ROLE OF COST AND MANAGEMENT ACCOUNTANTS IN INDIA'S CHEMICAL AND PHARMACEUTICAL INDUSTRY

Abstract

Solvent recovery in India's chemical and pharmaceutical sector is routinely characterised as an engineering and environmental compliance challenge. This article argues that it is, equally and perhaps more consequentially, a cost-accounting problem — and that Cost and Management Accountants (CMAs) are uniquely equipped to address the measurement, attribution, and reporting deficiencies that allow substantial recoverable value to remain invisible. Drawing on Central Pollution Control Board (CPCB) regulatory benchmarks, technology-provider data, and field observations from Indian active pharmaceutical ingredient (API) manufacturing clusters, this article identifies four distinct solvent-loss pools, analyses recovery economics across major industrial solvents, and delineates the specific reporting interventions through which CMAs generate measurable financial value. A structured case study from a Gujarat-based pharmaceutical manufacturer demonstrates that extending conventional material reconciliation to upstream solvent inputs revealed controllable losses amounting to Rs 1.60 crore annually — entirely invisible under conventional reporting. Four CMA intervention categories — measurement, attribution, benchmarking, and decision support — are presented with implementable frameworks. The article concludes with five sector-level policy initiatives through which the Institute of Cost Accountants of India (ICMAI) can institutionalise solvent recovery costing as a recognised professional domain, advancing both corporate profitability and national sustainability objectives.

CMA Ashwin G. Dalwadi
Council Member &
Former President, ICMAI
Ahmedabad
agdandco@gmail.com

The Solvent Landscape and Why It Matters

A solvent is a substance — ordinarily a liquid — that dissolves a solute to form a solution. In industrial chemistry, solvents constitute the medium within which reactions are conducted, crystals precipitated, products washed, and extractions performed. They are, in the truest sense, the vehicle of chemistry rather than its destination. Yet the financial and environmental stakes attached to their management are extraordinary.[1]

India’s chemical and pharmaceutical sector consumes solvents at a scale that is easily underestimated. In active pharmaceutical ingredient (API) manufacture, solvents typically represent 80–90% of the non-aqueous mass of a process and 60–70% of the resulting waste stream (Constable et al., 2007). Comparable profiles characterise paints, agrochemicals, adhesives, and specialty chemicals, albeit with differing solvent palettes. The aggregate implication is significant: of the 5–6 million tonnes of major organic chemicals processed through Indian chemical and pharmaceutical plants annually, an estimated 1.5–2 million tonnes function as reaction solvents.

India remains heavily import-dependent for high-value solvents — methanol, dimethylformamide (DMF), N-methyl-2-pyrrolidone (NMP), tetrahydrofuran (THF), and acetonitrile. Recovery of these solvents compresses the import bill, creating a national-policy dimension that reinforces the company-level cost argument. A 1% improvement in industry-wide recovery yield would alone liberate solvent worth several thousand crore rupees.

From a cost-accounting standpoint, four parameters determine recovery economics: (a) unit price of the solvent, (b) volatility governing handling and storage loss, (c) boiling point governing recovery energy cost, and (d) azeotrope formation determining recovery complexity. Taken together with feed contamination levels, these parameters define the recovery cost per kilogram and, therefore, the business case.

Why Solvents Are Lost — and the Cost of Losing Them

A kilogram of solvent charged to a reactor does not invariably translate into a kilogram available for the next batch. Between these two reference points lies a cascade of losses that are, in most Indian plants, systematically unmeasured.

1. The Four Loss Pools

Solvent losses concentrate in four identifiable pools with distinct characteristics and remediation profiles:

- Production-stage handling losses arise from evaporation during reactor charging, breather-valve venting, transfer spillage, scrubber and carbon-bed losses, and dryer carry-over. These typically account for 3–6% of the solvent charged per batch and, despite their materiality, rarely appear as distinct line items in batch manufacturing records.
- Storage losses accumulate through tank breathing from diurnal temperature cycles, drum-handling shrinkage, evaporation from partly-filled vessels, and occasional pilferage. Fixed-roof tanks without vapour recovery are particularly susceptible, and aggregate losses typically reach 1–4% of held inventory per annum.
- Spillage and housekeeping losses are individually small — drip-pan accumulations, hose residues, cleaning solvents not segregated for recovery — but aggregate to 0.5–2% and are almost universally absorbed into 'normal loss' without further analysis.
- Recovery-plant losses arise from column venting, still bottoms, azeotrope losses, and entrainer carry-over, typically representing 5–10% of the spent feed. Unlike the three upstream pools, this pool is routinely measured and reported.

Figure 1 presents a conceptual flow of solvent through the manufacturing process, identifying the points at which each loss category occurs.

Figure 1

Solvent Loss Pathways in API Manufacturing

FRESH SOLVENT PURCHASED

↓

STORAGE LOSSES

Tank breathing • Drum handling • Evaporation • Pilferage

(Typical: 1–4% of inventory p.a.)

↓

PRODUCTION-STAGE HANDLING LOSSES

Reactor charging • Venting • Transfer spillage • Scrubber losses

(Typical: 3–6% per batch)

↓

SOLVENT CHARGED TO PROCESS

↓

SPENT SOLVENT TO RECOVERY PLANT

↓

RECOVERY-PLANT LOSSES
Column venting • Still bottoms • Azeotropes • Unrecovered fraction *(Typical: 5–10% of spent feed)* *[This pool is routinely measured; the two upstream pools are not]*
↓
RECOVERED SOLVENT RETURNED TO STOCK

Note. Yellow-shaded rows represent controllable loss points typically absent from conventional cost-accounting systems. Green-shaded rows represent tracked inventory positions. The figure illustrates why plant-level recovery-plant yields (routinely measured) systematically overstate true enterprise-level solvent recovery.

2. The Financial Magnitude of Unreported Losses

Consider a mid-sized API plant consuming 1,000 MT of toluene per annum at Rs 85/kg. A 95% recovery-plant yield — the CPCB benchmark (Central Pollution Control Board [CPCB], n.d.) — appears commendable: 950 MT recovered, Rs 8.08 crore saved. However, this yield measures performance on the spent stream that reaches the recovery plant, not on the solvent originally purchased. If 5% is lost to handling and 2% to storage upstream, true overall recovery is approximately 88% — a shortfall worth Rs 1 crore that is entirely invisible in conventional reporting.

The consequences extend beyond procurement cost. Each kilogram lost represents: (a) a fire and explosion hazard entailing insurance obligations; (b) a fugitive emission liability under the Air (Prevention and Control of Pollution) Act, 1981; (c) an occupational health exposure for chlorinated or reprotoxic solvents; and (d) for listed pharmaceutical companies, an under-reported Scope 1 or Scope 3 emission under the Securities and Exchange Board of India (SEBI) Business Responsibility and Sustainability Report (BRSR) framework (SEBI, 2023). As independent BRSR audits intensify, unmeasured solvent losses increasingly expose companies to greenwashing risk.

Benchmarking Solvent Recovery — Yield, Purity, and Cost

A defensible business case rests on three benchmarks: physical recovery performance, cost per kilogram of recovered solvent, and regulatory compliance.

1. Physical Recovery Benchmarks

The headline Indian regulatory benchmark derives from the CPCB Draft Guidelines for the Pharmaceutical Industry, which prescribe a minimum 95% captive recovery of spent solvent with cumulative annual losses not exceeding 5% of inventory (CPCB, n.d.). The CPCB Standard Operating Procedure for Spent Solvent Utilisation (CPCB, 2016) establishes technical parameters: fractional distillation with single or two-stage cooling, residual Total Organic Carbon below 20 ppm, and quarterly NABL-accredited monitoring.

Internationally, the U.S. Environmental Protection Agency's Resource Conservation and Recovery Act (RCRA) reclamation exemption requires ≥ 95% recovery to avoid a 'sham recycling' classification (U.S. Environmental Protection Agency, n.d.), while the EU Industrial Emissions Directive (European Union, 2010) imposes VOC limits of 20–50 mg-C/Nm³ that functionally mandate condensation-based recovery. These converging benchmarks establish 95% as the effective global standard.

Table 1 presents achievable recovery yields, purities, and indicative operating costs across major Indian industrial solvents.

Table 1

Physical Recovery and Cost Benchmarks by Solvent

Solvent	Recovery Yield	Achievable Purity	Indicative Opex (Rs/kg)
Methanol	92–97%	≥ 99.5 wt%	5–7
Toluene	90–95%	≥ 99.5 wt%	8–10
Acetone	90–95%	≥ 99.5 wt%	6–8
Ethyl Acetate	85–92%	≥ 99 wt%	7–9
IPA	88–93%	≥ 99.5% (dry)	12–15
MDC (DCM)	85–92%	≥ 99 wt%	7–9
THF	93–95%	≥ 99.8 wt%	13–16

DMF	85–92%	≥ 99 wt%	15–18
NMP	85–92%	≥ 99 wt%	17–20
Acetonitrile	90–95%	≥ 99.5 wt%	15–18

Note. IPA = isopropyl alcohol; MDC = methylene dichloride; THF = tetrahydrofuran; DMF = dimethylformamide; NMP = N-methyl-2-pyrrolidone. Opex benchmarks assume Indian industrial tariffs of Rs 3.0/kg steam and Rs 8.5/kWh electricity, excluding capital amortisation.

2. The Economics of Recovery

Recovery operating expenditure is driven by steam consumption (1–4 kg/kg solvent), electricity and chilled water, and fixed overheads. A practical decision rule emerges from the cost structure: where recovery opex remains below 20% of fresh-solvent price, captive recovery delivers unambiguous positive economics. Every major solvent in Indian manufacturing comfortably satisfies this threshold.

Azeotrope-forming solvents — IPA, THF, acetonitrile — command a 60–100% cost premium over non-azeotropic peers, necessitating entrainers, molecular sieves, or pervaporation membranes. Even so, the economics of recovery remain compelling given the high absolute prices of these solvents.

The CMA Reporting Framework: Four Categories of Intervention

The CMA's contribution to solvent recovery costing organises logically into four categories — measurement, attribution, benchmarking, and decision support — each addressing a specific information gap that currently impedes sound management decisions.

1. Measurement — Extending the Material Reconciliation

The first and foundational intervention is to measure what is currently unmeasured. A monthly solvent-reconciliation report, closed at period-end, converts solvent loss from an engineering abstraction into a profit-and-loss line item. The statutory basis for this discipline is well-established: Section 148 of the Companies Act, 2013, read with the Companies (Cost Records and Audit) Rules, 2014, already mandates material reconciliation for specified industries including pharmaceuticals and bulk drugs. Extending this framework to solvent inputs requires no new regulatory authority — only disciplined application of existing cost-accounting tools.

Table 2 presents the recommended reconciliation template with sourcing protocols.

Table 2

Monthly Solvent Reconciliation Report — Template Structure

#	Reconciliation Line Item	Source Document / System	Reporting Purpose
1	Opening stock (drums, bulk tanks, in-process)	Stores inventory ledger; tank-dip records	Establishes period baseline
2	Fresh solvent purchases (quantity & unit value)	Vendor invoices; Goods Receipt Notes (GRN)	Validates purchase ledger and unit cost
3	Recovered solvent returned to stock	Recovery-plant daily log; QA release report	Captures internal recycle for net-cost calculation
4	Solvent charged to each batch / product	Batch Manufacturing Record (BMR)	Links consumption to costed output
5	Spent solvent dispatched to recovery plant	Internal transfer slips; tank-farm log	Separates recoverable stream from disposal
6	Spent solvent sent to hazardous-waste disposal	HW Manifest / Form 10 (HW Rules, 2016)	Reconciles physical flows to statutory disposal records
7	Closing stock	Period-end physical count	Closes the reconciliation

8	Residual loss — split by category (handling / storage / unaccounted)	Computed from items 1–7	Quantifies controllable loss for management action

Note. GRN = Goods Receipt Note; QA = Quality Assurance; BMR = Batch Manufacturing Record; HW = Hazardous Waste. Item 8 should decompose losses into handling, storage, and unaccounted categories to enable targeted remediation. For multi-solvent facilities, apply the framework per solvent or per solvent group depending on financial materiality.

2. Attribution — Activity-Based Costing of Recovered Solvent

The second intervention produces a defensible cost per kilogram of recovered solvent by attributing steam, electricity, cooling water, labour, maintenance, and capital amortisation to each solvent stream processed by the recovery plant. Without Activity-Based Costing (ABC), low-value solvents subsidise high-value ones, distorting decisions on stream prioritisation, capacity expansion, and the captive-versus-CSRP (Common Solvent Recovery Plant) choice. The corrected attribution typically reveals that methanol recovery, despite low absolute cost, may be economically marginal when capacity is constrained — a finding invisible without per-stream cost accounting.

3. Benchmarking — Translating Gaps into Rupees

The third intervention compares actual performance against regulatory (CPCB 95% floor), technical (technology-provider data), and cost benchmarks. The CMA's distinctive value lies in translating percentage gaps into rupee consequences: a recovery yield of 88% against a 95% benchmark, on 1,000 MT/year of toluene at Rs 85/kg, represents Rs 59.5 lakh of avoidable annual loss. Presented alongside the benchmark source and gap analysis, this figure changes management behaviour in ways that a percentage variance column cannot.

4. Decision Support — Capex, Make-or-Buy, and Scenario Analysis

The fourth category constitutes traditional CMA territory: capital expenditure appraisal for recovery investments, make-or-buy analysis comparing captive recovery against CSRP utilisation, and scenario analysis across solvent price trajectories, steam tariff changes, and regulatory transitions. These analyses determine whether sustainability investments survive budget reviews and reach board approval. The CMA who can present a robust payback model for a vapour-recovery system, anchored to reconciliation-derived loss data, occupies an indispensable role in the decision architecture.

Case Study — ABC Industries Ltd

1. Context and Presenting Problem

ABC Industries Ltd is a 120-reactor API facility manufacturing cardiovascular and anti-diabetic intermediates, with annual solvent consumption dominated by toluene (35% by mass), methanol (22%), and ethyl acetate (18%). The plant operated a captive three-column distillation unit consistently reporting 94–95% yield, ostensibly meeting CPCB benchmarks.

Management commissioned a CMA-led intervention in January 2024 after observing a persistent paradox: the recovery plant performed within specification, yet fresh solvent procurement showed no corresponding decline across successive years despite stable production volumes. This disconnection pointed to unmeasured losses upstream of the recovery plant.

2. Baseline Measurement and Findings

Over a three-month pilot (Q1 2024), the CMA team implemented a stagewise material reconciliation tracking each solvent through eight control points (aligned with the template in Table 2). The baseline revealed a striking pattern: while recovery-plant yield held at 94–95%, overall enterprise-level solvent yields were materially lower — approximately 88% combined. The 115 MT quarterly shortfall, valued at Rs 79 lakh, was entirely invisible in prior reporting. Table 3 summarises performance across the intervention period.

Table 3

Pharmatech Industries — Performance Before and After CMA-Led Intervention

Performance Metric	Baseline (Q1 2024)	Post-Procedural Changes (Q2 2024)	Post-Capex (Q4 2024)
Overall solvent yield (%)	87.6	91.3	93.8
Storage losses (% of throughput)	2.8	2.2	0.9
Handling losses (% of throughput)	4.8	2.1	1.8
Segregation to HW disposal (%)	18.0	8.2	6.5
Recovery-plant yield (%)	95.1	95.4	95.6
Quarterly unaccounted loss (MT)	115	79	57
Quarterly financial impact (Rs Cr)	0.79	0.54	0.39
Annualised savings vs baseline (Rs Cr)	—	1.00	1.60

Note. Q1 2024 = Baseline (January–March). Q2 2024 = Post-procedural changes only (April–June); zero capital required. Q4 2024 = Full implementation including nitrogen blanketing and vapour recovery systems, approved capex Rs 42 lakh (October–December). HW = hazardous waste. Storage and handling losses expressed as percentage of quarterly solvent throughput.

3. Causal Analysis

Investigation identified four loss mechanisms. First, fixed-roof bulk storage tanks exhibited breathing losses of approximately 2.8% per quarter, absorbed into 'evaporation loss' without quantification. Second, open reactor charging generated visible vapour clouds estimated at 4.2% loss per batch, economically unjustifiable without measurement data. Third, drum reconciliation revealed 3.7% shrinkage attributable to incomplete evacuation and transfer-hose retention. Fourth, 18% of solvent-laden waste streams — wash solvents, drip-pan accumulations — were routed to hazardous-waste disposal rather than recovery, representing 12 MT of recoverable solvent incinerated per quarter.

4. Intervention Results and Transferable Insights

Procedural changes alone — drum handling protocols, reactor charging discipline, segregation SOPs — captured approximately 60% of total improvement opportunity at zero capital cost, delivering Rs 1.00 crore annualised savings by Q2 2024. Targeted capex of Rs 42 lakh (nitrogen blanketing, vapour recovery) captured the residual opportunity, sustaining Rs 1.60 crore annualised savings by Q4 2024 against annual measurement infrastructure cost of Rs 8–10 lakh — a 16:1 benefit-cost ratio.

Three generalisable principles emerge: (a) the largest opportunity resides in measurement itself — making visible what is currently invisible; (b) approximately 60% of improvement potential requires discipline rather than capital, directly challenging the engineering-centric framing of solvent recovery; and (c) the CMA's contribution lies in extending familiar tools — material reconciliation, variance analysis, ABC — into a domain that has historically resisted financial discipline.

The Policy Dimension — A Professional Opportunity for ICMAI

The CMA profession faces a collective opportunity to shape how solvent recovery is costed and reported across India's chemical sector. ICMAI is well-positioned to lead five specific initiatives.

First, a **Sectoral Guidance Note on Solvent Recovery Costing,** standardising cost-sheet format, overhead absorption rules, and scrap/by-product treatment on the model of existing ICMAI guidance notes for sugar and fertiliser industries (Institute of Cost Accountants of India [ICMAI], n.d.), would eliminate current fragmentation in reporting practices and establish a common professional standard.

Second, **mandatory disclosure of spent-solvent quantity, recovered quantity, and loss percentage as separate line items in Cost Audit Report Form CRA-3** (Government of India, 2014), rather than their present absorption into 'other materials', would create sector-wide visibility and inter-firm comparability for the first time.

Third, a **Joint CPCB–ICMAI Sectoral Dashboard** combining physical recovery percentages from pollution-control disclosures with Rs/kg cost data from cost accounts — anonymised at plant level but published at sector level — would provide empirical foundations for evidence-based regulatory policy and practitioner benchmarking.

Fourth, a **Cost-of-Compliance Study** quantifying the Rs/kg impact of moving from 85% to 95% recovery across plant sizes and solvent mixes would replace anecdotal industry representations to regulators with empirically derived cost functions, substantially strengthening ICMAI's policy engagement.

Fifth, inclusion of an **ESG-Costing Module in the CMA Final Syllabus,** ahead of SEBI BRSR Core mandatory deadlines from FY 2026–27 (SEBI, 2023), would ensure that Scope 1 and Scope 3 emissions linked to solvent use are quantified and audited by practitioners trained for the task rather than improvised by finance teams without the requisite framework.

Insights, Implications, and the CMA Opportunity

Solvent recovery is conventionally framed as a problem for plant engineers and environment managers. This framing, while operationally useful, is analytically incomplete. The engineering challenge of achieving 95% column yield is well-resolved; the regulatory framework under the Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (Government of India, 2016) is established; technology providers are competent and available. What remains systematically underdone is the measurement, reconciliation, and reporting architecture — the infrastructure that renders physical performance visible as financial performance and converts hidden losses into accountable figures.

This is, fundamentally, CMA work. It requires no chemical engineering qualification, no displacement of environmental managers, and no assumption of QA responsibilities. It requires Cost and Management Accountants to apply the discipline their training equips them for — to measure what is unmeasured, attribute costs to activities rather than departments, reconcile inputs to outputs, and present resulting numbers in decision-grade form. The Pharmatech case study demonstrates concretely that this discipline, applied to solvent recovery, generates a 16:1 benefit-cost ratio from measurement infrastructure costing under Rs 10 lakh annually.

The following specific recommendations are advanced for the consideration of ICMAI Council, practising CMAs, and corporate managements in the chemical and pharmaceutical sector:

1. **Plant-level:** Every chemical or pharmaceutical facility subject to cost audit under Section 148 of the Companies Act, 2013, should implement a monthly solvent reconciliation report structured on the eight-point template presented in Table 2. This requires no capital investment and generates immediate visibility into controllable losses.
2. **Firm-level:** CMA firms serving the chemical and pharmaceutical sector should proactively position solvent recovery costing as a defined engagement service, applying the four-category framework — measurement, attribution, benchmarking, decision support — as a structured deliverable.
3. **Institute-level:** ICMAI should issue the proposed Sectoral Guidance Note on Solvent Recovery Costing and engage with the Ministry of Corporate Affairs to introduce explicit solvent-loss disclosure requirements in Form CRA-3, with immediate effect from the next revision cycle.
4. **Curriculum-level:** The ESG-costing module incorporating Scope 1 and Scope 3 solvent emission quantification should be integrated

into the CMA Final syllabus no later than the 2025–26 academic cycle, given SEBI's FY 2026–27 implementation deadline.

Solvent recovery is one instance of a broader pattern. Across every domain where environmental performance intersects with financial performance — water recycling, energy efficiency, circular-economy material flows — the measurement and costing work remains incomplete. A prepared profession, equipped with the right frameworks and professional standards, can establish itself as the natural custodian of these emerging practice areas. The companies that need this work will commission it; the regulators who depend on it will mandate it; and the next generation of CMAs will enter an expanded professional domain that delivers demonstrable economic and environmental value. MA

References

1. *Central Pollution Control Board. (n.d.). Draft guidelines on techno-economic feasibility of implementation of wastewater treatment, solvent recovery and use of cleaner production practices in the bulk drug and pharmaceutical industry. Ministry of Environment, Forest and Climate Change, Government of India.*
2. *Central Pollution Control Board. (2016). Standard operating procedure (SOP) for utilisation of spent solvents generated from bulk drugs and pharmaceutical industries. Ministry of Environment, Forest and Climate Change, Government of India.*
3. *Constable, D. J. C., Jiménez-González, C., & Henderson, R. K. (2007). Perspective on solvent use in the pharmaceutical industry. Organic Process Research & Development, 11(1), 133–137. https://doi.org/10.1021/op060170h*
4. *European Union. (2010). Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions (integrated pollution prevention and control). Official Journal of the European Union.*
5. *Government of India. (1981). The Air (Prevention and Control of Pollution) Act, 1981 (Act No. 14 of 1981).*
6. *Government of India. (2013). The Companies Act, 2013. Ministry of Corporate Affairs.*
7. *Government of India. (2014). The Companies (Cost Records and Audit) Rules, 2014. Ministry of Corporate Affairs.*
8. *Government of India. (2016). Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Ministry of Environment, Forest and Climate Change.*
9. *Institute of Cost Accountants of India. (n.d.). Guidance notes on cost accounting standards [Sector-specific series]. Cost Accounting Standards Board.*
10. *International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. (2021). Q3C(R8): Impurities — guideline for residual solvents.*
11. *Securities and Exchange Board of India. (2023). Business responsibility and sustainability report (BRSR) core framework (Circular No. SEBI/HO/CFD/CFD-SEC-2/P/CIR/2023/122).*
12. *U.S. Environmental Protection Agency. (n.d.). Resource Conservation and Recovery Act (RCRA), 40 C.F.R. § 261.2: Definition of solid waste.*

Congratulations!!!

CMA Asim Kumar Mukhopadhyay

Heartiest Congratulations to CMA Asim Kumar Mukhopadhyay, honoured at Bharat 2.0 Conclave 2026 as a "Visionary Leader in Enterprise Transformation, Mobility Innovation & Sustainable Value Creation – 2026" on 31st May 2026 at J.W. Marriott, Mumbai. The award was presented by Dr. Kiran Bedi.

His achievements continue to inspire professionals across industries and reflect a dedication to excellence and progressive leadership.

We wish CMA Asim Kumar Mukhopadhyay continued success, good health, and many more accomplishments in all his future endeavours.