

ADVANCING PROJECT SUSTAINABILITY IN INDIA'S ENERGY TRANSITION THROUGH ENVIRONMENTAL COST ACCOUNTING AND LIFE-CYCLE MANAGEMENT: THE ROLE OF CMAs

Abstract

India's energy transition is rapidly moving toward green power, but the financial and environmental costs of this shift are still not fully recognized. This article explores the gap between the falling cost of renewable technologies and the wider costs of deploying them, covering environmental impacts, system reliability and financing. Drawing on Indian regulatory frameworks, intergovernmental evidence and peer-reviewed research, it asks whether these dimensions are adequately accounted for in current approaches to project appraisal, and highlights the role of Cost and Management Accountants (CMAs) in bringing environmental and system costs into financial evaluation. Three observations emerge: technology costs have fallen mainly through manufacturing gains and stronger supply chains rather than through environmental cost internalisation; the availability of affordable capital is shaped increasingly by the financial position of distribution utilities and the investment needed for storage; grid integration and reliable supply remain insufficiently reflected in project costs.

Introduction

India's energy transition has reached a critical point. The country has committed to 500 GW



Arush Raman

Researcher (Economics and Energy Policy)
Shillong

aaditarush@gmail.com



CMA Raman Kumar Jha

General Manager (Finance)
North Eastern Electric Power Corporation Limited
Shillong

cmacsraman@yahoo.in

of non-fossil electricity capacity by 2030 and to net-zero emissions by 2070, and the pace of delivery has picked up sharply. Non-fossil capacity stood at 300.50 GW by 31 July 2026, taking India past 60 per cent of its 2030 target and past 54 per cent of a total installed base of roughly 552 GW. Solar leads at 164.59 GW, ahead of wind, hydro, bio-power and nuclear¹. On capacity, India is delivering. However,

the harder question is whether environmental costs are adequately being accounted for in project appraisal.

Traditionally, environmental damage in the form of emissions, waste and resource depletion was treated as an externality. The costs were borne by the ecosystems and communities rather than those causing them. This tilted investment towards whichever option looked cheapest once environmental impacts had been excluded. Coal-fired plants historically offered low upfront costs however this cost came with hidden costs in air pollution, public health and ecological damage.

Life-cycle costing, environmental cost accounting, and energy justice frameworks are changing this picture. However, as the Indian case shows, integration into project planning remains partial and reactive, and is frequently overshadowed by financing constraints.

Life-cycle costing and environmental accounting in India

Life-cycle assessment quantifies a project's environmental burden across its full trajectory, following ISO 14040, covering mining, manufacture, installation, operation, and decommissioning². Life-cycle costing tallies the cost of that journey rather than the price at purchase, with ISO 15686-5 supplying the procedure for constructed assets³. Material flow cost accounting, under ISO 14051, traces money lost to waste within a production system⁴. Applied to India's renewable sector it would expose inefficiencies in module manufacturing, blade disposal, and transmission losses, though it is rarely used.

Two limitations recur. The first is methodological: a review of ninety integrated studies found monetising environmental impacts difficult, and the underlying datasets inconsistent in volatility and assumptions⁵. The second is organisational, and more consequential. A review of 274 papers on building design found life-cycle assessment is generally conducted late, when it can no longer substantially influence the design⁶. Indian public procurement shows the same pattern, emphasising capital expenditure over total life-cycle cost and understating long-term impacts.

Pricing environmental damage: from PAT to a compliance carbon market

India has changed the way it prices environmental harm, and the shift is more than cosmetic. The Perform, Achieve and Trade (PAT) scheme, introduced in 2012, set energy-efficiency targets for over a thousand units across thirteen energy-intensive sectors. It is now giving way to the Carbon Credit Trading Scheme, which asks a different question: not how much energy a plant consumes, but how much it emits per unit of output. Seven sectors, roughly 490 units, moved across in FY2026 and now carry legally binding intensity obligations for FY2026 and FY2027 against a FY2024 baseline⁷. For now, power generation remains outside the scope of the scheme.

Disclosure has advanced in parallel with the transition

Disclosure has advanced alongside it. Business Responsibility and Sustainability Reporting, which applies to the top thousand listed companies by market capitalisation, is the main instrument through which Indian firms report environmental performance⁸. Between them these give the country verified emissions data at scale for the first time. What they do not provide is a way for that data to reach a project appraisal. Eco-cost accounting would close the gap by attaching a shadow price to the water a thermal plant uses, the particulates it releases or the biodiversity a reservoir displaces. Without such prices, a project can pass every financial test and still be environmentally unsustainable.

Carbon pricing is widely assumed to fall hardest on the poor, yet evidence from 87 mostly low- and middle-income countries points the other way: below roughly USD 15,000 per capita, moderate increases proved on average progressive⁹. Recycled into decentralised solar for rural households, those revenues could narrow inequality rather than widen it.

What made renewable electricity cheap

It may be tempting to read about the falling renewable costs as evidence that environmental accounting has succeeded. Between 2010 and 2024 the global weighted-average levelised cost

of utility-scale solar fell by 90 per cent, from USD 0.417 to USD 0.043 per kilowatt-hour, and onshore wind by 70 per cent, from USD 0.113 to USD 0.034. IRENA attributes this to technology improvement, competitive supply chains and economies of scale.¹⁰ Carbon pricing and eco-cost accounting do not appear in that decomposition. Where financing conditions have been studied empirically in Germany they accounted for 5 per cent of the drop in photovoltaic costs and 24 per cent of the drop in wind costs¹¹. In India the cost reached USD 0.038 per kilowatt-hour in 2024, which's below the global average¹⁰.

The fall has been uneven, as Figure 1 shows. Over the same period the cost of hydropower rose by 30 per cent and geothermal by 9 per cent, mainly on higher installed costs¹⁰. That matters in India, where large hydro brings displacement, biodiversity and seismic risks rarely given a price. Appraisal assuming every low-carbon technology followed the same path will misprice them.

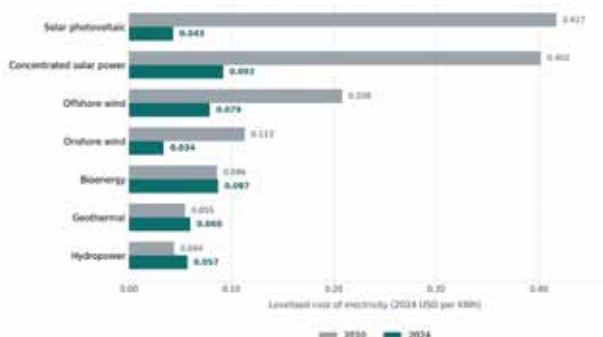


Figure 1. Global weighted-average levelised cost of electricity from newly commissioned utility-scale renewable projects, 2010 and 2024, in 2024 USD per kilowatt-hour. Data from IRENA, Table S1 (ref. 10).

The rate that decides who builds

A low levelised cost does not establish that a project can be built. Levelised cost is a discounted quantity, and the rate applied is the cost of capital. Renewable assets are unusually sensitive to it, because almost all their cost falls at the outset and is recovered over decades. The IEA estimates that financing was around half the levelised cost of solar plants reaching final investment decision in emerging economies in 2021¹².

Two independent estimates indicate where India

stands, though they rest on different methods and should not be combined arithmetically. IRENA, using regional assumptions, applied a weighted average cost of capital of 3.8 per cent in Europe and 12 per cent in Africa for 2024, and a review of 46 countries found wide variation within country groups as well as between them^{10,13}. The IEA, drawing on developer and financier surveys, puts advanced-economy solar cost of capital at 5.0 to 6.5 per cent and India's at roughly 80 per cent higher^{12,14}. Together these show a substantial Indian financing penalty, though well below the highest-risk markets.

Investors in India cite regulatory, currency, and off-taker risk as their main concerns¹⁴. Off-taker risk is not unique to India, but its scale and its origin in distribution utility balance sheets are distinctive, and it is fundamentally an accounting problem. As at March 2022, distribution companies held accumulated losses of about USD 70 billion and paid generators 163 days late on average. Late Payment Surcharge rules and payment security through the Solar Energy Corporation of India have helped, and dues fell from USD 18 billion in June 2022 to USD 9 billion in January 2024¹⁴. In short, the financial health of the buyer sets the discount rate for the seller.

The consequences are measurable. When region-specific capital costs enter energy-system models rather than being assumed away, projected green output in developing regions falls sharply. The authors call this a climate investment trap: perceived risk raises premia, deterring investment, which sustains the conditions generating the risk¹⁵. Across five models, Calcaterra and colleagues found that convergence of premia improves climate and equity outcomes together¹⁶. Where financing is half of levelised cost, a percentage point on the cost of capital is among the largest determinants of what gets built.

The cost of reliability

Solar and wind energy have variable generations. Solar output falls at night and the monsoon season, while dust and heat reduce efficiency whereas wind resources are concentrated in a few states with inadequate evacuation infrastructure. The solutions are storage, hybrid projects and grid modernisation.

These solutions require substantial capital investment, yet such costs are rarely captured in project-level appraisal. The Central Electricity Authority estimates that India will need about 411 GWh of storage by 2031–32¹⁷, through batteries and pumped hydro. Independent estimates put the 2030 requirement at 132 GWh of batteries and 100 GWh of pumped hydro, compared with only about 360 MWh operational in January 2025¹⁸. The gap is substantial and costly to close, yet these costs are not reflected in the levelised cost of solar power. A tariff excluding the storage and network investment needed to make generation dependable is incomplete, and system-level life-cycle costing is the correction.

Equity, disclosure and accountability

India's energy transition must balance two imperatives: an ecological ceiling she cannot exceed and a social foundation she cannot fall below. Access is no longer the primary constraint, with average rural electricity supply increasing from 12.5 hours a day in 2014 to 22.6 hours, while the national energy shortage fell to just 0.03 per cent in FY2025–26.¹⁹ Reliability, however, remains uneven across states, while coal-dependent districts continue to face significant livelihood risks as the energy system undergoes structural change. Hall and colleagues set out six principles for just energy finance: affordability, good governance, due process, intra-generational equity, spatial equity and financial resilience²⁰. These sit alongside distributional concerns in the just transition literature²¹.

Role of CMAs in Environmental Cost Accounting and Project Sustainability

Cost and Management Accountants can help ensure that India's energy transition is financially as well as environmentally sustainable, integrating environmental costs into appraisal rather than

Energy transition has yet to account fully for its environmental and life-cycle costs, a gap CMAs can bridge by integrating them into project appraisal

relying on capital expenditure analysis alone.

- 1. Life-cycle costing and appraisal.** CMAs can apply life-cycle costing so that long-term environmental and social impacts are monetised, correcting the procurement bias towards upfront cost.
- 2. Environmental cost accounting.** Using eco-cost and material flow cost accounting, CMAs can assign shadow prices to emissions, water use, waste and biodiversity loss, making hidden costs visible in financial terms.
- 3. Carbon market and compliance.** Under the Carbon Credit Trading Scheme, CMAs can help organisations measure and manage emissions intensity, ensuring compliance while identifying ways to recycle carbon revenues into equitable access.
- 4. Financing and risk management.** CMAs can analyse the cost of capital, off-taker risk, and distribution utility health, quantifying exposures that shape project design and policy advocacy.
- 5. Reliability and system costs.** CMAs can bring storage, grid balancing and backup costs into project economics, preventing the under-pricing of solar and wind against dispatchable plant.
- 6. Energy justice and accountability.** CMAs can embed affordability, equity and resilience into financial models, strengthening disclosure under SEBI's reporting framework.
- 7. CMA as an Independent Sustainability Assurance Practitioner:** Under the proposed Standard on Sustainability Assurance (ISAS 1), CMAs can undertake assurance engagements on the disclosure of sustainability-related information, including sustainability-related risks and opportunities and their impact that is useful to stakeholders²².

Conclusion

India's energy transition is both an opportunity and a challenge. Environmental costs are becoming visible through life-cycle assessment, the carbon market, and sustainability reporting, but their integration into project planning remains incomplete, and financing conditions continue to determine where deployment happens.

Four measures follow. Environmental cost accounting should be institutionalised within appraisal rather than appended to it. Financing costs should be treated as a policy variable, addressed through off-taker reform and payment security. The system costs of reliability should be counted within project economics. And energy justice criteria should be written into policy rather than assumed. Delivering these depends on professionals able to translate environmental impact into financial terms, which is where CMAs have a distinctive part to play.

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