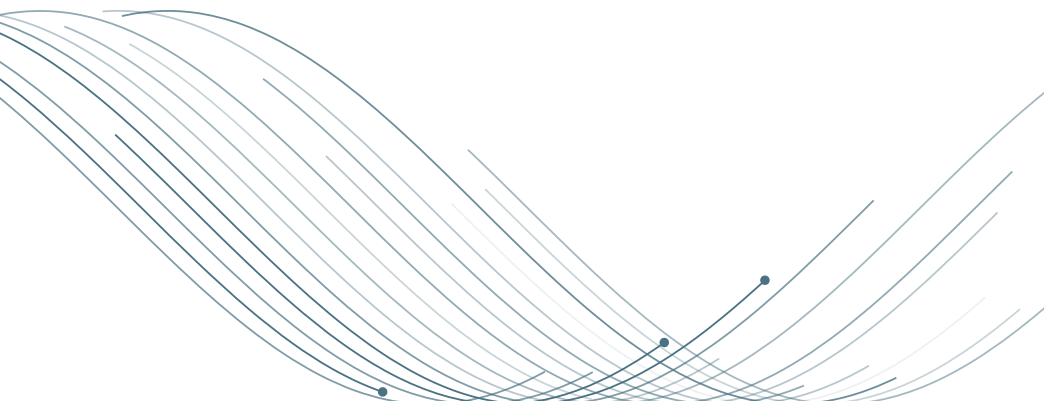


THE ENERGY EFFICIENCY IMPERATIVE

Lessons from the Past, Leadership for the Future



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THE ENERGY EFFICIENCY IMPERATIVE

Lessons from the Past, Leadership for the Future

Released on the occasion of 25th CII Energy Efficiency Summit 2026

CONTENTS

- 1. From Conservation to Competitiveness 01**
A preface on 25 years of the CII Energy Efficiency Summit
CII Green Business Centre
- 2. Efficiency First: India's No-Regrets Path to Decarbonisation and Productivity 12**
Energy productivity is India's strongest route to competitive decarbonisation.
Ajay Mathur
- 3. From Energy Efficiency to Energy System Efficiency 22**
India's next transition will be shaped as much by flexibility in demand as by clean supply.
Alok Kumar
- 4. Making Buildings Accountable for Performance 36**
The next frontier in sustainable buildings is not better intention, but continuous proof of performance.
Ashish Rakheja
- 5. Built the Framework. Now Build the Market 44**
India's next phase of energy efficiency will be decided by finance, by the states, and by how the country measures value.
Ashok Sarkar

6. From Sufficiency to Productivity **58**

India's next efficiency frontier is energy system resilience and investment quality.

Brian Dean

7. India's Energy Efficiency Journey - Reflections and Priorities **66**

The task of energy efficiency professionals will be to ensure that efficiency is treated as the first fuel, a resource in its own right that is planned, financed and delivered with the same rigour as new energy supply.

Brian Motherway

8. India's Energy Efficiency Story — Time for the World to Take Notice **74**

India's energy-efficiency journey is no longer only a domestic achievement. It is a practical national capability — built with industry, tested at scale, and increasingly relevant to a world seeking credible pathways for sustainable growth.

Chandrajit Banerjee

9. Competitiveness, Powered Efficiently **80**

Why efficient energy use is becoming central to the cost competitiveness, market access and innovation strength of Indian manufacturing.

Cristiano Pasini

10. Beyond Conservation: India's Next Efficiency Agenda 92

India's next efficiency chapter must deliver productivity, flexibility and competitiveness.

Girish Sethi

11. Efficiency First for India's Energy Future 100

India's next efficiency frontier must link competitiveness, energy security and net-zero growth.

Harikumar R

12. Why Energy Efficiency Is India's Cheapest Insurance Policy 110

Unlike other fuels that need to be imported, stored or transported, energy efficiency is available where the demand is.

James Abraham

13. From Capacity to Capability: India's Next Twenty-Five Years 118

Installed capacity shows ambition; delivered energy, and how productively we use it, will show real progress.

Jamshyd N. Godrej

14. The Efficiency Imperative: Why Energy Productivity Will Define India's Net Zero Manufacturing Journey **128**

Before manufacturing can decarbonise, it must first become efficient. The sequence matters more than the sentiment.

Kamal Bali

15. Efficiency First: Building the Foundation of India's Energy Transition **136**

Twenty-five years of institution building — and the agenda that will define the next twenty-five.

Krushna Chandra Panigrahy

16. India's Energy Efficiency Journey: Two Decades of Quiet Transformation **148**

If the last two decades were about building the institutional architecture to prove that efficiency can scale, the next decade should be about stronger cross-sectoral enforcement to drive implementation.

Madhav Pai

17. Efficiency Was Never a Choice. It Must Not Become One **158**

Indian cement led the world because efficiency meant survival. That compulsion must now be rebuilt.

Madhavkrishna Singhania

18. Efficiency Begins with Attention 168

Energy efficiency has never begun with technology. It begins when someone notices what everyone else has stopped noticing — and India's next decade of gains will come from that same discipline.

Meher Pudumjee

19. From Reports to Results: Building India's Energy-Performance Economy 178

India's first 25 years made energy efficiency a profession and a market. The next 25 must make performance continuous, measurable and investable.

Milind Chittawar

20. Energy Productivity: The Competitiveness Test Behind India's Trade Opening 188

Trade agreements will open markets; only the productivity of every unit of energy will decide who wins them.

Mukundan R

21. India's Next Energy Efficiency Challenge: Cooling, Flexibility and Electrification 194

As India's energy demand grows, efficiency must become a core part of how the country plans its grid, shapes markets and builds industry.

Nikit Abhyankar and Amol Phadke

22. From the Boiler Room to the Boardroom 206

India's next energy-efficiency leap must make efficiency its first fuel and productivity its central metric.

Padu S. Padmanabhan

23. From Equipment to Ecosystem: Cement's Next Efficiency Frontier 216

India's most efficient industrial sector has taken equipment-level gains close to their limit. The next chapter depends on reliability, circularity and the wider ecosystem beyond the factory gate.

Raj Narayanan E R

24. Energy Efficiency as the First Fuel 226

Powering India's electrification journey with productivity, resilience and system value.

Ravichandran Purushothaman

25. From National Ambition to State-Level Delivery: The Next Chapter of Energy Efficiency in India 236

The next 25 years of energy efficiency will not be won by building one strong institution at the Centre, but by building the capacity to deliver in every state.

Satish Kumar

- 26. Energy Productivity: India's Next Growth Frontier** **252**
- The next phase of efficiency must make energy a source of productivity, competitiveness and resilience.
- Saurabh Kumar**
- 27. Green Buildings and the Next Frontier of Energy Efficiency** **262**
- From efficient components to intelligent, low-carbon and grid-responsive buildings.
- Shekar Reddy C**
- 28. Automation, AI and India's Next Energy Efficiency Frontier** **276**
- Digitalisation and automation are the means; higher economic value from every unit of energy is the goal.
- Tejpreet S Chopra**
- 29. Beyond the Machine: India's Next Efficiency Frontier** **288**
- Two decades of labelling transformed the Indian appliance; the harder task now lies outside it.
- Thiagarajan B**
- 30. The Backbone Question: Taking Efficiency to Every Tier of Indian Manufacturing** **300**
- Large industry has made its transition. The next quarter-century belongs to the Tier 2 and Tier 3 enterprises that carry the manufacturing base.
- Vikram Sitaram Kasbekar**

KEY TAKEAWAY

The first twenty-five years established India's energy efficiency foundation through policy, institutions, professional capacity and market transformation. The next phase must convert this foundation into a national movement for energy productivity, competitiveness and system-level impact.

FROM CONSERVATION TO COMPETITIVENESS

A preface on 25 years of the CII Energy Efficiency Summit

Confederation of Indian Industry

CII – Green Business Centre

Twenty-five years ago, energy efficiency in Indian industry was largely understood as a technical and operational discipline. It was important, but often located within the utility section, the maintenance function or the periodic energy audit. Its vocabulary was shaped by conservation, housekeeping and cost reduction. It asked an essential but limited question: how much energy could be saved?

Over the past quarter-century, India has moved decisively beyond that narrow framing. What began as an effort to reduce avoidable energy use has evolved into a management discipline: measure, benchmark, improve, verify and replicate. Energy efficiency has emerged as a strategic instrument of competitiveness, climate action, energy security and sustainable growth. The more relevant question today is not only how little energy can be consumed, but how much economic value, industrial output, comfort, resilience and social benefit can be created from every unit of energy used.

This evolution is one of the important contributions of twenty-five years of the CII Energy Efficiency Summit. The Summit has served not only as a platform for showcasing technologies, but also as an institutional forum for dialogue among industry, government, technology providers, financial institutions, utilities, academia and professionals. It has enabled benchmarking, peer learning, recognition of leadership and wider dissemination of proven practices. In doing so, it has helped make energy efficiency more visible, credible and replicable across Indian enterprise.

As CII marks the Silver Jubilee of this platform, the occasion calls for reflection as well as renewed resolve. There is reason for satisfaction, because few areas of industrial transformation in India have combined policy, market creation, professional capacity and enterprise action as effectively as energy efficiency. The foundation built over the past twenty-five years now provides a strong platform to advance a more ambitious agenda for the coming decades.

BUILDING THE FOUNDATION

India's energy efficiency journey acquired shape and momentum through the sustained efforts of CII and the Bureau of Energy Efficiency. CII helped create an industry platform for awareness, peer learning, benchmarking and adoption of best practices, while the Energy Conservation Act, 2001, and the establishment of the Bureau of Energy Efficiency provided the country with a statutory anchor, a policy architecture and a sustained implementation mandate.

Under BEE's leadership, four instruments came to define this phase: Standards and Labelling for appliances and equipment; Perform, Achieve and Trade for energy-intensive sectors; building energy codes; and demand-side management across utilities, municipalities and agriculture. Together, these BEE-led interventions established minimum performance expectations and created the basis for measurement, comparison and improvement.

A less visible but highly consequential achievement of BEE's work was the creation of professional capacity. Certified energy managers and auditors, plant engineers, consultants, utility professionals and institutional teams helped translate BEE's policy architecture into audits, baselines, targets, projects and verified outcomes. Indian industry developed a shared technical language and a professional ecosystem capable of delivering improvement at scale.

The other achievement was market transformation. Efficient products and solutions moved from premium niches to mainstream markets

when volumes grew, standards rose, and demand was aggregated. EESL's role in the LED transformation demonstrated that price barriers could fall when ambition, procurement, policy and industry capability moved together. This lesson remains central to the next phase: markets change when the demand signal is clear enough for supply chains to respond.

MAKING ENERGY PRODUCTIVITY THE GROWTH METRIC

The defining message emerging from this Silver Jubilee collection is clear: conservation remains necessary, but it is no longer sufficient. India must move from energy saved to the more productive use of energy. This approach asks whether every unit

"A saved unit is not merely a unit not consumed; it is capacity avoided, fuel not imported, emissions not released and resilience gained."

consumed is generating the highest possible economic and social value. It treats energy not merely as a cost to be reduced, but as a strategic input to be managed with the same discipline as capital, labour, technology and time.

This is why energy efficiency must move more firmly from plant-level reporting to board-level governance. When efficiency is viewed only as reduction, it remains largely the responsibility of the plant engineer. When it is viewed as productivity, it becomes a concern of the chief executive, the board and the investor. It influences competitiveness, margins, export readiness, carbon exposure and resilience in volatile markets.

This shift is urgent because the global context has changed. Tariffs, carbon border measures, supply-chain disclosure and customer expectations are beginning to convert energy and carbon intensity into commercial variables. No company can negotiate the global price of fuel. Every company can decide how productively it uses the fuel, power and heat it buys.

For Indian industry, this is both a responsibility and an opportunity. Firms that can demonstrate verified energy performance will carry a competitive advantage in procurement, finance and trade. Those that integrate efficiency into business strategy will be better placed as markets increasingly value carbon and energy performance.

For this reason, the next measure of leadership must extend beyond energy intensity alone. Efficiency must be valued for the capacity it avoids, the peak demand it reduces, the grid investment it defers, the imports it displaces, the carbon exposure it lowers and the competitiveness it strengthens.

ADVANCING A SYSTEMS APPROACH

The first phase of India's efficiency journey succeeded because it created standards, targets and professional discipline. Compliance has created a strong foundation; the next phase must raise ambition through markets, leadership and peer learning. The gains that remain in many leading plants are harder, more integrated and less financially obvious than the early opportunities. The next leap will come from combining technology, operations, finance and system-level planning.

The next gains lie in systems. In industry, this means optimising the value chain, not only the plant. In buildings, it means closing the gap between design intent and actual performance. In cooling, it means addressing the installed stock, not only the equipment sold this year. In cement, it means reliability, alternative fuels, material characterisation and demand for low-carbon products. In the power sector, it means treating flexible, efficient demand as part of the energy system, not as an afterthought.

Cooling illustrates this new complexity with particular force. Standards and labelling can improve the efficiency of new equipment, but a very large installed stock of older machines will continue to shape demand for many years. With greater attention to end-of-life policy, service quality, technician skills and building design, India

has the opportunity to avoid locking in inefficient cooling demand while expanding affordable comfort as an essential element of health, productivity and quality of life.

The same distinction applies to buildings and industrial assets. A high-performance design is not automatically a high-performance building, and a modern plant is not efficient merely because it contains efficient equipment. Actual performance depends on commissioning, controls, maintenance, reliability, measurement and operating discipline. The next energy efficiency agenda must therefore reward measured outcomes, not only good intent at the design or procurement stage.

Equally important is the discipline of attention before investment. Observation identifies the opportunity, measurement quantifies it, and technology then delivers the solution. This sequence must become a normal part of management practice, so that efficiency is achieved through continuous operational improvement and not only through periodic capital expenditure.

Visibility remains a fundamental barrier. A megawatt of generation is tangible; a saved megawatt-hour appears only as a smaller bill. Renewable energy scaled faster partly because it could be seen. Efficiency must now be made equally visible in corporate accounts, national energy balances, utility planning, financing structures and public recognition.

Bankability is the second barrier. Savings do not automatically translate into investment. They become financeable only when baselines are trusted, performance is independently verified, contracts are standardised and lenders can recognise avoided expenditure as a credible cash flow. The next phase will require public and concessional capital to function less as subsidy and more as risk capital that crowds in private finance.

Finance will also have to move from isolated projects to market-making. Cluster portfolios, standard contracts, guarantees, partial

risk-sharing mechanisms and super-ESCO-type platforms can convert dispersed savings into investment-ready pipelines. Public capital should be used to reduce risk, build confidence and crowd in private finance, rather than merely subsidise individual purchases.

SCALING THE UNFINISHED AGENDA

Large industry has largely internalised energy efficiency because it had the management capability, technical depth and balance-sheet strength to do so. The next quarter-century must take this discipline to Tier 2 and Tier 3 enterprises, clusters, suppliers, commercial buildings, cold chains, logistics systems, municipal services and agriculture.

MSMEs are not unwilling; they are under-supported. Their central barrier is confidence: confidence that the technology will work, production will not be disrupted, savings will materialise, finance will be available, and service support will continue after installation. A foundry cluster, a forging cluster and a glass furnace cluster cannot be treated as the same problem under different labels. Each requires diagnostics, technology packages, vendor ecosystems, financing structures and handholding suited to its own operating reality.

Scale will also depend on demand creation. Low-carbon and resource-efficient products will not move from demonstration to norm unless buyers specify them, procurement systems value them and markets reward their performance. The lesson from cement and other sectors is clear: technology readiness is not enough. Industry must help create the customer pull that makes better products commercially unavoidable.

This is where institutions such as CII have a distinctive responsibility. Industry platforms can aggregate demand, publish volume signals, create benchmarking confidence, convene technology providers, develop cluster protocols, recognise leadership and enable structured peer learning. Regulation can establish the minimum. Institutional platforms can help raise ambition.

This peer-learning effect has been one of the strengths of the CII platform. When a company places its performance in the public domain, it creates a benchmark for others to match and exceed. In this way, transparent comparison and recognition can raise sector ambition even where regulation only sets the baseline.

PUTTING EFFICIENCY FIRST IN ELECTRIFICATION

India's energy transition will be stronger when it is built on efficient demand. If renewable capacity, storage, transmission and distribution infrastructure are sized without first addressing avoidable consumption, the transition may become larger and costlier than necessary. Energy efficiency is therefore not a parallel agenda; it is the first layer of the transition.

At the same time, electrification and decarbonisation cannot wait for efficiency to be completed. The real task is to advance them together. Efficient motors, variable-speed drives, heat pumps, waste-heat recovery, district energy, smart cooling, grid-interactive buildings and intelligent controls are not merely savings measures. They are flexibility resources. Flexible demand must be treated as an industrial asset and a system resource, helping a renewable-rich grid become reliable, affordable and productive.

The new categories of demand—data centres, semiconductors, electrified industrial heat, electric mobility and cooling—must be planned correctly from the beginning. It will be important not to connect them as conventional loads and then retrofit intelligence later. India has the opportunity to design the next demand curve, not merely forecast it.

This places DISCOMs and system operators at the centre of the next phase. They must see efficiency and flexible demand not as reduced sales, but as system resources that can reduce peak stress, defer network investment and improve system reliability. Digital

metering, reliable data, time-sensitive tariffs, loss reduction and sub-transmission planning will decide whether India can co-optimize generation, transmission, storage and demand flexibility as one system rather than as disconnected investments.

The digital transition brings its own paradox. Artificial intelligence, advanced analytics and automation can make energy use more observable and more productive, but data centres and digital infrastructure are themselves fast-growing loads. Digitalisation should improve decisions, not multiply unverified estimates. The answer is not to slow digitalisation, but to make it energy-disciplined from the start: efficient by design, flexible in operation, supported by credible data and accountable for system impact.

BUILDING THE NEXT INSTITUTIONAL COMPACT

The articles that follow offer diverse perspectives, but their call to action is notably consistent. Policymakers must align standards, codes, industrial programmes, carbon markets and grid planning around the larger objective of energy productivity. Standards must remain ahead of the market rather than follow it. State-level implementation, local bodies and utilities must become central to delivery.

India's emerging carbon market framework, including the Carbon Credit Trading Scheme, should be used to deepen this discipline and not reduce it to a compliance requirement. Carbon markets must reward real performance, credible measurement and progressively higher ambition. Over time, they should support movement from intensity-based measurement alone towards stronger productivity and absolute-impact outcomes where sectors are ready.

States and local institutions will determine whether national ambition becomes practical reality. State Designated Agencies, municipal bodies and urban local authorities must be strengthened to implement building codes, agriculture and municipal DSM, local energy planning and enforcement. The next phase cannot be delivered only from

national platforms; it must be embedded in state systems and city-level execution.

Industry must treat energy productivity as a board-level business measure. Every expansion proposal should first ask whether existing assets are delivering design performance. Every procurement system should recognise carbon and energy intensity. Every large company should extend efficiency discipline to suppliers and clusters, because competitiveness now sits across the value chain.

Financial institutions must learn to lend against verified savings. Utilities must become digital and demand-responsive. Technology providers and academia must develop solutions for Indian conditions. Professional education must prepare engineers who can work across thermal systems, power electronics, controls, data analytics and grid interaction.

India must also become a developer of efficiency solutions, not only a large market for them. Several of the technologies the country needs—affordable high-temperature heat pumps, MSME-ready process solutions, efficient cooling for hot climates, flexible industrial electrification and low-cost controls—will not automatically emerge from markets whose operating conditions are different from ours. The value for India lies increasingly in application engineering, localisation, service ecosystems and manufacturing depth.

Skills must therefore be treated as core infrastructure. Energy managers of the future will need to work across thermal systems, electrical drives, digital controls, analytics, finance, operations and grid interaction. Technician capacity in cooling, building operations and industrial maintenance will be as important as advanced technology. Without people who can operate, verify and improve systems continuously, efficiency will remain an installed promise rather than delivered performance.

Above all, India must now convert energy efficiency from a programme

architecture into a wider movement of productive enterprise. The first twenty-five years demonstrated that policy, industry leadership and institutional platforms can transform markets. The next twenty-five years must demonstrate that energy productivity can transform the quality, resilience and competitiveness of growth itself.

This compact is not only important for India's domestic transition. It also positions India to contribute meaningfully to other growing economies seeking practical pathways to industrial efficiency, affordable growth and sustainable development.

TAKING INDIA'S EXPERIENCE TO THE WORLD

There is also a larger opportunity. India's experience is not a narrow domestic success story. It is a development pathway of significant relevance to the Global South. It demonstrates how a growing economy can combine industrial expansion with efficiency improvement; how standards can raise markets without excluding affordability; how professional cadres can turn regulation into practice; and how industry platforms can accelerate learning among competitors.

India should now carry this experience outward with confidence and humility. The offer is not only technology. It is institutional design, implementation capability, market-making, trained professionals, cluster models, benchmarking protocols and the evidence that progress is possible at scale under real-world conditions.

The CII Energy Efficiency Summit has been one of the important platforms behind this national capability. It has helped turn isolated excellence into shared practice. It has given recognition to early movers, confidence to wider industry, and a trusted forum where enterprises could learn from one another and move forward together.

A LEADERSHIP AGENDA FOR THE NEXT PHASE

As we look to the next two to three decades, the task is sharper and more demanding. India must grow rapidly, urbanise responsibly,

electrify intelligently, decarbonise competitively and deliver a better quality of life to hundreds of millions of people. This cannot be achieved by building supply alone. It will require every unit of energy to work harder than before.

This is the promise of energy efficiency at twenty-five: not a smaller economy using less energy, but a stronger economy creating greater value with less waste. Not conservation as restraint, but productivity as leadership. Not an obligation imposed on industry, but a discipline embraced by industry because it is central to competitiveness, resilience and national purpose.

As this publication is released, CII invites Indian industry to treat the productive use of energy as a defining leadership responsibility for the decades ahead. The task is to move from pilots to platforms, from compliance to competitiveness, from isolated projects to value-chain transformation, and from incremental savings to measurable system impact. This will require boards to set clear ambitions, enterprises to invest in verified performance, financial institutions to recognise savings as bankable cash flows, utilities to value flexible demand, and technology providers to develop solutions suited to Indian conditions. Working with BEE, CII will continue to support this transition through advocacy, benchmarking, capacity building, recognition, market creation and industry-led collaboration. The next phase must be pursued with urgency, discipline and shared purpose, because India's growth, competitiveness and climate leadership will depend on how productively the nation uses every unit of energy.

KEY TAKEAWAY

Efficiency is not a completed chapter but the first step in the decarbonisation sequence. Energy that is never consumed does not need to be decarbonised, which makes efficiency the cheapest and most certain contribution to India's net-zero pathway, and the reason it must be measured as productivity rather than compliance.

EFFICIENCY FIRST: INDIA'S NO-REGRETS PATH TO DECARBONISATION AND PRODUCTIVITY

Energy productivity is India's strongest route to competitive decarbonisation.

Ajay Mathur

India's principal instrument for industrial energy efficiency has, for most of the last fifteen years, measured a single, deceptively simple thing: how much energy a unit of output consumes. The Perform, Achieve, Trade (PAT) scheme built an entire architecture of targets, audits and tradable certificates around reducing this intensity number, sector by sector, cycle by cycle. It worked well enough that some of India's most energy-intensive sectors, cement among them, now count among the most efficient in the world. But a scheme designed to capture the easiest gains first was always going to face a harder question once those gains were captured. That question is what comes after intensity.

That question has become urgent for two reasons. First, industry's absorption of efficiency has been distinctly uneven, not only between sectors but within them, and the improvement curve inside many sectors has visibly flattened.

Second, and more consequentially, the national conversation has moved on: decarbonisation, not efficiency, now occupies the centre of policy attention, embodied in the shift from Perform, Achieve, Trade to the Carbon Credit Trading Scheme. The risk in this transition is that efficiency gets treated as yesterday's agenda, a box already ticked, while the country rushes toward net-zero commitments built

on a foundation that was never as complete as the intensity numbers suggested. Energy efficiency therefore needs to be reframed: from an intensity metric that measures compliance to a productivity metric that measures the economic value India extracts from every unit of energy it uses. That shift is not incidental to India's decarbonisation and growth ambitions. It is a precondition for both.

The distinction matters in practice. Energy intensity asks how much energy a unit of output consumes, and rewards a plant for trimming losses at the margin. Energy productivity asks the opposite question: how much economic value each unit of energy delivers.

A plant raises its productivity only by getting more value out of the same energy, through better products, higher-value processes and less waste. The first is a compliance measure, reported to a regulator. The second is a competitiveness measure, of the kind industry already applies instinctively to every other input it buys.

WHAT TWENTY-FIVE YEARS OF EFFORT ESTABLISHED

The value of a platform that brought the entire industry together around a single theme, sustained over a quarter of a century, is easy to underestimate because its output was rarely visible in any single year. That platform was the Energy Efficiency Summit convened by the CII Green Business Centre, and in the early phase of what became India's energy efficiency movement its task was largely definitional: agreeing on what a workable trading scheme should look like, identifying which technologies made commercial sense at the time, and persuading industry that efficiency investments served both the bottom line and long-term competitiveness rather than one at the expense of the other.

This was, in effect, an exercise in building a shared technical and

commercial language across an industrial base that had never before been asked to think about energy in these terms.

That foundation shows up today in more than the intensity numbers. It produced testing infrastructure, technical benchmarks, and a policy scheme, however imperfect, that could later be adapted rather than discarded when priorities shifted.

The conversion of Perform, Achieve, Trade into the Carbon Credit Trading Scheme, achieved only after substantial coordination between the environment and power ministries, is itself evidence that institutional apparatus built for one purpose can be repurposed for an adjacent one, provided the underlying coordination habits exist.

That is not a small achievement, and it deserves to be recognised as the base on which the next stage of work must be built, rather than dismissed as a scheme that has run its course.

WHY THE CURRENT MODEL IS RUNNING OUT OF ROOM

The unevenness in industry's response to Perform, Achieve, Trade is instructive precisely because it is not random. Some sectors, cement being the clearest example, achieved efficiency gains across the board. Others, textiles among them, show a much wider spread: certain producers now rank among the most efficient anywhere in the world, while others have done little more than meet the minimum target required of them. Compared across sectors rather than within them, the electricity sector itself has lagged considerably behind industrial sectors such as cement in meeting its own targets.

The pattern points to a single conclusion. The low-hanging fruit identified fifteen years ago has still not been picked everywhere, because intensity targets calibrated primarily to what was administratively achievable were never capable of driving uniform

improvement across a genuinely heterogeneous industrial base.

This matters more today than it would have a decade ago, because the country is no longer treating energy efficiency and decarbonisation as separate conversations happening on separate tracks. They are now, correctly, being treated as sequential and interdependent: an economy cannot meaningfully decarbonise consumption that has not first been made efficient, because doing so simply directs renewable capacity toward meeting inflated, wasteful demand rather than genuine need. Energy efficiency, in this framing, is not an alternative to decarbonisation or a competing priority for policy attention; it is the necessary first step without which decarbonisation investment delivers a fraction of its potential value.

Any industrial strategy that treats efficiency as settled business risks building its net-zero ambitions on precisely the uneven foundation the sectoral data reveals.

THE MISSING MIDDLE IN TECHNOLOGY DEVELOPMENT

A second constraint compounds the first. Much of the efficient technology available to Indian industry today, in air conditioning, in industrial heat, in motors, originates with technology developers in the West, and is optimised neither for Indian cost points nor always for Indian performance requirements. For a meaningful band of applications, this gap is manageable. A heat pump that delivers hot water at 95 degrees Celsius using gas as an input is commercially available and economically justified today, and industry should adopt it wherever it makes sense to do so.

At the more demanding end of the specification range, the position is different. A heat pump that delivers an outlet temperature of 120 degrees Celsius from a 30-degree input is not something any existing global market has a strong enough incentive to develop, because the specific combination of application and cost sensitivity that would

justify it exists most acutely in India.

The implication extends beyond any single equipment category. If a substantial share of the efficiency gains India needs over the next two decades depend on technology specifications that only Indian conditions demand, then adoption and import alone cannot carry the agenda. India will need to become a genuine developer of efficient technology, not merely its largest market. This has a further, less obvious consequence for industrial strategy: the greatest commercial value in this shift is unlikely to sit in manufacturing or assembly, which analysis of margins suggests contributes comparatively little value-add.

What returns the greater margin is the work of application engineering, understanding precisely how a given technology should be adapted to a specific industrial context, a capability that is inherently harder to import and therefore more durably valuable to build domestically.

LESSONS FROM THE RENEWABLES EXPERIENCE

India's own recent history offers a useful comparison. Renewables scaled far faster than efficiency, even though both sat under broadly similar institutional stewardship at various points. Two structural differences explain most of that gap, and both carry direct lessons for how efficiency should be positioned going forward.

The first is visibility. A more efficient boiler looks exactly like an inefficient one; a more efficient building is indistinguishable from its neighbours. Rooftop solar panels or wind turbines, by contrast, make the adopter visibly different from those around them, and this visual distinctiveness turns out to matter more than is generally acknowledged in explaining adoption behaviour. It is the same insight that made the five-star appliance rating programme work: a visible marker converts a technical attribute into a signal that consumers and businesses respond to.

The corollary is that wherever efficiency can be paired with renewables and storage, in effect creating a visible showpiece, adoption tends to follow more readily, and the combination produces greater decarbonisation than efficiency alone would have delivered.

Energy efficiency has generally lacked an equivalent aggregation mechanism: individual companies negotiate individual technology purchases, each too small on its own to move a manufacturer's pricing behaviour. A forum of the kind the CII's Energy Efficiency Summit already provides, capable of aggregating expected demand across an entire industry and communicating that volume credibly to technology suppliers, could replicate for efficient equipment the price trajectory that made renewables commercially unstoppable.

"A visible marker converts a technical attribute into a signal that consumers and businesses actually respond to. That is what efficiency has always lacked, and what pairing it with renewables can restore."

INSTITUTIONS THAT COORDINATE WITHOUT OVERREACHING

The institutional architecture for pursuing this agenda already exists in fragments: renewables sit with the Ministry of New and Renewable Energy, efficiency with the Bureau of Energy Efficiency under the Ministry of Power, and overall decarbonisation strategy with the Ministry of Environment. The conversion of Perform, Achieve, Trade into the Carbon Credit Trading Scheme demonstrates that coordination between the environment and power ministries is achievable when the underlying policy logic requires it.

Extending equivalent coordination to renewables is harder, since the ministries responsible for power and for renewable energy tend to view themselves as competing over the same underlying resource, electricity, rather than as complementary contributors to a shared outcome.

A more workable path may be a tripartite coordination mechanism between the Bureau of Energy Efficiency, the Ministry of New and Renewable Energy, and the Ministry of Environment, built specifically to manage the efficiency-renewables-decarbonisation interface without requiring the Ministry of Power to lead it.

Financing, deliberately, should sit outside this structure. Finance is inherently cross-cutting, serving health, education and many sectors beyond energy, and the financial sector needs the flexibility to develop new instruments independent of any single ministry's mandate.

Green bonds, instructive in this respect, did not originate in renewables or efficiency at all; they were developed elsewhere and later adapted first to renewable energy and subsequently to efficiency financing. Keeping financing institutionally separate preserves this capacity for cross-sector innovation, rather than constraining it within a narrower coordination structure built for a different purpose.

THE WAY FORWARD

India's aspiration for 2047, the Viksit Bharat milestone, gives this agenda a natural time horizon and a clear test of success. The most consequential outcome would be for India to become the most energy-productive economy among developing nations, an advantage available to it specifically because it is still building new industrial capacity, and can embed efficient technology into that capacity from the outset, rather than retrofitting or discarding an existing capital stock the way developed economies must.

A second, closely related outcome would be for a substantial share of the world's energy-efficient equipment, measured by value captured through margins and by employment generated, to be produced within India itself, not by displacing trade in the best available global technology, but by capturing more of the value-added that lies in adapting that technology intelligently to specific applications.

Acting on this does not require waiting for new legislation or large public expenditure. Three things can begin now. A mechanism to aggregate expected demand for efficient equipment across an industry, and to communicate that volume credibly to technology suppliers, would give manufacturers the visibility on scale that drove down solar photovoltaic prices.

A deliberate pairing of efficiency projects with renewables and storage would give efficiency the visible marker it has always lacked. And a sustained build-up of application engineering capability would ensure that technology adapted to Indian conditions is developed in India rather than imported. A tripartite coordination mechanism between the Bureau of Energy Efficiency, the Ministry of New and Renewable Energy and the Ministry of Environment would give this work an institutional home.

None of this requires abandoning what the last twenty-five years achieved. It requires recognising what that period was actually for: building the technical language, the testing infrastructure, and the coordination habits that intensity-based schemes could establish, so that the next quarter-century can move beyond intensity toward productivity, beyond adoption toward domestic technology development, and beyond compliance toward a genuinely economic case for efficiency that industry pursues because it serves competitiveness, not because a target requires it.

Getting this sequencing right, efficiency before decarbonisation, visibility and aggregation before mandate, application engineering before assembly, is what will determine whether India's next twenty-five years of energy efficiency match the ambition of the growth it is meant to support.

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KEY TAKEAWAY

The next phase of India's energy-efficiency journey must move from saving energy in individual assets to optimising the entire electricity system. Flexible demand, stronger DISCOM capabilities, better forecasting and coordinated planning across generation, transmission and storage will be central to delivering reliable, affordable and cleaner power.

FROM ENERGY EFFICIENCY TO ENERGY SYSTEM EFFICIENCY

India's next transition will be shaped as much by flexibility in demand as by clean supply.

Alok Kumar

THE CENTRAL CHALLENGE OF THE NEXT TWENTY-FIVE YEARS

India's first twenty-five years of energy efficiency established an important principle: economic growth and energy performance can improve together. The challenge before the country is no longer confined to reducing energy consumption per unit of output. India is now pursuing two transitions at once — continued improvement in energy efficiency across the economy, and transformation of the energy system itself through electrification, renewable integration and decarbonisation.

These two efforts are closely interconnected, yet they are not identical in what they ask of policy, institutions and the system. Efficiency remains a critical pillar, yet the future demands a wider perspective: raising the share of electricity in final energy consumption while simultaneously reducing the emission intensity of electricity itself.

The scale of this task is evident globally. The International Energy Agency's Electricity 2026 assessment describes the arrival of an "Age of Electricity". Global electricity demand is projected to grow by about 3.6% a year between 2026 and 2030, roughly 50% faster than the average of the previous decade, and electricity consumption is now expected to rise at least two and a half times faster than overall energy demand.

For the first time in three decades outside crisis periods, electricity

demand is growing faster than the global economy. Renewables and nuclear together met about 42% of world electricity demand in 2025 and are expected to supply about half by 2030. For India, electrification is therefore not a marginal adjustment but a structural shift that must be planned alongside grid decarbonisation, reliability and affordability. The central question for the next twenty-five years is not how to use less energy, but how to combine generation, transmission, storage and demand response as efficiently as possible — moving beyond efficient technologies towards efficient systems.

ENERGY TRANSITIONS MUST BE VIEWED THROUGH A LONG-TERM LENS

Every major energy transition in history has taken considerable time to work its way through the economy. The shift from biomass to coal, from coal to oil and gas, and later to electricity unfolded over decades and sometimes centuries, shaped by new technologies, supporting ecosystems and the gradual retirement of older assets.

The transition now under way follows much the same pattern, because electrification involves far more than deploying equipment: electric mobility needs charging infrastructure, supply chains, service networks, financing, insurance acceptance and lender confidence, and the same applies to storage, distributed renewables and industrial electrification. Such ecosystems require standards, skills, business models and market confidence, and cannot be built in a year or two.

The second constraint is the capital already deployed across the value chain — power plants, transmission, fuel supply systems, oil and gas assets, industrial facilities and distribution networks that support economic activity, employment and financial stability.

Retiring them prematurely affects investors, lenders, workers and local economies alike. The energy transition must therefore also be a just and orderly transition.

This realism matters for India, which is expanding energy access, supporting industrial growth and decarbonising at the same time. India has committed to 500 GW of non-fossil capacity by 2030 and net zero by 2070, and progress has been remarkable.

The country reached 50% of installed capacity from non-fossil sources in June 2025, more than five years ahead of the target set under its Nationally Determined Contribution. As on 31 July 2026, non-fossil installed capacity stood at 300.50 GW

"The critical question is no longer how much generation capacity must be added. It is how best to combine generation, transmission, storage and demand response to deliver reliable, affordable and cleaner electricity."

— over 60% of the 2030 target and more than 54% of a total installed base of about 552 GW. Solar accounts for 164.59 GW, wind 58.14 GW, hydro 57.24 GW, bio-power 11.75 GW and nuclear 8.78 GW, with a record 55.29 GW of non-fossil capacity added in 2025-26 alone.

Sustaining this momentum will call for capacity addition to be optimally matched by transmission, storage, market design, distribution readiness and demand-side flexibility, so that the country accelerates intelligently while safeguarding affordability, reliability and economic stability.

ELECTRIFICATION AND DECARBONISATION MUST PROCEED TOGETHER

The future energy system will be built around electricity, not only because electricity enables renewable integration, but because electrification is often more efficient in itself. Electric motors convert far more input energy into useful work than internal combustion engines, and electric heating, boilers, arc furnaces and other industrial technologies can deliver higher conversion efficiency than fossil-fuel alternatives. Electrification therefore does two things at once: it improves efficiency while opening pathways for decarbonisation.

As more end uses shift to electricity, the economy can reduce primary energy demand intensity even before the grid becomes fully low-carbon.

A recurring debate is whether large-scale electrification should wait until electricity itself becomes greener. Such sequencing would prolong the transition unnecessarily: if the system spends a decade reducing emission intensity before electrification accelerates, and electrification then needs another decade to scale, the transition becomes needlessly long.

Equally, electrification without greening the grid would not deliver the full climate and efficiency gains India seeks. The two are complementary and must be pursued in parallel.

India's own experience reinforces the value of moving on both fronts together. The Bureau of Energy Efficiency reports that efficiency schemes saved 50.98 million tonnes of oil equivalent in 2022-23, equal to 6.65% of primary energy supply, avoiding 306.40 million tonnes of CO₂-equivalent emissions and delivering estimated savings of ₹1,94,320 crore.

Efficiency is already a national-scale resource, and electrification can multiply that value as demand shifts from less efficient combustion to high-efficiency electric technologies on an increasingly low-carbon grid.

FROM MEETING DEMAND TO OPTIMISING THE SYSTEM

Conventional planning evolved to serve a straightforward objective: forecast demand and build enough generation to meet it. That approach served the country well and helped build one of the largest integrated power systems in the world. The emerging system now allows planners to go further. Electricity differs from other commodities — coal, oil and gas can be stored and used when required, whereas electricity,

unless supported by storage, is generally consumed the moment it is produced.

This becomes more significant as renewable penetration rises. Solar output does not coincide with the evening peak, wind varies by season and geography, and hydropower depends on rainfall. System performance and emissions generated therefore rests not only on installed renewable capacity but equally on demand patterns and system operations.

Recent evidence shows both the pace of progress and the widening agenda. India added about 65 GW of generation capacity in FY 2025-26, of which a record 55.29 GW was non-fossil, including 44.6 GW of solar. Renewable generation rose to 477.79 billion units in 2025-26, up from 190.96 billion units in 2014-15. Over the same period, peak demand met touched an all-time high of about 271 GW in May 2026, comfortably supplied without any significant shortage.

The next set of gains lies in the gap between capacity and delivered energy: non-fossil sources now make up more than 54% of installed capacity but contributed about 29% of electricity generated in 2025-26, and thermal plants still carry much of the evening peak.

Closing that gap is a question of storage, transmission and system operation rather than of panels alone. The timing of consumption is becoming as important as the source of generation, and efficiency must therefore extend beyond equipment and facilities to the entire power system.

THE FOUR PILLARS OF FUTURE SYSTEM EFFICIENCY

The emerging system rests on four interconnected resources: generation, transmission, storage and demand flexibility. Generation historically received the greatest attention — when demand rose, the response was to build or procure more capacity. That response now

captures only one part of a much larger solution. India increasingly operates as an integrated system supported by expanding markets and networks: electricity can move from surplus to deficit regions, storage can shift energy across time, and flexible demand can relieve stress and postpone new infrastructure.

The central challenge is therefore optimisation — identifying the least-cost combination of all four resources to meet a properly forecast demand curve reliably, rather than planning each of them in isolation from the others.

Distribution companies do not start from identical positions. Legacy generation portfolios, demand characteristics, network constraints and resource availability vary widely across regions. Planning frameworks should therefore aim at least-cost system outcomes rather than prescribing identical pathways for every utility.

Different combinations of renewable energy, transmission, storage and demand flexibility can achieve similar national objectives at lower overall cost.

The objective should be optimisation of the electricity system rather than uniformity of resource choices, particularly as renewable-energy obligations expand.

DEMAND FLEXIBILITY BECOMES A STRATEGIC RESOURCE

The role of demand within the system is itself undergoing a fundamental change. Historically it was treated as a fixed quantity that utilities forecast and then supplied. Demand can instead be flexible: consumers can shift consumption to periods when renewable energy is abundant and reduce it during system stress. Industrial, commercial and even residential consumers can help balance the system, turning demand from a passive requirement into an active resource.

Time-of-day tariffs are one mechanism, aligning prices with system

conditions. Beyond them lies incentive-based demand response, under which consumers are compensated for reducing or shifting load, making flexibility itself a service they provide to the system.

The investment implication is significant: in many situations demand response may cost less than additional generation or storage. Efficiency becomes not only a question of using less energy, but of using it at the right time. The sequence of reform matters -- resource planning and efficient power procurement first, then continued reduction of distortions and cross-subsidies in tariffs, wider adoption of time-of-day pricing and, ultimately, incentive-based demand response.

Emerging planning tools increasingly allow demand flexibility to be treated as a quantifiable resource alongside generation, transmission and storage, letting planners test whether it can meet system needs more economically than new infrastructure.

CAPTIVE GENERATION AND THE EVOLVING ROLE OF THE GRID

India's substantial captive power base emerged when shortages and reliability concerns strongly influenced industrial investment decisions. Captive generation gave industry control over supply reliability and operating costs, and was in many cases a rational response to prevailing conditions. That context has since changed in important ways.

Grid reliability has improved significantly, and the scale advantages of an integrated system matter more than before. Shared generation, wider balancing areas and expanding transmission can often deliver more efficient outcomes than isolated assets. Continued reduction of cross-subsidies and sustained improvement in reliability can encourage gradual migration from captive generation to grid-based supply, reducing duplication of infrastructure and allowing industry to benefit from the scale, diversity and flexibility of a larger system.

Such a migration will not take place on its own, and several conditions need to be met. Reliability remains critical for industrial consumers, particularly those running continuous processes; industry cannot afford disruptions that affect export deadlines and other commitments. Grid-based solutions must therefore keep strengthening reliability while improving cost competitiveness.

Migration will also require adequate network infrastructure and connectivity, since moving large captive loads to the grid can call for investment in substations, transformers and networks. The objective should be grid integration that improves both reliability and system economics.

BETTER FORECASTING AND BETTER PLANNING

A more dynamic system calls for a considerably higher standard of forecasting. Short-term forecasting is shaped by weather and operational variables, while medium- and long-term forecasting depends on technology adoption, fuel costs, electrification trends and economic growth; each horizon needs a different analytical approach.

As electrification accelerates and consumer behaviour evolves, forecasting must mature to feed into formal resource adequacy planning.

The objective is no longer how much generation to add, but which least-cost portfolio of resources can meet future demand while maintaining reliability — evaluating generation, transmission, storage and demand flexibility together rather than in isolation.

As the system grows more complex, resource adequacy planning must become the foundation for investment decisions, and its quality will depend on robust forecasting, granular data and strong analytical capability within the utilities.

DATA AND VISIBILITY AS THE FOUNDATION OF THE FUTURE

The next phase of system efficiency will be driven by visibility. Traditional planning relied on annual demand figures and broad projections, and that basis is no longer adequate for a system of this complexity. Modern systems need far more granular information — hourly demand patterns, local network conditions and substation-level visibility all matter, because congestion, voltage constraints and distributed generation strongly influence performance.

Smart meters, SCADA and other digital infrastructure now allow consumers and networks to be understood in far greater detail, and this base is expanding rapidly: over 7 crore smart meters have been installed across the country, of which about 6 crore under the Revamped Distribution Sector Scheme, with sanctions covering nearly 20 crore consumers.

Data by itself, however, creates limited value. Utilities must be able to acquire, clean, organise and analyse it, and the effectiveness of artificial intelligence and machine learning depends on strong data foundations and institutional capability. Visibility is becoming a prerequisite for efficiency, since it is what makes forecasting sharper, planning more effective and optimisation possible. Distribution companies therefore stand to gain most from stronger data systems, more granular load visibility and the confident use of smart meters, SCADA, forecasting tools and artificial intelligence in day-to-day operations.

BUILDING STRONGER DISCOM CAPABILITIES

Technology and data alone will not determine the success of this transition. Distribution companies occupy a central position in India's electricity system, and their responsibilities now extend well beyond procurement and billing: they are becoming planners, network managers, data custodians and facilitators of consumer participation. This wider mandate opens the way for an equally

wider set of institutional capabilities. Analytical tools and modelling platforms are readily available, and the greatest value comes when utility professionals use them with confidence; external support can accelerate implementation, while core competencies are best built and retained within the utility.

Once teams understand the assumptions, limitations and implications of the models they use, they can weigh alternative combinations of generation, transmission, storage and demand flexibility against reliability, affordability and system efficiency. A transition supported by sophisticated tools succeeds when institutions are equipped to use them well.

DISTRIBUTION NETWORKS: THE NEXT EFFICIENCY FRONTIER

While generation and transmission dominate policy discussions, distribution networks are becoming increasingly important. Distributed renewable energy is changing the nature of networks: flows are more complex, and reverse flows, voltage management and local constraints now require closer attention. India has built a strong tradition of scientific transmission planning over several decades, and that tradition offers a ready template. As distributed deployment accelerates, extending the similar analytical rigour to sub-transmission and distribution planning is the natural next step.

Distribution also offers one of the most immediate efficiency opportunities available today, and the progress here has been striking. Aggregate technical and commercial losses at the pan-India level came down to 15.04% in FY 2024-25 from 21.91% in FY 2020-21, bringing the sector to the threshold of the 12-15% band targeted under the Revamped Distribution Sector Scheme.

Every further reduction lowers the electricity that must be generated and transported. In a grid where fossil fuels still play a significant role, loss reduction directly lowers emissions, making it an energy-

transition strategy in its own right and not merely a utility-performance objective. Structured approaches that drive measurable improvement in utility performance therefore deserve continued support.

As India expands its carbon-market architecture, new mechanisms can complement direct utility-efficiency initiatives, with distribution companies continuing to be guided towards time-bound loss reduction.

REPOSITIONING DEMAND-SIDE MANAGEMENT

Demand-side management must evolve in step with all these changes. For years it was associated mainly with reducing consumption. That objective remains valid, and its future role is broader: DSM increasingly becomes a mechanism for creating flexibility — shifting demand, supporting renewable integration, deferring infrastructure investment and improving system utilisation.

Realising this potential calls for sustained institutional attention. Incentives lie at the heart of the matter, since distribution companies depend on electricity sales for revenue, particularly from well-paying consumer segments, and aligning commercial interest with demand-side outcomes will help DSM take its place in mainstream utility planning.

The enabling regulation is largely in place, as the necessary provisions already exist in most frameworks. What will make the difference now is institutional priority, implementation capacity and sustained ownership, since DSM sits alongside immediate concerns such as tariff design, generation adequacy and network expansion.

A dedicated institutional champion within the energy ecosystem, backed by adequate technical, financial and organisational capability, would help DSM realise its full potential. This need not be a permanently government-funded programme; measures with attractive returns can increasingly become self-sustaining, with public intervention focused on creating markets, building capability, aggregating demand and

helping new technologies reach scale.

The broader objective is to move from a model in which demand is simply forecast and supplied to one in which demand is an active, measurable resource in system planning.

THE WAY FORWARD

India's first energy-efficiency journey showed that improved performance and economic growth can advance together. The next must show that an entire energy system can become more intelligent, flexible and efficient. Electrification and decarbonisation must proceed in parallel. Generation, transmission, storage and demand flexibility must be planned as complementary resources rather than independent silos, within frameworks that recognise the diversity of India's utilities and allow least-cost pathways suited to their circumstances.

Demand must be recognised as an active contributor to system optimisation, distribution networks must receive greater strategic attention, data must become the foundation of planning and operations, and utilities must build the capabilities to manage a more dynamic system.

Tariff reform and a gradual shift from captive generation towards the integrated grid can reinforce these gains, provided reliability and competitiveness remain central.

Most importantly, energy efficiency must expand beyond individual technologies and programmes. The next twenty-five years will be defined not only by how much renewable capacity is installed, but by how effectively India builds an energy system that delivers reliability, affordability, competitiveness and sustainability together. The future of energy efficiency lies in energy system efficiency. That is where the next chapter of India's energy transition will be written.

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KEY TAKEAWAY

The next leap in building efficiency will come from making performance visible every day, not only at design stage or during periodic audits.

MAKING BUILDINGS ACCOUNTABLE FOR PERFORMANCE

The next frontier in sustainable buildings is not better intention, but continuous proof of performance.

Ashish Rakheja

For more than two decades, India's green building movement has helped shift the industry toward better design, stronger codes and more efficient systems. Yet one important gap remains. A building can meet the code, earn a rating and still perform poorly once it is occupied. The reason is simple: design intent is checked before construction, but actual performance is often not measured with the same rigour after handover. The next stage of India's building efficiency journey must therefore move beyond design excellence and focus on performance accountability: the ability to measure, disclose and improve how buildings operate over time.

UNDERSTANDING THE PERFORMANCE GAP

The gap between design intent and actual performance is not new. In the 1990s, many leading buildings in India were conservatively designed with oversized cooling systems and larger equipment capacities in the name of factor of safety. At the time, there was little operating data to validate whether those assumptions were correct. That caution was rooted in the engineering culture of the time. As HVAC and air-conditioning systems became central to India's new commercial and institutional buildings, designers often relied on broad rules of thumb. These assumptions surely helped complete the design in a shorter time, but not always better. Due to this complacency in performance, a large building, for example, could be designed within days, without the depth of load analysis expected today. The cost of

this lack of performance accountability became visible only later to the owners, when a building planned with multiple chillers used only a fraction of their installed capacity because actual operating loads were far lower than the selected capacity. What looked like a prudent safety margin was often systemic over-provisioning.

Energy modelling, introduced widely through the green building movement in the early 2000s and led in India by the CII Indian Green Building Council (IGBC), changed that conversation. It showed that assumptions could be questioned, measured and improved. Since then, electro-mechanical building design has advanced significantly through higher energy efficiency, safer refrigerants and better indoor environmental quality, but the underlying lesson remains the same: progress begins when performance is made visible.

This history offers a clear lesson. The sector has improved whenever it has moved from assumption to evidence. Future progress will depend on making that evidence continuous, not occasional. Verification should not depend only on special audits or unusually committed teams. It should become a normal operating feature of every building.

THE SHIFT FROM PERIODIC DISCLOSURE TO CONTINUOUS VERIFICATION

Even when buildings commit to measurement and disclosure, the process is often manual. Systems need calibration, sensor drift must be noticed, data must be compiled and reports must be published. Over time, this effort weakens, and many buildings stop producing reliable performance data. Technology now offers a practical way to solve this problem. Artificial intelligence can sit on top of existing building automation systems and continuously identify sensor drift, operational gaps and abnormal energy use. In other words, the future is not only about better passive and active design strategies; it is also about buildings that can monitor themselves and alert owners before small inefficiencies become large failures. This is also a start of shift towards autonomous buildings.

The size of this verification gap is already clear. In one leading energy-efficiency award programme, most buildings failed to meet the criterion of demonstrating

"Tomorrow's best buildings will not just promise performance. They will prove it continuously, transparently and over time."

reliable operating data through their installed building management system. A contrasting example comes from a high-performance office building designed for an Energy Performance Index below 100 kWh/m²/year. Thereafter, through a continuous improvement plan, it achieved an EPI of 89 kWh/m²/year in its second year. Later, as sensors drifted and operating conditions changed, an AI layer was added over three to four months. It identified hidden inefficiencies and reduced consumption by roughly another 10 kWh/m²/year. Because performance data had been disclosed publicly from the beginning, transparency became a benchmarking tool rather than a reputational risk. The larger lesson is simple: each building needs a realistic performance target for its budget, use, context and a reliable way to prove whether it is meeting it.

This shift matters beyond energy. Buildings are in near future expected to account for embodied carbon, operational carbon and occupant wellness. Tracking all of these reliably across thousands of buildings cannot depend on manual reporting. It will require automated, sensor-driven systems. Digital twins, continuous commissioning and AI-based anomaly detection are therefore not just technical upgrades. They are the infrastructure that can make accountability a normal condition of building operation.

A digital twin changes verification in a practical way. Instead of comparing a building with a static design model created before construction, a live digital twin compares actual operating data with an updated performance baseline. Drift can be flagged as soon as it begins, rather than years later during a manual audit. Combined with predictive maintenance, this approach can identify failing components,

inefficient equipment and poorly calibrated controls before they seriously affect performance. Within the next decade, owners of large portfolios should be able to monitor many buildings from a single dashboard. Automated alerts can replace periodic, resource-heavy audits. That shift from occasional inspection to constant oversight, is what can make accountability scalable across the millions of square feet India will build every year and also retrofit its existing stock.

RENEWABLES AND GRID-RESPONSIVE BUILDINGS AT SCALE

The same principle applies to renewable energy and grid-responsive buildings. A net-zero building that is designed only around peak demand can require far more solar capacity, batteries and capital investment than necessary. A smarter building first understands when energy is needed, then shifts non-critical loads to match generation and grid conditions. This reduces the size and cost of renewable systems while improving reliability. What is done today through detailed energy modelling by specialist teams should, in the future, become a standard capability built into the building itself.

A resort project designed in the Maldives demonstrated how large this opportunity can be. Planned on a reclaimed island and designed to be self-sufficient in energy and waste, the project initially appeared to need about 50 MW of solar capacity to meet its net-zero goal. Once the team modelled the loads alongwith schedules and matched the demand with generation through staggered equipment operation, the overall energy demand reduced to roughly 30 MW. Net zero performance, in other words, is not about addition of renewable source until the numbers balance, it is achieved by first reducing and reshaping demand, which lowers panels, batteries, capital cost and system complexity at the same time.

The next step is to make this intelligence a standard layer in every building. As renewable energy share increases on the grid, utilities will need more demand-side flexibility to manage variability. Buildings

with automated load-scheduling and demand-response capability can transform from passive electricity consumers to responsive grid assets thereby switching non-critical loads in response to grid stress, time of day tariffs or renewable energy availability. This is where AI, IoT and asset twins shall connect most directly with their objective of decarbonisation: not only by reducing energy use, but by making buildings respond intelligently to grid.

Across a city, the impact could be much larger. A group of buildings with automated scheduling and on-site storage shall operate like a coordinated virtual power plant. Together, they could smooth local demand peaks and absorb surplus renewable generation, benefiting the wider grid as well as individual owners. Falling battery costs strengthens this case further. Buildings that have ability to store surplus solar power during the day and use it during evening peaks can reduce both grid dependence and the need for oversized renewable systems. The technology already exists and is being deployed in some projects to replace dependence on diesel generating sets. The task now is to make it a default specification for new constructions.

WRITING ACCOUNTABILITY INTO CONTRACTS

For performance accountability to become mainstream, it must also be built into construction contracts. Today, buildings are mostly judged at handover on their KPI's of time & cost, even though their true performance is revealed only during operation. Data centres offer a useful precedent as they are commonly contracted against clear performance targets, with consequences if those targets are not met. A similar approach can extend to commercial and institutional buildings as automated monitoring becomes more affordable. In such a model, a performance guarantee would not be a design promise. It would become a lifecycle commitment by the designer or contractor or both jointly.

This distinction is central to the sector's next phase: a high-performance design is not the same as a high-performance building. A design of

building can include selection of efficient systems, integrated strategies and ambitious energy targets. However, real performance is shaped by quality of execution, adherence to commissioning protocols, controls, operations and maintenance after occupancy. Integrated design and building systems commissioning have helped the industry move forward, but they have not fully closed the gap because accountability often ends at handover. Performance-based contracts shall extend responsibility beyond drawings and specifications. They will require project teams to demonstrate that a building achieves its committed performance rather than just a design promise.

Technology alone will not deliver this transition. Continuous verification shall be necessary that force facility teams to act on the shortcomings. Thus, building operations shall be data led and not organised around reactive maintenance. Training, clearer operating mandates, continuous commissioning and construction contracts that reward sustained performance shall be as important as the installed technology.

CLOSING THE POLICY GAP FOR A NATIONAL SYSTEM

India does not need to begin from scratch. The Energy Conservation & Sustainable Building Code (ECSBC 2024) and National Building Construction Standards (NBCS 2026) already provide a strong foundation. The challenge is implementation. Codes must be adopted more consistently across states, and regulation must keep pace with technologies that can verify performance continuously. Policy should also remove barriers that prevent net-zero buildings from sharing surplus solar power with the grid. Without these changes, regulation will remain focused on one-time design compliance while buildings themselves move toward real-time accountability.

THE WAY FORWARD

Realising this future will require action on several fronts. Policymakers

should harmonise adoption of the ECSBC 2024 and NBCS 2026 across states, remove restrictions that work against net-zero and grid-feedback ambitions, and evolve future building policy around continuous performance data rather than one-time certification. Developers and contracting authorities should bring performance-based contracting into mainstream buildings, supported by sensor verification through the building's life. Technology providers and building owners should treat AI-based monitoring and digital twins as baseline requirements for new construction, not optional upgrades. And as renewable energy share increases on the grid, designers and utilities should build automated load-scheduling and demand-response capability into buildings by default.

The first twenty-five years of India's building efficiency movement proved that better design was possible. They created the codes, rating systems and professional capability needed to scale green buildings. The next twenty-five years must focus on something equally important: ensuring that buildings continue to perform after they are occupied. The future of sustainable buildings will be defined not by claims made at design stage, but by actual performance that is measured, reported and improved throughout the building's life. It is a journey towards autonomous buildings which is the ultimate future.

Ashish Rakheja is Managing Partner at AEON Integrated Building Design Consultants, with over three decades of experience designing more than 4,000 projects across hotels, airports, hospitals, and commercial spaces. He has led electro-mechanical design for eleven Net Zero Energy Buildings and over 100 platinum-rated green projects in India, and chairs both the Technical Committee of the Indian Green Building Council (IGBC) and the CII Green Cooling Council. A Presidential member of ISHRAE, he is also the first Indian designated to serve as President of ASHRAE Global for the year 2027-28.

KEY TAKEAWAY

Key Takeaway India spent twenty-five years building the institutions of energy efficiency. The next twenty-five must build the market. That means using public and concessional money as risk capital rather than project capital — as demonstrated by the PRSF's 3.3-times leverage of private capital and the PforR's scaling of EESL's programmes — translating the national framework into what each state is actually trying to achieve, giving state agencies the authority to enforce and not only the skills to advise, and measuring efficiency by the system value it creates — capacity avoided, peak reduced, competitiveness gained, jobs created, security improved — rather than by units saved.

BUILT THE FRAMEWORK. NOW BUILD THE MARKET

India's next phase of energy efficiency will be decided by finance, by the states, and by how the country measures value.

Ashok Sarkar

India is attempting something few economies have managed: to grow rapidly, industrialise deeply and decarbonise within the same generation. Each ambition makes a claim on energy. Electrifying transport and industry is good for emissions, but it raises electricity demand, which is rising anyway with growth, and industry must hold its cost position throughout.

The 2070 net-zero commitment rests, in practice, on choices being made now, because buildings and industrial plants have lifetimes of thirty and forty years, and what is designed inefficiently today stays inefficient into the 2060s. In this setting, the cheapest, fastest and least contested resource available to the country is the energy it does not need to produce at all. Energy efficiency has therefore moved from the margins of energy policy to its centre.

The record of the past 25 years is, above all, one of successful institution-building. The Energy Conservation Act, the Bureau of Energy Efficiency (BEE), appliance standards and labelling, building codes, the Perform, Achieve and Trade scheme and a large professional cadre of energy auditors and managers together constitute a working ecosystem. The next quarter century builds directly on that foundation, converting the ecosystem into a market. Success will be measured not by the instruments created, but by the private capital mobilised, the depth of implementation in the states, and the value efficiency delivers to the energy system as a whole.

This is precisely the shift that the World Bank Group (WBG)'s 2025 flagship approach paper, "Power More with Less: Scaling Up Energy Efficiency for Growth and Energy Security," calls for globally — elevating energy efficiency from a line item in national energy plans to a strategic priority backed by policy, finance, and institutional commitment. India's experience offers one of the most instructive case studies in that global argument.

AN ECOSYSTEM, NOT A PROGRAMME

The story did not begin in 2001. Energy conservation work was under way well before, driven by the oil shocks and high fuel prices of the 1970s and 1980s and carried forward by organisations such as the National Productivity Council and the Petroleum Conservation Research Association. That effort was real but fragmented.

The Energy Management Centre, set up under the Ministry of Power in 1989, served as an important bridge through the 1990s, drawing scattered initiatives into something closer to a

"Efficiency is not a subsidy to be granted. It is an asset class waiting to be recognised."

national agenda. The Energy Conservation Act of 2001, and the Bureau of Energy Efficiency that followed in March 2002, was the decisive turning point: it converted a collection of programmes into a mandate, with statutory backing and a permanent home in government.

What made the mandate work was the recognition that it could not be delivered centrally. Energy is used in factories, buildings, farms, homes and distribution networks spread across a federal country, and no single agency in Delhi could reach them.

The framework therefore depended from the outset on partnership: with state governments and their designated agencies, with industry associations, utilities, private companies and development partners. The catalytic role of institutions such as USAID, GIZ and the World Bank in the formative years mattered less for the funds they brought

than for the models they helped test.

The CII–Green Business Centre is itself a product of that approach, emerging from precisely such a conversation between public agencies and private industry. Several industry bodies were present at that table, but it was the Confederation of Indian Industry that took the leadership and carried it forward, and the public–private partnership that resulted was a genuine game changer — reaching well beyond what government budgets or donor funding alone could have achieved.

On that foundation a layer of secondary regulation and market mechanisms was built steadily: labelling for appliances, air conditioners, refrigerators and lighting; standards for motors and compressors; codes for buildings; and a trading mechanism for energy-intensive industry.

Alongside it came capacity, arguably the least celebrated achievement of the period. India moved from modest training courses to the systematic certification of energy managers and auditors, creating a professional cadre large enough to give the regulations practical meaning.

Market transformation did the rest. As volumes grew, economies of scale brought down the price of the very technologies whose incremental cost had once been the principal barrier — not only lighting, but efficient motors and double-glazed windows, barely available in India a generation ago.

The lesson the sector can now apply with confidence is that efficiency need not remain a regulatory obligation indefinitely: a market properly created will make the efficient option the commercially attractive one. Seen from a distance, this progression follows a discernible order. Successful efficiency transformations rest on five pillars — policy and regulation, awareness, capacity building, institutional development and financing — and countries climb them in sequence, in what may be described as an efficiency ladder.

Instruments work best when the market is ready for them, which is why energy service companies, or ESCOs, though written into the Act in 2001, took time to find their footing. They were never intended to be a magic bullet: performance contracting, shared and guaranteed savings, and measurement and verification were new to Indian customers and equally to Indian banks, and confidence had to be built on all three sides together.

Utility demand-side management followed a similar arc. The first such effort began in 1997, with USAID support, at the Ahmedabad Electricity Company — the first investor-owned utility in India to run a DSM programme — built around lighting, capacitors and reactive power management, with pilot results published in 1998-99. It was a demonstration well ahead of the market it would later create. India has climbed that energy efficiency financing and implementation “ladder” with unusual discipline. Four pillars are firmly in place. The fifth, financing, offers the greatest headroom, and it is where the next phase begins.

FROM SEEDING A MARKET TO SCALING ONE

The first opportunity is financial. The original approach was simple: use public and donor funds to meet the incremental cost of efficient equipment. It was exactly right for a market that had to be seeded, and it worked — but it was designed to seed a market rather than to scale one. Global investment in energy efficiency and end-use now runs at roughly US\$350 billion a year, and the World Bank estimates that two-thirds of the energy the world produces is wasted, a loss worth close to five per cent of global GDP, while government and development programmes operate in millions.

The opportunity is therefore far larger than budgetary support alone was ever meant to address. The World Bank's own analysis shows that scaling energy efficiency delivers a return of three to five dollars for every dollar invested — a ratio that makes the case to finance ministers as compellingly as it does to energy planners.

Within this context, the philosophy for scaling up energy efficiency in India has also evolved, particularly since the late 2010s, from using public money to pay for efficiency to using limited public money, both Government and development partner-financed resources, to unlock far larger pools of private capital. The gap that now matters is not the gap in potential — India's energy efficiency potential is enormous and has been demonstrated many times over. The prize lies in converting it into investment and implementation at scale, leading to energy savings.

The World Bank-supported Partial Risk Sharing Facility (PRSF) for energy efficiency in India was the clearest expression of that shift. Its purpose was to de-risk lending so that commercial banks would finance ESCOs and their projects, and it demonstrated performance contracting across small and medium enterprises, municipal street lighting, buildings, agriculture, industry and even electric mobility.

SIDBI, and other commercial banks came into the market, and the Bureau's certification of ESCOs gave lenders and customers a basis for confidence. Estimates suggest that roughly US\$37 million corpus in the PRSF first phase leveraged around \$143 million of ESCO-implemented actual efficiency investment, yielding a commercial leverage ratio of approximately 4.

The PRSF — a US\$43 million facility combining a US\$18 million GEF grant and US\$25 million in Clean Technology Fund guarantee support, started in 2015 and managed through SIDBI — provided partial credit guarantees of up to 75 percent of principal for ESCO-backed projects, covering up to five years of tenor.

By early 2025, PRSF had supported 88 ESCO sub-projects with a cumulative investments mobilising private capital at a leverage ratio of more than four times the public contingent funds deployed. Fifteen major financial institutions, including the State Bank of India, joined the platform.

Sub-projects ranged from variable-speed drives in industry to LED street lighting in municipalities, together saving over 465 GWh and cutting over 350,000 tonnes of CO₂ emissions annually. A key design lesson, confirmed by the project's implementation experience, was that technical assistance must accompany financial incentives: the US\$6 million TA component, used to standardise ESCO transaction tools like energy savings performance contracts (ESPCs) and measurement and verification (M&V) protocols, and train banks, proved as important to market confidence as the guarantee itself.

The precise numbers matter less than the principle established: efficiency can be a bankable proposition, and public finance is most powerful when it crowds in commercial finance and private capital rather than substituting for it.

A parallel instrument addressed markets that private companies were not yet ready to enter. The super ESCO was conceived with two functions: to serve segments the private sector finds difficult to reach in the early stages, and to build confidence there until private players are ready to follow.

Energy Efficiency Services Limited (EESL) has performed the first with considerable effect, using bulk procurement to transform the market for domestic lighting and taking street lighting, electric vehicles and super-efficient air conditioners into municipal and public markets that were then largely untested. The second function — deliberately crowding in and strengthening private ESCOs — is the larger opportunity now opening up, and the more important of the two for the decade ahead.

The UJALA programme alone implemented by EESL — deployed over 350 million LED bulbs in the residential sector through demand aggregation and bulk procurement — which exemplifies the super ESCO model at its most effective: using EESL's market power to drive down unit costs and stimulate a market that private players could then enter and scale up. Similarly, about 6 million LED street lights

were installed by the Super ESCO.

The World Bank's US\$220 million Program-for-Results (PforR) financing, structured around disbursement-linked indicators tied to verified LED bulbs, fans and street lights deployment and institutional milestones achieved by EESL, helped consolidate and scale these results between 2017 and 2022.

Behind both examples lies a practice the sector is well placed to improve. Efficiency projects in India are still designed by technical experts and taken to a financial institution once the engineering is settled. By that stage the bank is being asked to appraise a technology, a savings mechanism and a business model all new to it, and it responds as any prudent lender would. Bringing technical and financial expertise together from the design stage changes that conversation entirely.

The wider objective is not to finance a particular project but to build familiarity within the financial sector with efficiency as an asset class — which is why lenders benefit from sitting on the juries of efficiency awards and on industry platforms, where they see completed projects with verified savings rather than proposals on paper.

The second opportunity is geographic. A law becomes a policy, a policy a strategy, a strategy an action plan — and the further that chain travels, the more investment and measurable savings it delivers. The Perform, Achieve and Trade scheme shows how much is possible when the mandate, the measurement and the counterparty are all clear. In buildings, agriculture and small enterprise, the greatest gains are still to be captured at the state level, where implementation actually happens.

Rankings of state performance make those opportunities visible, though a score is a starting point rather than a diagnosis. States progress at different paces and for different reasons: some designated agencies would benefit from additional staffing, some from deeper technical skills, some have capable teams who would achieve far

more with clearer authority to enforce a building code or a utility obligation, and some are pursuing priorities not yet connected to efficiency. Capacity and empowerment are distinct opportunities, each with its own remedy.

The market itself has changed decisively. Indian consultants, auditors, energy managers and service companies are far more sophisticated and commercially mature than two decades ago, and efficiency is no longer a technical matter confined to the plant. It runs from the shop floor to the boardroom, because it is understood as the first fuel — the first resource to examine before any new supply is added — and because it bears directly on costs, competitiveness and exposure to volatile fuel prices.

That maturity is precisely why the delivery model must change. Efficiency at the scale India now requires cannot be delivered by any single institution; it needs government, industry, financial institutions and technology providers acting together, each on the part of the problem it is best placed to solve.

FROM KILOWATT-HOURS TO SYSTEM VALUE

Even with the financing and implementation gaps closed, efficiency could not remain a standalone programme, because the system around it is being rebuilt. Renewable generation, storage, green hydrogen, electric mobility, digital control and demand response are arriving together, and the direction of change can be summarised in three movements: digitalisation, decarbonisation and decentralisation.

Power is shifting from a few large stations towards distributed resources, and storage from a few large installations towards potentially millions of batteries sitting in vehicles and buildings. The central engineering challenge is no longer the efficiency of an individual motor or chiller but the integration of buildings, vehicles, storage, distributed generation and flexible demand into a single system. Efficiency is one wedge within that transition, not the whole

of it, and it will be valued for how well it fits with the others.

This shapes how the sector organises itself. Energy conservation, energy efficiency, demand-side management and demand response have often been treated as separate agendas with separate constituencies, when they are stages of one virtuous cycle. The goal is optimisation of the whole energy system rather than maximisation of any single metric, which means moving from using less energy to using energy more intelligently and more flexibly.

The same logic argues for reviving integrated resource planning in a serious form. Efficiency and solar belong together, and the natural sequence is to remove waste first and then size the renewable supply to the demand that remains. Planning that brings supply additions and demand reduction together will deliver far more for the utilities, states and industries that have to implement it.

It also requires a broader account of what efficiency is worth. Justifying it through saved kilowatt-hours and avoided tonnes of carbon dioxide understates the case considerably. Efficiency lowers peak demand and therefore the capacity that has to be built; it reduces household and commercial bills, releasing money to be spent or invested elsewhere in the economy; it improves the competitiveness of Indian industry; and it strengthens energy security by reducing exposure to volatile fossil-fuel prices. It is also unusually employment-intensive, involving manufacturing, construction, installation, auditing and servicing, with direct, indirect and induced effects well beyond the project itself.

International comparisons consistently show that energy efficiency and renewable energy generate significantly more jobs per dollar invested than fossil-fuel supply — a finding supported by the WBG's analysis in the "Power More with Less" paper and documented in ESMAP's work on the job creation potential of the clean energy transition. India's own efficiency programmes bear this out: EESL's LED and street lighting programmes alone involved large-scale manufacturing, logistics, installation, and maintenance chains across the country. On

this reckoning, efficiency is a genuine no-regrets option, pursued for reasons of cost and security quite apart from climate mitigation.

Technology is making the next phase affordable as never before. Artificial intelligence, big data, remote monitoring, asset-performance analytics and low-cost sensing can extend the reach of energy management systems, cut the cost of measurement and verification, make demand side management and demand response practical at scale, and turn assessments that once required expensive site work into routine exercises — a drone survey of a rooftop or a flare stack or remote thermal imaging of buildings being a small illustration of a large change.

The sector will gain most by concentrating on applications that deliver measurable energy value, and the most useful will emerge when data and artificial intelligence specialists work alongside energy engineers rather than in parallel, and when auditors, energy managers and service companies are equipped for a role that rewards finance and data skills as much as thermodynamics.

What gives this urgency is the arithmetic of asset lifetimes: buildings and plants commissioned today will run for thirty to forty years, so efficiency designed into them now is efficiency secured until mid-century — precisely when India's 2070 “Net-Zero” commitment falls due.

THE WAY FORWARD

Four commitments would carry India's efficiency agenda from paper to practice.

The first is to treat public and concessional money as risk capital rather than project capital, using it to de-risk lending and draw commercial banks into segments they are still getting to know, and to bring financiers in at the point where projects are conceived rather than sanctioned. The PRSF demonstrated this principle at the ESCO

level; the EESL PforR demonstrated it at the programme level. The next step is to replicate the model in segments — agriculture, cold chains, small industry, affordable housing — where the financing gap remains wide and no bankable instrument yet exists at scale.

The second is to deepen how the centre engages the states. Rather than asking every state to implement the same national action plan, the starting point can be what the state itself is trying to achieve — employment, lower government energy expenditure, lower consumer bills, industrial competitiveness, housing or energy security — with the national framework then translated into the interventions that serve that objective.

Kerala, for instance, where remittances finance a large share of new housing, might achieve more by linking building-code compliance to cash incentives or lower-interest home finance through local banks than by attempting to cover every commercial building and small enterprise at once. Prioritisation is not a compromise when resources are finite; it is the surest route to scale.

The third is to empower the institutions that enforce. State designated agencies need trained people, and they will achieve still more with statutory authority, standing with utilities and municipalities, and political backing to secure compliance. Diagnostics can usefully complement scorecards: for each state, which single enabler — staffing, skills, authority, enforcement or aligned incentives — will unlock the fastest progress, and how best to provide it.

The fourth is to measure what truly matters. While the metric remains saved units of electricity, efficiency will be read as a subsidiary of supply. Once it becomes system value — capacity avoided, peak reduced, competitiveness gained, jobs created, security improved — efficiency takes its rightful place in integrated planning alongside generation and storage.

To the next generation of energy efficiency and net-zero professionals in India, the message is this: the instruments have been built, and they work. Your generation's task is not to design new frameworks but to implement them — at a pace set by India's growth, at a depth that reaches every state and sector, and with a financial sophistication that turns efficiency from a project into an asset class. The country's 2070 net-zero commitment will not be met by the policies written today; it will be met by the investments made in the next ten years, in buildings, factories and cities that will still be standing in 2060. You are the generation that makes that happen.

India is perhaps halfway through this transition. The first half was the harder intellectual task: building a legal framework, a national institution, a professional workforce and public conviction where almost none existed. The second half is the harder institutional and financial task, because it requires converting all of that into investment, in thousands of enterprises and across every state, at a pace set by the country's growth rather than by the budget cycle.

Government, industry, financiers and technology providers each hold a part of the answer and none holds all of it. The next 25 years will not be judged by the policies India writes. They will be judged by the capital it mobilises, the states that deliver, and the energy the economy never has to buy.

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KEY TAKEAWAY

This journey proved that energy efficiency is not merely about saving kilowatt-hours or gigajoules; it is about decoupling economic growth from greenhouse gas emissions, enhancing energy security, driving innovation, and delivering direct economic benefits to hundreds of millions of households and enterprises. Today, India is no longer just adopting solutions, it is leading the global conversation on energy efficiency.

FROM SUFFICIENCY TO PRODUCTIVITY

India's next efficiency frontier is energy system resilience and investment quality.

Brian Dean

For me, this story starts with the opportunity to work in India alongside the people driving early progress and training the next generation who have since grown into energy efficiency leaders across the country and around the world. Over the past quarter-century, I have seen the evolution of building codes, standards, labeling, and an energy efficiency culture that has shifted from a novel concept to a widespread norm.

A SHARED EXPERIENCE

At the turn of the 21st century, India was facing severe electricity supply deficits, rapidly escalating energy demand driven by economic expansion, high transmission and distribution losses, and an industrial sector operating with energy intensities above global benchmarks. At the time, energy efficiency was largely viewed as energy sufficiency - where people and businesses were encouraged to conserve energy rather than seeing efficiency as an indispensable pillar of national infrastructure, macroeconomic stability, and environmental stewardship.

When I moved to India in 2007, those structural challenges were evident in daily life. Yet, navigating the daily constraints forged a shared survival experience: a common consciousness around conserving energy and operating homes, businesses, and mobility efficiently to withstand power outages and lead a dignified life. This groundwork

met a massive shift when New Delhi entered a major modernization boom in preparation for the 2010 Commonwealth Games. That period catalyzed a rapid transformation in transport efficiency across personal vehicles, urban transit, and aviation, successes that quickly swept across other Indian cities.

Fast forward to today, and energy efficiency has evolved into a central engine of India's energy policy, industrial competitiveness, and climate strategy. India is now recognized globally as a pioneer in institutionalizing demand-side management, deploying market-based efficiency mechanisms, and scaling high-efficiency technologies at unprecedented speed and low cost.

"India's journey toward its 2070 Net Zero commitment will be constructed in the coming decades on the foundation laid over the past quarter-century. The opportunity to shape a resilient, sustainable, and prosperous India is in your hands."

Active building codes, appliance labeling, and advanced tech deployment are now standard practice. Energy efficiency in everyday life today - a home with LED lighting, electric cooking, efficient ceiling fans, efficient air conditioning, and more. All of this has set the stage for electrification systemically across both energy supply and energy demand in India.

This transformation did not occur by accident. It is the result of deliberate capacity building, policy design, statutory framework development, groundbreaking institutional models, aggressive industry adoption, and international multi-stakeholder collaboration.

As India progresses toward its ambitious target of reducing the emissions intensity of its GDP by 45 percent by 2030 from 2005 levels and achieving Net Zero emissions by 2070, the lessons learned over the last 25 years offer both a proven foundation and a strategic blueprint for the decades ahead.

DELIBERATE STEPS TO DELIVER PROGRESS

India's energy efficiency evolution is anchored in foundational legislative and institutional framework. The statutory journey began with the Energy Conservation Act of 2001, which mandated energy standards for intensive industrial consumers and established the Bureau of Energy Efficiency (BEE) in 2002 under the Ministry of Power. BEE serves as the central agency executing nationwide regulatory standards and capacity building.

This legislative mandate was significantly broadened by the 2022 Amendment Act, which introduced carbon reduction mechanisms and laid the ground for energy efficiency in the Indian Carbon Market.

To transform consumer behavior and drive market efficiency, the government launched the Standards & Labeling program in 2006. Featuring the recognizable 1 to 5 “Star Rating” system, the initiative shifted buyer behavior from upfront cost consideration to long-term lifecycle energy savings.

The program made star ratings mandatory for major high-volume appliances—such as air conditioners, refrigerators, and ceiling fans—while periodically tightening baseline performance criteria to force manufacturers to adopt more efficient compressors, motors, and electronics.

In the industrial sector, energy conservation took a market-based leap following the 2008 National Mission for Enhanced Energy Efficiency, which introduced Perform, Achieve and Trade, which set mandatory consumption targets for over 1,000 heavy industrial facilities across multiple cycles and created direct financial incentive to lower industrial energy usage.

Complementing regulatory mandates, public-sector innovation transformed technology deployment. In 2009, four state-owned power

utilities established Energy Efficiency Services Limited (EESL) to act as a super-ESCO. EESL implemented bulk procurement strategies to lower technology costs, most notably through the 2015 lighting programme UJALA that distributed over 360 million bulbs nationwide.

Finally, addressing the rapidly expanding built environment, BEE introduced sector-specific building codes. The Energy Conservation Building Code, launched in 2007 for commercial structures, evolved through updates in 2017 and expanded into the comprehensive Energy Conservation and Sustainable Building Code in 2024.

For the residential sector, BEE rolled out the Eco-Niwas Samhita in 2018 to prioritize passive cooling, daylighting, and thermal comfort, embedding sustainable design directly into urban development.

MOVING FORWARD WITH ECONOMIC VALUE

While the accomplishments of the last 25 years are extensive, the next decade presents a fundamentally different landscape. Energy efficiency is no longer isolated to reduction of power consumption, it is now intrinsically tied to deep decarbonization, power grid integration, electrification, and digital transformation.

Deep Industrial Decarbonization and Green Hydrogen: Energy-intensive industries (hard-to-abate sectors like steel, cement, heavy chemicals, and refining) must transition from incremental energy efficiency gains to radical process innovation. Opportunities include:

Smart Grids, Demand Flexibility, and Energy Storage: As variable renewable energy (solar and wind) reaches higher grid penetration levels, energy efficiency must evolve into dynamic Demand-Side Flexibility. Priorities include mass deployment of 100s of millions of smart meters for real-time time-of-day tariff optimization, integration of automated demand response to align load profiles with renewable generation peaks and combining battery energy storage systems with

pumped hydro storage, thermal storage and other non-battery energy storage.

Net-Zero Buildings and Cooling: With massive urban infrastructure build-outs expected across secondary cities, building energy efficiency is a high priority, including to scale up net-zero energy and net-zero carbon buildings through passive design, high-performance building envelopes, super efficient appliances/equipment and building-integrated photovoltaics; implementing the strategic goals of the India Cooling Action Plan to reduce cooling demand, refrigerant demand and the expansion of no-GWP and low-GWP refrigerants; enforcement of Eco-Niwas Samhita in local building bylaws for efficient sustainable homes.

Electrification of Mobility and Logistics: The rapid growth of electric vehicles across two-wheelers, three-wheelers, four-wheelers, commercial vehicles and transit presents both efficiency gains and grid challenges including to capitalize on the higher tank-to-wheel efficiency of electric powertrains compared to internal combustion engines; implement smart charging infrastructure and vehicle-to-grid frameworks to avoid localized grid congestion; and accelerating rail electrification and intermodal freight logistics optimization to lower overall transport energy intensity.

Energy Efficiency in the Indian Carbon Market: Transitioning from Perform Achieve Trade to a full-fledged compliance carbon market under the Carbon Credit Trading Scheme will drive capital directly into high-impact decarbonization and energy performance projects.

OPPORTUNITY FOR ALL

To the upcoming generation, you inherit an energy efficiency sector operating on a massive scale, supported by a strong foundation of policy and innovation. Innovate and take small actions that can drive

big change over time. Celebrate the great people around you - they will be with you for your whole career and together you and they can make the world a better place.

The challenges of the next 25 years will require a shift in mindset:

Think Systemically: Energy efficiency can no longer be evaluated in isolation. Design holistic energy systems where energy savings, renewable generation, energy storage, dynamic demand management, and carbon accounting work as an integrated ecosystem.

Embrace Digitalization: The fusion of Artificial Intelligence, Internet of Things sensors, cloud analytics, and machine learning with traditional thermal and electrical engineering will define the next frontier of hyper-efficient operations.

Prioritize Equity and Affordability: True sustainability must be inclusive. Solutions must deliver thermal comfort, clean mobility, and reliable power access to underserved communities without burdening them with high capital costs.

Drive Bold Business Models: Technology alone is insufficient without innovative financing and business models. Focus on creating scalable service contracts, green finance structures, and venture-backed technology enterprises.

Brian Dean, is the Director, Energy Transition at Sustainable Energy for All. He supports governments and organizations globally with energy efficiency and energy transitions. Over the last 29 years energy efficiency has been a priority topic for him, including in India with ICF International nearly twenty years ago, more recently with the International Energy Agency and now at Sustainable Energy for All.

KEY TAKEAWAY

India's cooling challenge is about both scale and timing, and increasing renewables is not the whole solution. Ensuring sufficient power is available during evening peaks, when cooling demand is growing rapidly but renewable output is low, is emerging as a critical electricity security challenge. Energy efficiency can help.

INDIA'S ENERGY EFFICIENCY JOURNEY - REFLECTIONS AND PRIORITIES

The task of energy efficiency professionals will be to ensure that efficiency is treated as the first fuel, a resource in its own right that is planned, financed and delivered with the same rigour as new energy supply.

Brian Motherway

India's energy efficiency journey over the past quarter of a century has been one of securing affordable universal energy access to drive sustained economic development. Since 2000, India's energy use has doubled, improving the lives of Indian citizens. Indians now have greater access to services such as cooling, transport, appliances and locally manufactured products than ever before.

At the same time, the economy's energy intensity has decreased by over 40%, indicating that the growth in energy consumption and the economy has been coupled with energy efficiency gains.

The defining feature of this journey has been the effort to use efficiency not only as a climate or energy-security tool, but also as a development strategy.

Energy efficiency has played a central role in lowering costs for consumers and businesses, also reducing pressure on electricity systems and supporting access to modern energy services across India. The Energy Conservation Act of 2001 laid the foundation for much of the energy efficiency policy that is in force today.

With the Bureau of Energy Efficiency at the helm, the Act ushered in an age of sustained efficiency action. India introduced its emblematic

star rating system for appliances in 2006, building energy performance requirements in 2007, and established Energy Efficiency Services Limited (EESL) in 2009. EESL has since become the world's largest super-ESCO, saving nearly 50 billion kWh.

The success of its UJALA LED programme helped put energy efficiency on the map in India's policy landscape. It used bulk procurement to cut LED bulb prices by over 80% in three years and expand the market tenfold within five years, demonstrating to international audiences how market aggregation, rather than subsidies, can scale efficient technologies while supporting innovation and industrial growth. Plans to implement similar schemes for electric cooktops and e-bikes show India's continued commitment to faster efficiency improvements.

Policies in industry, such as the Perform, Achieve and Trade (PAT) scheme, have also shown how India has leveraged sectoral and government collaboration to drive progress. As the world's first market-based mechanism that specifically targets energy efficiency in industry, it is also a pioneering case.

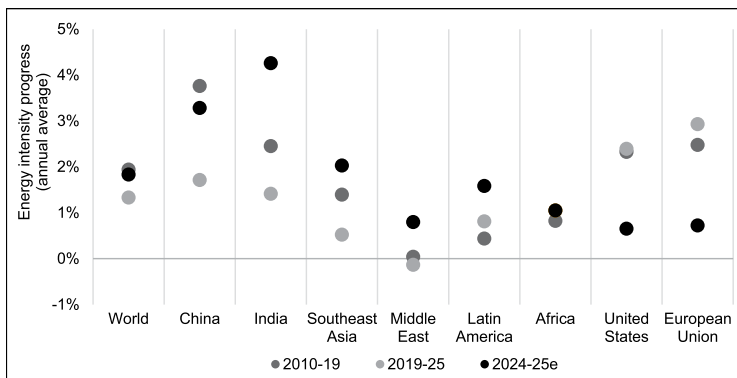
Since 2012, PAT has set mandatory energy-saving targets for energy-intensive industrial plants while giving companies flexibility on implementation. The first PAT cycle (2012-2015) alone achieved 8.67 Mtoe (about 0.36 EJ) in energy savings, with a cumulative saving of nearly 26 Mtoe (about 1.1 EJ) today.

The Bureau of Energy Efficiency's early engagement with key industry stakeholders, such as the Confederation of Indian Industry, was instrumental in the design and outcomes of the PAT scheme. It demonstrates that energy policy and industrial development go hand in hand, driving both domestic markets and jobs, while supporting Indian enterprises that have become major players in international markets. India's energy efficiency policy has thus delivered not only substantial energy savings but also significant socio-economic benefits.

The consistent improvement rate of energy intensity (around 2.5%) in

India between 2010 and 2019 attests to the strength of these policies, and a recent rebound suggests that India is still a global leader on efficiency.

Improvement in primary energy intensity, selected countries and regions, 2010-2025e



IEA. CC BY 4.0.

Note: 2025e = estimated values for 2025.

Source: IEA (2025), Energy Efficiency Progress Tracker.

India's role on the international stage reflects this. During India's G20 presidency in 2023, working with the IEA, the government developed the Strategic Plan for Advancing Energy Efficiency across Demand Sectors by 2030, showing that a 3.2-4% global annual improvement in energy efficiency is possible by the end of the decade.

It also championed the role of efficient cooling and thermal comfort through the G20 Voluntary Action Plan. Beyond this, the IEA has been a proud partner of India on its energy efficiency journey, working closely with the Bureau of Energy Efficiency on policy matters since 2014 and hosting Energy Efficiency Policy Training weeks in New Delhi in 2018 and 2023. This collaboration has significantly contributed to the IEA's analysis and understanding of global policy best practices.

EMERGING OPPORTUNITIES AND PRIORITIES FOR THE COMING DECADES

The next decades will be shaped by the scale of India's demand growth. IEA analysis finds that India is set to see faster energy demand growth than any other major economy, driven by urbanisation, rising appliance ownership, cooling demand, industrial expansion and infrastructure development. Energy efficiency can ensure the benefits of this growth are fully realised.

Buildings in particular represent an opportunity for increased efficiency gains. As more than 80% of India's buildings are yet to be constructed, strengthening building energy code coverage and enforcement represents a crucial measure to ensure that the homes, offices, hospitals, schools and factories constructed in the coming years are not only efficient but also ready to play a part in future energy systems.

Further developing India's current building energy code to include elements such as energy management systems and building-to-grid interactivity can support the transformation of the country's buildings into highly efficient, proactive participants in the country's energy system. Here, the IEA has collaborated with experts in India to outline potential further policy opportunities for efficient grid-interactive buildings.

INDIA IS RISING TO THE CHALLENGE OF GROWING COOLING DEMAND AND GRID PRESSURE

In recent years, India has risen to the challenge of pairing energy efficiency with solar power to provide more extensive cooling services against the backdrop of increasing temperatures. In the last decade, penetration of air conditioners in India has grown from 5% to 16%. This necessary, growing uptake of air conditioners is placing increasing pressure on India's power system.

According to IEA data, every additional degree of average temperature in 2026 added around 11 GW of peak electricity demand, up from about 7 GW in 2024 and around 4 GW in 2019.

To meet this growing demand, India has invested significantly in renewable energy. Solar PV alone has attracted USD 113 billion in cumulative investment in the past decade, compared with USD 112 billion for all fossil fuel power generation sources combined. It has also driven the uptake of rooftop solar through programmes such as PM Surya Ghar: Muft Bijli Yojana.

However, India's cooling challenge is about both scale and timing, and increasing renewables is not the whole solution. Electricity demand in hot seasons peaks both in the middle of the day, when there is abundant solar, and at the end of the day, when solar is limited. Ensuring sufficient power is available during evening peaks, when cooling demand is growing rapidly but renewable output is low, is emerging as a critical electricity security challenge. Energy efficiency can help.

India has taken action to encourage efficient cooling that drives down these peaks. Examples include requiring a 24°C default temperature setting for all room air conditioners since 2020, the deployment of super-efficient fans, piloting district cooling systems and community-led cool roof programmes that encourage passive cooling solutions in cities such as Jodhpur, Bhopal, Surat, and Ahmedabad.

The government is also putting increased emphasis on demand-side flexibility with new rules that will enable consumers to receive price signals to shift electricity consumption away from peak periods. Ensuring the ongoing success of these policies will be vital to India's future energy systems.

MESSAGE TO THE NEXT GENERATION OF PROFESSIONALS AND LEADERS

Four key elements related to India's efficiency journey bear repeating explicitly. First, rising energy demand makes efficiency indispensable: as India's buildings, industries and services grow, efficiency's role is of growing significance. Second, efficiency is not only an energy and climate measure but a driver of wider socio-

economic development, lowering costs for households and businesses, supporting access to cooling and appliances, and strengthening industrial competitiveness.

"Efficient buildings constructed today, efficient appliances sold this decade, and efficient industrial systems installed now can maximise the potential of power generation and grid systems by laying the groundwork for decades of smart, efficient demand."

Third, India has shown that this progress can be achieved with policies that create domestic industries and jobs as well as internationally competitive products. Fourth, greater demand flexibility is needed to manage integration of renewables to secure affordable and clean power as demand patterns become more dynamic.

The next generation of energy efficiency professionals in India, therefore, inherits a sector that sits at the heart of the energy transition. It's a sector that has played an important role in providing electricity access to over 700 million people since 2000 and is central to ongoing affordability, competitiveness, flexibility and decarbonisation.

It is also a sector that is experiencing significant growth - global employment in energy efficiency in recent years has been led by India.

The task of energy efficiency professionals will be to ensure that efficiency is treated as the first fuel, a resource in its own right that is planned, financed and delivered with the same rigour as new energy supply.

Those working in the field must remain aware of both the big picture and the daily impacts of energy efficiency. From factories to households, it goes beyond just how energy can be saved, impacting the design of cities and homes, the products people buy, the ways they commute and their daily habits.

Efficiency means improving quality of life and securing enough power for everyone to be able to turn the lights on, but also creating behaviours and systems that, when suitable, turn the lights off.

The IEA's partnership with actors such as the Bureau of Energy Efficiency and the Confederation of Indian Industry has allowed it to both collaborate on and learn from policy in India.

The country has already shown that efficiency can be delivered at scale, from LEDs to industrial energy savings; it is a pioneer in both grassroots and systemic energy efficiency solutions. But as the urgency to reduce emissions and respond to increasing temperatures increases, so too does the importance of energy efficiency.

The stakes today are higher than ever before, and as the world's fastest growing and most populous economy, the mission of efficiency professionals in India is one of global significance.

This is not just because India's energy system has global impacts, but because the thoughtfully designed and targeted measures provide important lessons for the wider international community.

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KEY TAKEAWAY

India's energy efficiency journey has delivered more than energy savings and avoided emissions. It has created a practical capability: the ability to improve industrial productivity through better use of energy, supported by institutions, markets, professionals, and industry confidence. The opportunity now is to deepen that capability at home, and to share it with others working towards similar goals.

BUILDING CAPABILITY, NOT JUST SAVINGS

How energy efficiency became a business discipline in Indian industry – and what remains to be done.

Chandrajit Banerjee

Twenty-five years ago, energy efficiency sat at the margins of most industrial conversations in India. Today, it shapes how well-run companies plan investment, manage operations, and measure performance.

The change came through patient institution-building, sustained industry participation, credible measurement, and a willingness to treat efficiency not as a compliance obligation but as a source of competitiveness. We have learnt a great deal from global practice along the way, and we continue to learn. That, more than any single number, is the achievement of the last twenty-five years.

AN ARCHITECTURE BUILT FOR ACTION

One lesson stands out: durable outcomes need a durable architecture. The Energy Conservation Act, the Bureau of Energy Efficiency, the Perform, Achieve and Trade Framework, and later the move towards a carbon market created a system in which policy ambition could be translated into repeatable action. Its strength lies in its practicality. It did not prescribe a single route for every plant, recognising that each facility has a distinct history and opportunity set. As per data published by the Ministry of Power in 2025, the Perform, Achieve and Trade Scheme covers 1,333 units across 13 energy-intensive sectors, and has delivered savings of 27.07 million tonnes of oil equivalent. It has drawn about ₹75,000 crore of investment into energy-efficient technologies. Once efficiency enters the balance sheet, it moves

to the centre of management attention. Over time, the system did something even more valuable than deliver savings: it changed behaviour. Plants began to measure performance more seriously, management teams treated energy productivity as a business issue,

"Efficiency should not be positioned as a restraint on growth, but as a way to make growth stronger, more competitive, and more resilient."

and policymakers gained confidence that market-linked mechanisms could work in Indian conditions. The Carbon Credit Trading Scheme is therefore a progression rather than a disruption, resting on a working platform of measurement, accountability, and verification.

CREDIBILITY BUILT ON THE GROUND

Policy architecture matters, but conviction comes from performance on the ground. Indian industry has increasingly embedded efficiency into daily operations rather than treating it as an occasional project, and the results are visible nationally. The International Energy Agency, in its Energy Efficiency 2025 report, estimates that India's energy intensity improved by more than 4 per cent in 2025, against a global improvement of 1.8 percent. Collaboration has helped. Voluntary rating systems, national awards, plant assessments, and peer-learning platforms have allowed companies to compare, learn, and improve together. One practical insight has emerged from this: efficiency need not be added later as an afterthought. It can be built into investment decisions and management systems from the beginning, which is often easier and less expensive.

WHY THE PERFORMANCE ENDURES

Endurance rests on people as much as on policy. India has built a growing community of energy professionals, auditors, and managers who carry this agenda inside enterprises. Industrial change is sustained not by aspiration alone, but by responsibility placed in capable hands. When energy performance becomes someone's mandate, it gains

continuity. The same is visible on the consumer side. According to the Bureau of Energy Efficiency, the Standards and Labelling Scheme now covers 41 categories of equipment and appliances, of which 19 carry mandatory labelling, and is projected to save about 11.2 billion units of electricity and avoid close to 9 million tonnes of CO₂ by 2030. This has built consumer trust, encouraged manufacturers to improve, and created the institutional habit of raising ambition.

THE TASK THAT REMAINS

A fair assessment must also recognise what remains to be done. The next frontier is to carry this discipline beyond large enterprises into smaller firms and dispersed industrial clusters, which often work with limited access to finance, advice, and technology. As per the Ministry of Micro, Small and Medium Enterprises, over 9 crore enterprises are registered on the Udyam platform, employing more than 40 crore people, and the Economic Survey 2025-26 places their contribution at about 31 per cent of GDP and nearly half of our exports. For many smaller enterprises, the challenge is not intent but confidence – that a new technology will work, that production will not be disrupted, that savings will materialise, and that finance will be available on sensible terms. The answers are practical: cluster programmes that aggregate small opportunities into a financeable proposition, demonstration units a proprietor can walk through, better advisory support, risk-sharing and financing models, and measurement systems designed for units never audited before. This is the work now under way.

SHARING WHAT WE HAVE LEARNT

Some of this experience has travelled abroad as case studies, and Industry in other countries have taken an interest in it. India's experience in building these solutions amid capital constraints, uneven measurement systems, varied firm sizes, and rapid growth could be valuable to many developing economies facing similar conditions. Where that experience is useful, India can contribute equipment designed for demanding operating conditions, engineering and retrofit

services grounded in field practice, measurement and verification capabilities, rating systems, and professionals who know how to make efficiency work inside real enterprises. We continue to learn from partners elsewhere in equal measure.

FROM ENERGY SAVED TO VALUE CREATED

We should also change how we speak about efficiency. For years the conversation has centred on energy saved and emissions avoided. These remain important, but the more useful lens is energy productivity: how much value, output and service we create from every unit of energy consumed.

Seen this way, efficiency is not an environmental add-on but a competitiveness agenda. It lowers operating costs, strengthens resilience against price volatility, improves resource security, and increasingly supports market access. As global trade becomes more sensitive to carbon performance, verified efficiency will become a commercial credential.

CII has had the privilege of working with Indian industry through much of this journey. Over three decades, its platforms on energy efficiency have brought together companies, policymakers, experts, and practitioners to learn from one another and raise ambition. Enquiries now come from within India and from other countries seeking benchmarking, plant assessments, and capability-building.

THE NEXT TWENTY-FIVE YEARS

Three priorities should define the period ahead. First, complete the domestic task by carrying efficiency into smaller enterprises and industrial clusters, where the largest untapped gains lie. Second, position efficiency as a competitiveness agenda rather than a compliance obligation, so that boards track energy productivity as closely as cost, quality, and delivery. Third, build our technologies, services, and professional capabilities steadily, so that they are ready when partners abroad find them useful.

To Indian industry, the call is a simple one. Treat energy productivity as a boardroom priority, carry your suppliers and smaller partners along with you, and keep improving. India has learnt much from the world over these twenty-five years and now has some experience of its own to offer in return. The next phase should be defined by the quality of what we build at home, as well as by our willingness to work alongside others travelling the same road.

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KEY TAKEAWAY

Industrial energy efficiency will scale when technical demonstration is paired with bankable finance, institutional support, market confidence, and enterprise-level capacity turning proven savings into standard business practice.

COMPETITIVENESS, POWERED EFFICIENTLY

Why efficient energy use is becoming central to the cost competitiveness, market access and innovation strength of Indian manufacturing

Cristiano Pasini

India's industrial sector has arrived at a defining juncture. Manufacturing growth and innovation are central to the vision of Viksit Bharat 2047, and the question of how industry uses energy, and how efficiently it does so, has moved from a technical concern to a strategic one. Over the past twenty-five years, energy efficiency in India has travelled from the margins of plant housekeeping to the centre of industrial policy. The focus has now shifted from proving that efficiency works, to ensuring that efficiency is central to industrial expansion and diversification.

For the United Nations Industrial Development Organization (UNIDO), this convergence of competitiveness and sustainability sits at the heart of its mandate, and is central to its long-standing collaboration with India's industrial ecosystem. That collaboration, spanning clusters, financing institutions, technology developers and government programmes, offers a useful vantage point from which to consider what the next phase of India's efficiency journey will entail.

A GLOBAL CONTEXT

UNIDO's recent Industrial Development Reports situate these questions within a set of megatrends reshaping global production, foremost among them the energy transition, alongside the fourth industrial revolution, shifting trade patterns and demographic change. The argument running through them is that access to sustainable energy

underpins development more broadly, and that industrial policy would benefit from treating the energy transition as an organising principle for growth rather than a constraint upon it.

Read against this global picture, India's experience is particularly interesting. Few economies are attempting industrial expansion and industrial decarbonisation

"Efficiency is no longer only about cost savings; it is becoming integral to competitiveness, market access, and the future strength of Indian manufacturing."

at the same time, on a comparable scale, with a manufacturing base as widely dispersed. National energy intensity can improve steadily while the great majority of enterprises remain untouched. The more meaningful question for an energy transition is whether it reaches the smaller, dispersed and capital-constrained end of the industrial base, not only its largest players. It is on that front that India's MSME sector offers one of the clearest available demonstrations of what an inclusive transition can look like.

THE SCALE OF THE MSME CHALLENGE

India is home to more than sixty million micro, small and medium enterprises. Together they account for an estimated one-fifth to one-quarter of the country's industrial energy consumption, with associated emissions in the range of 110 to 200 million tonnes of carbon dioxide equivalent annually. They are also the enterprises facing the greatest constraints to optimize their energy usage.

A typical unit has typically no dedicated energy manager, no capital budget for equipment that is not yet in urgent need of replacement, and no scale with which to negotiate favourably with technology vendors. Investment decisions are taken under working capital pressure, where the immediate claim on cash usually prevails over the measure that

pays for itself within the year.

The Bureau of Energy Efficiency has identified 184 energy-intensive MSME clusters accounting for approximately ninety-two percent of the sector's total energy use and emissions. That concentration is significant, and encouraging. It means a challenge that is vast in enterprise numbers is far more tractable in geography, allowing for shared technical infrastructure, aggregated demand, common vendor networks and the peer effects that no enterprise-by-enterprise approach could generate. It also sets the standard against which any intervention must be judged: to matter at this scale, it has to be designed for structural rather than incremental impact.

WHY DEMONSTRATION ALONE DOES NOT SCALE

UNIDO's approach in India has combined direct engagement with manufacturing MSMEs across industrial clusters, identifying efficiency opportunities and supporting their adoption at enterprise level, with support for indigenous capacity to commercialise and deploy clean technologies suited to Indian operating conditions.

A consistent finding across this programming is that demonstration alone does not scale. Technology demonstration on its own has generally proved insufficient to sustain adoption once a programme concludes, unless it is accompanied from the outset by the institutional and financial infrastructure needed to carry that adoption forward.

A successful pilot is not a smaller version of a successful market. A demonstration establishes whether a technology works; it does not settle the questions that determine whether the next hundred enterprises will buy it, namely who finances it, who services it, who stands behind its performance, and who the enterprise turns to when faced with operational challenges.

International experience reflects the same pattern. Scaling industrial energy efficiency depends not only on the availability of finance or of proven technology, but on financial incentives, technical assistance, project preparation and institutional support working together, so that individual projects become genuinely bankable rather than dependent on continued grant support.

This understanding shapes the design of UNIDO's current programmes in India, which place as much emphasis on the financing instruments that allow efficiency gains to be sustained as on the technologies themselves. It extends to how innovation is supported as well. Mentorship, structured engagement with industry and access to investors have proved as decisive in moving a technology from validation to commercial deployment as the financing that accompanies them.

DE-RISKING ADOPTION: TECHNOLOGY AND FINANCE TOGETHER

Efficiency measures in small manufacturing units are frequently both effective and commercially attractive, with paybacks of well under a year documented for a range of interventions. The obstacle is rarely the arithmetic. It is the distance between an attractive calculation and a decision an enterprise owner is willing to take with limited capital, imperfect information and limited margin for a suboptimal solution.

Closing that distance is the purpose of Promoting Market Transformation for Energy Efficiency in MSMEs, a programme implemented with the Ministry of Micro, Small and Medium Enterprises with funding support “the Global Environment Facility. It works on two fronts simultaneously.

On the technical side, the programme has engaged twelve energy-intensive clusters, from tea processing in Jorhat to pharmaceutical

manufacturing in Medak and forging operations across Batala, Jalandhar and Ludhiana. Thirty-eight energy-efficient technologies have been approved for deployment, each accompanied by a technical specification and an estimator tool that allows an enterprise to assess likely savings and payback before committing. The intent is to replace persuasion with evidence the enterprise can verify for itself.

On the financial side, work is under way to establish the Energy Efficiency MSME Revolving Fund, with a corpus of one hundred and fifty crore rupees, structured through the Small Industries Development Bank of India together with Energy Efficiency Services Limited. The fund is designed to lend against the savings an efficiency investment generates, allowing it to operate as a self-sustaining mechanism rather than a one-time disbursement.

Convergence with existing government schemes, including the Bureau of Energy Efficiency's ADEETIE scheme and the Ministry of MSME's SPICE and RAMP programmes, is envisaged to bring the effective interest rate available to participating enterprises down to a range of two to five percent. For a micro enterprise weighing an efficiency investment against every other claim on its cash, that shift alters the underlying economics considerably, and is expected to prove catalytic in supporting adoption at scale.

This support is now being extended to sixty clusters across eight priority sectors, including textiles, steel re-rolling, chemicals, food processing, and foundry and forging, through a new decarbonisation-focused initiative supported by the Global Environment Facility and implemented by the Ministry of MSME.

Designed to work through instruments already in place, including the Perform, Achieve and Trade scheme, the Carbon Credit Trading Scheme, and the ADEETIE and RAMP programmes, it is expected to unlock lifetime emissions reductions of around 5.5 million tonnes of

carbon dioxide equivalent directly and 8.4 million tonnes indirectly. Building on existing schemes rather than creating parallel ones is deliberate, and it is what allows results to outlast the programme that produced them.

THE PROCESS HEAT FRONTIER

Motors, drives and lighting have long been the accessible entry points for MSME energy efficiency. Process heat is the more challenging frontier. It accounts for a substantial share of energy use and emissions in many manufacturing operations, yet has historically received far less attention, in part because solutions must be matched closely to the temperature, duty cycle and process requirements of each application.

UNIDO has approached this through two complementary interventions. The first, implemented with the Ministry of Micro, Small and Medium Enterprises with support from the Global Environment Facility, promotes concentrating solar thermal technologies for process heating and cooling applications in industry, and has supported close to 10,000 square metres of collector area to date.

At Natural Capsules Limited in Puducherry, sixty-four paraboloid dish concentrators pre-heating boiler feed water for capsule manufacturing delivered over 273 million kilocalories of useful heat in a single year, displacing more than 29,000 litres of diesel, with a payback period of 3.3 years.

Capital support under the programme has since been raised to fifty percent, with eligible costs widened to include thermal storage and heat pump integration, in recognition that solar thermal performs best when combined with the means to store and supplement what it produces.

The second intervention addresses industrial boilers, and is

implemented with the Ministry of MSME, the National Institute for MSME and the National Productivity Council. It targets 225 boiler interventions across eight clusters, including Panipat, Bidar, Sircilla and Surat, with approved targets of close to 50,000 tonnes of carbon dioxide equivalent in annual emissions reductions. Boilers attract limited attention, yet hold significant potential for accessible efficiency gains.

MANUFACTURING AS A SOURCE OF CLEAN TECHNOLOGY

One dimension of the industrial energy transition that also deserves increased recognition is the role of innovation. Globally, industrial firms account for most green patents registered worldwide. Manufacturing is not simply a consumer of clean technology; it is a primary source of it. India, with its engineering depth, cost competitiveness and proximity to some of the world's most demanding operating conditions, has every reason to be on the producing side of that equation.

The Facility for Low Carbon Technology Deployment, run with the Bureau of Energy Efficiency and supported by the Global Environment Facility, is built around that proposition. It has conducted nineteen innovation challenges and four accelerator cohorts. From close to 850 applications, 140 start-ups have been supported through technology validation, and 51 have achieved commercial deployment.

The leverage is worth noting. Direct project support of approximately USD 4.01 million, combined with USD 2.70 million in co-financing from the start-ups themselves, has helped catalyse some USD 41 million in follow-on investment and USD 23 million in confirmed market orders. The technologies commercialised through the facility are estimated to deliver annual savings of 179 gigawatt-hours of energy and 2.6 million tonnes of greenhouse gas emissions.

The validation process itself engaged more than 250 industry partners, giving early-stage innovators access to real operating conditions that are otherwise almost impossible to secure at that stage of commercialisation. That access, more than the funding, is often what determines whether a technology reaches the market. Investors need such validated evidence to support solutions beyond laboratory results.

The Green Business Centre of the Confederation of Indian Industry has played a valuable role in the success of this programme, and has extended similar support to innovators well beyond its formal scope. That contribution points to a wider feature of the Indian ecosystem: the institutions that convene industry are often those best placed to carry a technology across the gap between proof and purchase.

INSTITUTIONS, INDUSTRY AND THE ARCHITECTURE OF CHANGE

This body of work is carried out in close cooperation with government and functions symbiotically with India's own institutional architecture for energy efficiency and industrial policy. UNIDO's technical contribution is best understood as complementary to that framework, situated within its broader enabling functions of technical cooperation, analytical and advisory services, standards and normative support, and convening for partnership.

In practice, this means demonstrating technical and commercial feasibility at enterprise level, helping build the institutional and financial infrastructure required to sustain adoption beyond individual project cycles, and generating primary evidence to inform future initiatives and policy discussion.

Private sector actors occupy an equally indispensable position within this architecture. Industry associations provide a direct channel of engagement with enterprises, convene platforms for peer learning,

and play a central role in translating technical possibility into standard business practice.

Equally important is the willingness of individual enterprises, from large industrial players to the smallest units, to participate in technology validation and demonstration, to adopt efficient processes once the commercial case has been established, and, in a number of instances, to carry the model further on their own initiative. It is through this sustained alignment of government policy, multilateral technical cooperation and private sector ownership that structural change in industrial energy use becomes achievable at the scale India's manufacturing sector requires.

THE DECADE AHEAD

As India continues to expand its manufacturing base, the energy efficiency of that expansion will shape both its cost competitiveness and its environmental footprint for decades to come. Decisions taken in this period will be locked into plant and equipment with working lives measured in twenty and thirty years.

UNIDO's global experience points to a consistent understanding of what sustains progress. Industrial energy efficiency works best as a driver of competitiveness rather than a cost of growth, and it is realised through policy and standards, institutional capacity, market know-how and finance working together, rather than through any one of these in isolation. India's experience reflects that pattern at considerable scale, and offers a useful indication of where the emphasis is likely to fall next.

Two developments appear particularly relevant to the period ahead.

The first concerns scale. The gains demonstrated at cluster and enterprise level over recent years have laid the groundwork for a broader ambition, namely extending those results across the full breadth of India's energy-

intensive clusters and moving from demonstrating what is possible to establishing what is standard. That transition depends less on new technology than on repetition, familiarity and the confidence that comes from seeing a neighbouring unit succeed.

The second concerns the changing commercial context for energy performance. As buyer requirements in export markets place growing weight on energy and emissions intensity, efficiency is increasingly bound up with market access itself.

What was once a cost argument made to a finance manager is becoming a condition of supply negotiated with a customer, and that changes both the urgency of the decision and where it sits within the firm.

Taken together, these developments point to a clear priority for the years ahead: closer alignment between the institutions, the financing and the market signals that shape industrial energy use, so that gains already demonstrated can take hold across the wider base.

Some useful insights have emerged with recent experience that may prove useful. Strategies that have worked include financing cluster-level efficiency against savings rather than collateral; developing verification that enterprises can trust before committing to a given technology; extending scope to different processes and equipment to maximize efficiency gains; giving Indian innovators earlier access to real industrial operating conditions; and aligning industry associations, financiers and government programmes to a common timeline rather than a sequential one.

UNIDO welcomes partners, in industry, in finance and in the innovation ecosystem, to continue building on this work at the scale India's manufacturing sector requires.

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KEY TAKEAWAY

Three conditions have determined where India's efficiency effort has succeeded and where it has stalled: visibility, bankability and scale. The next phase must add system value, ensuring that efficiency strengthens productivity, grid flexibility, renewable integration and long-term industrial competitiveness.

BEYOND CONSERVATION: INDIA'S NEXT EFFICIENCY AGENDA

India's next efficiency chapter must deliver productivity, flexibility and competitiveness

Girish Sethi

India will need more energy. That much is settled. The open question is whether the industrial capacity being locked in today will operate at its most efficient for the decades it is likely to remain in service. Cement and steel capacity will continue to expand, a new ecosystem around semiconductor manufacturing is emerging as an energy-intensive consumer, and data centres are becoming a more visible load on the grid. Together they mark a phase of industrial expansion that the energy efficiency movement has not previously had to reckon with.

Twenty-five years after energy efficiency was institutionalised as national policy, India's growth ambitions, framed by the vision of Viksit Bharat 2047, demand that efficiency be understood differently: not as a conservation exercise at the margins of industrial decision-making, but as a determinant of competitiveness, energy security and economic productivity. The next chapter must therefore shift from saving energy to multiplying the value every unit delivers.

FROM HOUSEKEEPING TO STRATEGIC PILLAR

The origins of India's energy efficiency effort lie in something more modest than today's low-carbon strategy. In the years before the Energy Conservation Act of 2001, efficiency was largely a housekeeping matter: switching off lights, trimming waste at the margins and improving operational discipline. Bodies such as the erstwhile Energy Management Centre, the National Productivity Council, industry

associations and international development agencies did much of the early spadework. The Act changed the register entirely. India placed energy efficiency on a statutory footing, and the institutional architecture that followed — the Bureau of Energy Efficiency at the centre, designated agencies in the states, and mandated energy managers and auditors in industry — turned efficiency from a voluntary virtue into a measurable, governable variable.

Two decisions from that early period explain how far the effort travelled. The first was the standards and labelling programme, where a deliberately simple star-rating system made efficiency legible to an ordinary consumer standing in a shop. That legibility helped reshape appliance markets and encouraged manufacturers to compete on efficiency. The second was the emphasis on measurement and reporting — the practical principle that what gets measured gets managed. Building a culture of data took time, but it created the substrate for subsequent instruments, from sectoral benchmarking to market-based schemes. Alongside these, LED market creation demonstrated that national-scale adoption requires deliberate demand creation, not merely the availability of better products. These accomplishments changed how efficiency is perceived. In leading industrial sectors, including cement, fertiliser, pulp and paper and other process industries, efficiency is no longer peripheral to engineering strategy. The stronger lesson, however, is not that a few sectors have improved; it is that sustained progress came when policy signals, technical capability, measurement systems and enterprise competitiveness reinforced one another. The next phase has to extend that logic beyond large industry and into the wider economy.

WHERE THE MODEL HAS NOT REACHED

What worked for large, relatively homogeneous and capital-rich industry has not worked nearly as well elsewhere, and the gap is now large enough to matter. Micro, small and medium enterprises (MSMEs) form a substantial part of India's industrial base, yet the

instruments that transformed large cement, steel and fertiliser plants have struggled to gain similar traction among fragmented clusters. The reason is structural rather than motivational: transaction costs are higher, technical needs differ sharply across sub-sectors, and no scheme conceived for MSMEs as a single undifferentiated category can absorb that heterogeneity.

Buildings present a related but distinct failure of design. India has building energy codes, but code implementation has not kept pace with the scale and diversity of construction activity. The constraint is institutional as much as technical: buildings are governed overwhelmingly

"Efficiency's next contribution will not be measured by how much less energy India consumes, but by how much more productivity, comfort and resilience it extracts from every unit consumed."

at the municipal and state level, and a nationally designed code has limited traction until it is embedded in local building-approval processes. Efficient buildings affect electricity demand, affordable comfort, cooling infrastructure, urban liveability and public health; the governance machinery must therefore be as important as the code itself. The renewable energy transition has introduced a paradox of its own: clean-energy procurement can blunt the efficiency agenda precisely when the two need to reinforce each other. As industrial consumers increasingly contract for round-the-clock renewable supply, the immediate financial incentive to invest further in efficiency weakens — the electricity bill appears solved even when energy consumed per unit of output has not improved and demand is not being met on a real-time, hour-by-hour basis. Left unaddressed, that logic will slow efficiency investment in exactly the plants best placed to make it.

Across all three cases — MSMEs, buildings and renewable-linked industry — the common failure is design that ignores the setting, and MSME clusters show this most clearly. A foundry cluster, a glass

furnace cluster and a forging cluster are not variations of the same problem; they require different technologies, vendors, replacement cycles and multi-year support systems. Finance matters, but credit alone does not solve adoption. Local handholding, trusted equipment suppliers, installation support and patient demonstration often determine whether efficient technologies move from recommendation to practice.

THE NEXT EFFICIENCY ARCHITECTURE

The future agenda must therefore be built around four connected shifts. First, efficiency must become visible in ways that matter to users, investors and regulators. Measurement and reporting helped establish discipline in the past; the next step is to connect measurement with value, including lower peak demand, improved equipment reliability, reduced import exposure, better plant productivity, lower lifecycle cost and increased resilience. In a renewable-rich grid, the time and location of energy savings will increasingly matter as much as the quantity saved. Second, efficiency has to become bankable. This requires moving beyond the assumption that savings automatically translate into investment. Savings must be measured credibly, contracts must allocate performance risk transparently, financiers must understand sector-specific technologies, and public schemes must reduce early-stage risk where markets are not yet mature. For MSMEs, aggregation through clusters, common service providers and sector-specific platforms can reduce transaction costs and make small opportunities visible to capital. Third, efficiency must move from isolated projects to market creation — the condition this article has called scale. The UJALA programme, which took LEDs from a niche purchase to a default one, showed that efficient products can become mainstream when demand aggregation, procurement, pricing and distribution are aligned. Similar thinking is needed for industrial equipment, high-efficiency motors, heat pumps, efficient cooling, low-temperature process heat solutions and green materials. Market transformation requires demand signals, not only technology supply.

Fourth, efficiency has to be understood as a system property. Data centres, electrified industrial heat, cooling loads and distributed renewables cannot be assessed only at the asset level. Their value depends on how they interact with the grid, tariffs, storage, digital controls and demand response. A renewable power contract that offsets annual consumption may not reduce real-time system demand. Efficiency must therefore be integrated with power-sector planning, renewable integration and resilience.

FROM EFFICIENT ASSETS TO AN EFFICIENT SYSTEM

These four shifts become most visible in the next frontier of efficiency: industrial heat, new electricity loads and low-carbon industrial processes. Much of the accessible gain in large, single-site industrial efficiency has already been captured; the more consequential gains now lie in decisions that are systemic rather than asset-level. Because many industrial processes rely on thermal energy, electrification through heat pumps, electric furnaces and similar technologies is not primarily a question of technology availability. It is also a question of tariff design, delivered electricity cost and system integration.

New categories of demand pose the same systemic question in a different form. Data centres are being planned largely as conventional grid-connected loads, even as their scale could raise new questions about flexibility, dedicated supply, storage and islanded operation. Heavy industry presents an even harder frontier. Technologies such as hydrogen-based direct reduced iron in steelmaking will not become commercially viable without sustained public investment in pilots and demonstration, because first-of-kind low-carbon technologies carry risks that firms competing globally cannot absorb alone.

These choices cannot be reduced to engineering decisions inside individual plants. They involve electricity regulators, tariff structures, public procurement, technology transfer, climate finance and the timing of investment decisions. The cost of getting them wrong is not

incremental: if new capacity in cement, steel and other legacy sectors continues to be built on conventional lines, India could lock in decades of higher emissions intensity precisely when a better option was still open. The window in which these decisions can be shaped is the same decade in which the capacity is being built.

FINANCING THAT FITS THE PROBLEM

If systemic integration is the technical challenge of the next phase, financing at the right scale and duration is its practical precondition. The evidence points away from generic finance schemes and towards long, patient, sector-specific programmes. Cluster interventions in India's glass and foundry sectors show that enterprises often self-finance once technology has been demonstrated, de-risked and locally serviced. The decisive factor is not merely cheaper credit, but confidence that the technology will work, that vendors can deliver, and that savings will be realised in operating conditions. The implication for policy design is clear, if unglamorous: MSME efficiency finance will not succeed as a single national scheme trying to serve many sub-sectors at once. It requires targeted, multi-year programmes built around specific clusters and technologies, with local service-provider capacity deliberately built over the life of the programme. Government and donor funding should concentrate on early demonstration, rigorous measurement and risk reduction rather than being spread thinly across fragmented interventions.

THE WAY FORWARD

The task ahead is less about inventing a new efficiency agenda than about applying the conditions that made the first 25 years work — visibility, bankability and scale — to the parts of the system that were left behind. The next phase must also add system value: the recognition that efficiency now has to be designed alongside renewable integration, grid flexibility, industrial electrification and affordable comfort.

That means four practical priorities. MSME and buildings programmes need the patience and specificity that large-industry benchmarking never had to demonstrate. Tariff structures must allow electrified, efficient processes to compete fairly with the fuels they are meant to replace. New categories of demand — data centres, semiconductor manufacturing and electrified industrial heat — must be planned for flexibility, storage and demand response from the outset, rather than connected as conventional loads and corrected later. And pilots and field demonstrations must remain the proving ground for new technology, because no simulation can substitute for the operational learning that comes from a running plant. None of this is achievable through domestic policy and domestic capital alone, particularly where frontier technologies such as hydrogen-based steelmaking are concerned. International climate finance and technology transfer will need to be honoured in substance, not merely reaffirmed in communiqués. At the same time, domestic institutions must allocate risk intelligently, support early pilots, build local service ecosystems and make measured savings bankable.

For India's policymakers, financiers and industry leaders, the mandate is to move deliberately from a model built on compliance and measurement to one built on productivity, integration and system-wide value. The first 25 years made energy efficiency a recognised national priority. The next 25 must ensure that the capacity being built today for a growing, decarbonising economy is also the most efficient version of itself for the decades it will serve.

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KEY TAKEAWAY

Energy efficiency must move beyond isolated savings projects to become a system-level economic capability — one that shapes competitiveness, energy security and the quality of India's net-zero growth.

EFFICIENCY FIRST FOR INDIA'S ENERGY FUTURE

India's next efficiency frontier must link competitiveness, energy security and net-zero growth.

Harikumar R

India's energy efficiency movement began with a lesson the world learnt abruptly in the 1970s: energy could no longer be assumed to be cheap, abundant or geopolitically secure. The oil crisis of 1973 forced economies to confront the vulnerability created by dependence on imported fuels and inefficient consumption. For India, as for many developing economies, the immediate concern was practical and economic. Reducing waste was a way to manage scarce resources, protect industry from volatility and extract more value from every unit of fuel and electricity consumed.

Over the following decades, that defensive response matured into a more purposeful discipline of energy management. Energy efficiency moved from an operating-cost concern to a wider question of productivity, environmental responsibility and industrial performance. By the time climate change and ESG reporting entered boardroom vocabulary, efficient energy use had acquired a new significance: it was no longer only about saving money, but about improving the quality of growth. Industries that reduced energy intensity strengthened cost competitiveness, reduced emissions exposure and demonstrated a more disciplined use of capital and resources.

The Energy Conservation Act of 2001 gave this movement the institutional foundation it required. It enabled the creation of the Bureau of Energy Efficiency at the national level and State Designated Agencies across the country, bringing together policy direction and implementation capacity. Over time, these State Designated Agencies

were also strengthened through BEE's technical and financial support, helping them develop capacity as institutions in their own right. This architecture was important because energy efficiency is not delivered from a single desk in government. It has to reach factories, buildings, municipalities, farms, homes and small enterprises; it has to be translated into standards, audits, financing models, equipment decisions and operating practices.

India's progress over the past twenty-five years has come from combining mandatory frameworks with voluntary

"An inefficient factory powered entirely by renewable electricity is still inefficient."

market-building. The Energy Conservation Building Code, Standards and Labelling, and the Perform, Achieve and Trade scheme established performance expectations in buildings, appliances and energy-intensive industry. Programmes such as Agricultural Demand Side Management (AgDSM) and Municipal Demand Side Management (MuDSM) extended the conversation beyond large industrial users into agriculture, urban services and public infrastructure. This mix of regulation, awareness and market enablement helped move efficiency from the margins of technical practice into the mainstream of development policy.

The central achievement of this period is not only that energy savings were realised, but that energy performance became visible. A household now recognises the star label on an appliance. A large plant measures specific energy consumption with far greater seriousness. A commercial building is judged not merely by its floor area or appearance, but increasingly by how efficiently it delivers comfort and utility. Visibility changed behaviour, behaviour created demand, and demand gave both policy and markets something to build upon. The question that follows is what such visibility should now be used to achieve.

FROM COMPLIANCE TO ECONOMIC VALUE

The National Mission for Enhanced Energy Efficiency marked the next stage in this progression. By bringing together the Perform, Achieve and Trade scheme, Market Transformation for Energy Efficiency, the Energy Efficiency Financing Platform and the Framework for Energy Efficient Economic Development, it recognised that efficiency does not scale through regulation alone. It needs a system in which performance can be measured, savings can be verified, efficient products can become affordable, and investment can flow into projects that are often technically sound but commercially underdeveloped. The Mission also helped demonstrate that energy demand growth could be de-linked from output growth in several sectors when performance targets, verification systems and sector-specific action were brought together.

PAT was especially important because it treated industry not as a passive recipient of instructions, but as an actor capable of choosing its own pathway to lower energy intensity. Instead of prescribing a uniform technology, it created a performance framework and allowed designated consumers to pursue sector-specific solutions. This distinction matters. Energy efficiency is rarely a single equipment replacement; it is usually a combination of process discipline, technology selection, maintenance, measurement and managerial attention. By embedding these questions in operating performance, PAT helped convert efficiency from a project activity into a continuing industrial capability.

Yet the same progress exposes the limits of the current approach. Compliance can establish a floor, but it cannot by itself create ambition. Labelling can guide consumer choice, but only where efficient products are available and affordable. Performance targets can shape the behaviour of large industry, while much of the wider economy consists of smaller, dispersed users whose projects are difficult to aggregate, verify and finance. The next twenty-five years will require

a shift from programme-led efficiency to value-led efficiency, in which saving energy is tied directly to productivity, bankability and economic growth.

This is where the efficiency agenda intersects with India's larger development trajectory. A country aspiring to become *Viksit Bharat* by 2047 will require far more energy services: cooling for homes and workplaces, power for manufacturing, reliable electricity for digital infrastructure, mobility for people and goods, and modern energy access for expanding urban and industrial centres. The strategic question is not whether energy demand will grow, but how productively it will grow. If every additional unit of energy produces more comfort, output and economic value, growth becomes more resilient. If demand expands through inefficient assets and operating practices, India will have to build, import, generate and finance far more energy than necessary.

FROM SAVINGS TO BANKABILITY

If efficiency is to deliver economic value at this scale, it must first become investible. The technical case for energy efficiency has always been stronger than its investment case. Many measures pay for themselves over time, yet that alone does not make them financeable. Projects tend to be small, dispersed and difficult for lenders to appraise; savings often depend on operating behaviour as much as on equipment performance; and smaller enterprises may lack audited baselines, reliable data or the capacity to prepare bankable proposals. Municipalities and public agencies face a parallel difficulty, recognising the value of efficient systems while struggling with procurement, risk allocation and long-term performance contracts.

This financing gap is particularly consequential for MSMEs. Large industrial consumers can often mobilise internal capital, access consultants and absorb technology risk. MSMEs operate with tighter margins, limited managerial bandwidth and competing investment

priorities. Yet they are central to manufacturing employment, supply-chain competitiveness and regional economic development. Energy inefficiency in this segment is not merely an environmental problem; it suppresses productivity, erodes margins and weakens the competitiveness of firms that are expected to support India's manufacturing ambitions.

Closing this gap requires institutions capable of aggregating demand, standardising solutions, validating savings and lowering transaction costs. CII has played a distinctive role in building precisely this capacity — mobilising industry members, creating platforms for peer benchmarking, disseminating practical knowledge and helping translate national policy objectives into sector-level action. Through sustained engagement with companies, technology providers and practitioners, CII has helped make energy efficiency a shared industry movement rather than a compliance exercise pursued in isolation.

Certified energy managers and auditors, ESCOs, technology providers, research institutions and state agencies complete this ecosystem, converting fragmented opportunities into credible portfolios. The task is no longer to persuade enterprises that efficiency is desirable; it is to make efficiency easier to diagnose, easier to finance and easier to implement at scale. Collaboration, in this sense, is not an accessory to policy but the delivery mechanism for the next phase — and its importance grows further as the power system itself begins to change.

EFFICIENT ELECTRIFICATION AND ENERGY SECURITY

That change is already under way. Solar and wind power are no longer peripheral additions to the grid; they are becoming central to India's power-sector future. Their growth creates an opportunity to reduce both emissions and imported-fuel exposure, but it also alters the nature of demand management. As electricity becomes cleaner, more end-uses will be electrified: mobility, cooking, certain forms of

industrial heat and a growing share of comfort cooling. Handled well, this strengthens energy security by reducing dependence on imported fossil fuels. Handled poorly, it places avoidable strain on a system already managing variability, if new demand is inefficient, badly timed or weakly managed.

Electrification and efficiency must therefore be designed together. A renewable-rich grid rewards flexibility: efficient appliances, smart controls, well-designed buildings, productive motors and processes able to reduce or shift demand without compromising service quality. Efficient cooling eases peak stress. Efficient industrial systems lower the clean-power capacity required for decarbonisation. Efficient electric cooking and mobility improve household and urban energy outcomes where reliable infrastructure and sensible load management exist. The objective is not merely to move demand from fossil fuels to electricity, but to ensure that every new unit of electricity delivers the greatest possible economic and social value.

This marks the emergence of a new energy security paradigm. Efficiency once protected the economy primarily from fuel-price shocks. In the phase now beginning, it will also shield the power system from avoidable capacity addition, protect consumers from rising service costs, and prevent the renewable transition from being diluted by wasteful consumption. Clean supply and efficient demand are not alternatives; they are mutually reinforcing conditions for a resilient energy economy. Sustaining that balance, however, depends on the ability to see how energy is actually being used.

DIGITAL INTELLIGENCE FOR CONTINUOUS IMPROVEMENT

This is where digitalisation becomes decisive. Energy efficiency has historically relied on audits, periodic measurement and equipment-level interventions. These remain necessary, but they are no longer sufficient in systems that are becoming more electrified, decentralised and data-rich. Sensors, controls, AI-enabled analytics and digital

monitoring can make inefficiency visible in real time, allowing buildings, factories and utilities to move from occasional assessment to continuous optimisation.

Digital capability also strengthens trust in savings, which is what financing ultimately depends upon. When baselines are clearer, performance is monitored and outcomes can be independently verified, efficiency projects become far easier for banks, investors and public agencies to underwrite. For MSMEs and municipalities, this could prove especially valuable. Digital measurement cannot substitute for institutional capacity, but it can supply the evidence base on which aggregation, contracting and risk-sharing rest.

Better visibility also exposes an uncomfortable truth about how decarbonisation is often pursued. An inefficient factory powered entirely by renewable electricity is still inefficient. An inefficient building supplied by clean power still consumes more resources than necessary. Inefficient motors, boilers, appliances and processes running on renewable power absorb clean capacity that could have served another user, and they quietly lock in poor design and operating practices behind the reassuring label of decarbonisation.

This is why “efficiency first” must become the organising principle of India’s net-zero pathway. The phrase is not a preference for one intervention over another; it is a sequencing discipline. Avoidable demand should be reduced first, electrification pursued where it is technically and economically sensible, and the remaining requirement met with clean energy. Sequenced in this order, the transition demands less capital for generation, transmission and distribution, improves affordability for consumers, and makes renewable integration considerably easier for the grid.

The larger implication for India is clear. Energy efficiency can no longer be treated as a supporting programme within the energy transition. It is an economic capability that determines how much infrastructure the country must build, how competitive its industries become, how

affordable urban comfort remains, how resilient the power system can be, and how credibly net-zero growth can be pursued. The next twenty-five years must therefore deepen the movement from compliance to competitiveness, from savings to bankability, from isolated projects to aggregated markets, and from static audits to digitally enabled continuous improvement.

THE WAY FORWARD

India's first twenty-five years of organised energy efficiency built institutions, awareness and measurable performance. The next twenty-five must build scale, investment confidence and system integration. That will call for stronger state-level capacity, deeper industry partnerships, more credible financing structures, digitally verifiable savings, and policy frameworks that place efficient demand on the same footing as clean supply. If India uses less energy to produce more value, it will do more than reduce emissions; it will improve the economic quality of growth itself.

The strategic proposition for the coming decades is therefore simple but demanding: India should not pursue a larger energy system to compensate for avoidable inefficiency. It should build an efficient economy that requires a smarter, cleaner and more resilient energy system. That is the difference between adding capacity and creating capability — and it is the difference that will define the next phase of India's energy-efficiency movement.

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KEY TAKEAWAY

Unlike other fuels that need to be imported, stored or transported, energy efficiency is available where the demand is. It goes way beyond just focusing on the supply side and scaling up renewables, to focusing on the demand side through optimisation and conservation, making it the "first fuel" of the transition in a real sense.

WHY ENERGY EFFICIENCY IS INDIA'S CHEAPEST INSURANCE POLICY

Unlike other fuels that need to be imported, stored or transported, energy efficiency is available where the demand is.

James Abraham

Today, the world is not only living in an energy-insecure environment, but is also facing the consequences of the ongoing West Asia crisis rippling across sectors and economies. For India, in particular, the West Asia crisis is a quick reminder of its existing vulnerabilities and energy dependencies. Today, India remains highly vulnerable to energy chokepoints like the Strait of Hormuz and the Strait of Malacca, each responsible for carrying 20-24 million barrels of oil per day. In fact, the country remains highly dependent on imports for oil and gas, importing 60 per cent of its LPG consumption, with 90 per cent coming through the Strait of Hormuz, which has been impacted due to the war. Additionally, 85 per cent of the country's crude comes from just six countries, including several West Asian nations, involved in the ongoing conflicts.

These disruptions have not only resulted in higher fuel prices, freight and inflation pressures but have also impacted economic competitiveness. And this is where the demand for energy efficiency and the "First Fuel Effect" is stronger than ever. Today, energy efficiency is no longer just a climate-energy policy, but should be looked at as geopolitical defence or a way to decrease fiscal strain, or, more importantly, a resilient fuel which will not only reduce pressure on India's current land, water, grids, and supply chains but will also reduce exposure to global price volatility and dependence on expensive peaking capacity.

India is also witnessing a demand surge, with its peak electricity demand more than doubling in the past decade. In reality, India's electricity demand is also accelerating and becoming more complicated than ever, increasingly being shaped by drivers that were barely visible in the system some 10 years ago. Cooling alone accounts for more than 10 per cent of India's annual electricity demand, with space cooling appliances accounting for more than half of the household electricity use and a quarter of the national peak demand in summers. And then, data centres are creating a massive new source of electricity demand. With India's focus on digitisation and AI adoption, India's data centre capacity is expected to be around 6.5 GW by 2030, with electricity demand surging by nearly fivefold during the same time.

"The second critical pillar is empowering the demand side through digitisation & citizens. Smart meters are powering India's future, acting as the IoT for utilities, with more than 70 million smart meters already installed under various initiatives."

As India electrifies more, it is not only creating a challenge of reliable electrons but also a new energy efficiency challenge, making this first fuel more relevant in times to come, being looked at as the new design principle or the cheapest insurance policy for our economy. In fact, unlike other fuels that need to be imported, stored or transported, energy efficiency is available where the demand is. It goes way beyond just focusing on the supply side and scaling up renewables, to focusing on the demand side through optimisation and conservation, making it the "first fuel" of the transition in a real sense.

Today, this first fuel is also delivering at scale. India has not only improved energy efficiency by 1.9 per cent (between 2000 – 2023), outpacing the global average of 1.4 per cent, but the country uses ~19 per cent less energy to produce one rupee of gross domestic product than it did 10 years ago. Additionally, the country has already achieved a reduction of ~37 per cent in the emissions intensity of its GDP during

2005 to 2022, with an enhanced target of 47 per cent by 2035.

THE HEROES OF THE PAST

As India targets cutting energy consumption by 89 Mtoe by 2030 through various efficiency initiatives across industry, buildings, appliances and transport, further doubling its energy efficiency, it is worth internalising and recognising the various heroes behind the transformation. Starting with the first hero: statutory bodies and the institutional architects. The stepping stones of energy efficiency were laid decades earlier, starting from the establishment of the Petroleum Conservation Research Association in 1978 for oil savings, established as a response to the 1973 global oil crisis and the skyrocketing oil import bills. In 2002, the Government of India established the Bureau of Energy Efficiency under the Energy Conservation Act, 2001. This institutional body has not only given a home to energy efficiency within the broader energy system, but has developed it into a critical area of policy; followed by the establishment of Energy Efficiency Services Limited in 2009 for implementing large-scale public efficiency projects.

The second hero focuses on transformative public programs and schemes. India's LED bulb market and the UJALA Programme are a perfect example of the country's ability to create a market and not only participate in it. Through the UJALA Scheme, the cost of these bulbs was reduced by ~85 per cent, with 368 million bulbs deployed nationwide by 2023, slashing household electricity bills and avoiding emissions by ~37 million tonnes of CO₂ annually, becoming the choice of millions. Similarly, the Street Lighting National Programme, has installed more than 13 million LED streetlights, with over 9001 Million Units of energy savings annually and a peak demand reduction of more than 1500 MW, becoming an example of better public services and better public finances.

The third, and another critical hero, was the introduction of industrial frameworks and structural drivers. The Perform, Achieve and Trade

(PAT) Scheme was not only a regulatory mechanism but also changed the path for energy-intensive industries, creating a framework around specific energy consumption targets, measurement, verification and tradable energy-saving certificates. The scheme has compelled over 1300 consumers across 13 energy-intensive sectors to internalise energy efficiency costs. In fact, PAT cycle I has delivered around 8.67 Mtoe in energy savings, with cycle II delivering another 14.08 Mtoe. Another critical example is the BEE Star Labelling Programme, helping consumers make informed choices about approximately 40 energy-consuming appliances. In 2025, energy savings due to S&L program accounted for ~90 Billion Units.

It is clear that while there were multiple heroes and drivers of energy efficiency in the past, it was never really a niche intervention. Over the years, it has been the core of an industrial and an economic intervention at large, which is increasingly becoming an energy-security intervention today.

CEEW'S JOURNEY PARALLEL'S INDIA'S EXTRAORDINARY ENERGY JOURNEY

At the Council, CEEW has not only watched India's transition and efficiency journey from the sidelines, but has played an active role in this transformation. Time and again, CEEW has gone back to the basics, asking incredibly important questions to households, consumers, industries, policymakers, and regulators. CEEW's India Residential Survey in 2020, the largest pan-India survey on household energy access and efficiency, helped identify the gaps; while it was one thing to put a five-star label on the appliance, making households understand the importance and influencing adoption is another. CEEW has also worked extensively with the industry and MSMEs, looking at cost curves and barriers to adoption.

Today, CEEW is working on the intersection of data, consumers and markets, helping the country enable a consumer-centric smart metering transition through this work. In fact, over the years CEEW's

work has also transitioned from just understanding and responding to now anticipating the shifts in the future. Through its recent work, CRAVIS, an AI-powered climate intelligence platform, CEEW is not only mapping granular district-level climate risks and future projections up to 2070 (covering 270+ district-level indicators and multiple scenarios), but is also identifying where demand pressures are likely to emerge, further helping design the most efficient systems before the problem arrives.

At CEEW, the Council has not only built tools for India's data, geographies, and policymakers, but has also witnessed a fundamental transition, from correcting inefficiencies to designing for efficiency in the future.

REIMAGINING AND REDESIGNING THE NEXT 25 YEARS

While the first 25 years were about building programs, schemes, markets and industrial standards, the next 25 years must focus on building energy-efficient systems on intelligence, institutions and integration, at scale. India must reimagine and redesign its energy efficiency systems, focusing on two critical pillars, addressing both the supply and the demand side.

The first pillar is strengthening the ecosystem with institutions, finance and markets. Over the years, BEE has implemented various flagship programmes, including S&L, building energy codes, and the PAT scheme, with limited resources at its disposal. The limitation in in-house technical expertise has not only hampered effective execution of these programmes, but has resulted in less ambitious targets, delays in revision of standards, and compliance challenges. The PAT Scheme is a clear example showcasing a visible decline in compliance rates and mounting regulatory backlogs across its successive cycles. In fact, the non-compliance rate increased from 9 per cent in PAT Cycle I to around 56 per cent in Cycle II, with an increasing pool of unsold ESCerts (around 34 lakh ESCerts mandated for purchase

left unattended); a clear result of delays, concessions and the absence of action. As next steps, firstly, the Ministry of Power should look at recapitalising BEE's enforcement budget, which has been halved since 2022-23.

Secondly, SIDBI along with other commercial banks should look at creating a dedicated risk guarantee instrument for the MSME's, unlocking institutional credit for India's 63 million MSMEs, accounting for nearly 30 per cent of the country's GDP and consuming 20-25 per cent of large industrial energy; making efficiency financeable.

Thirdly, EESL should focus on transitioning from a sole market player to a facilitator or a market maker. Today, India's energy efficiency market holds a potential of INR 150,000 Crore. And yet, ESCOs account for less than 5 per cent of this capacity, with only 150 ESCOs empanelled, making the sector overwhelmingly nascent. In fact, EESL, also known as the "Super ESCO," has faced multiple structural vulnerabilities, with huge payment defaults and multi-year delayed receivables due to its massive state-backed market aggregator operation model. EESL should look at developing an ESCO empanelment and accreditation instrument, enabling other private ESCO's to grow and thrive.

This digital transformation not only enables real-time data tracking, cutting losses, while eliminating manual billing errors, but will also enable and empower consumers to optimize electricity use, giving them the choice, the information, and the ability to respond to different price signals.

SMART METERS ARE POWERING INDIA'S FUTURE, ACTING AS THE IOT FOR UTILITIES.

DISCOMs and utilities should focus on using smart meters for advanced analytics, load profiling and understanding consumption profiles, which will not only help design better incentives, run targeted efficiency campaigns, but will transition passive consumers into active prosumers.

Additionally, CEEW's India Residential Energy Survey revealed how action and programs do not automatically translate into awareness and vice versa. Even after more than a decade and a half since the launch of the S&L programme, only a quarter of respondents recognised the star label on appliances. As India builds the energy efficiency programs of the future, BEE should relaunch the program; transitioning from a government-led program to a citizen-led movement, helping create millions of energy citizens through last-mile awareness as well as local convergence.

India's next big opportunity is not only producing enough and securing its energy; but is really about using energy better. Realising energy efficiency is India's cheapest insurance policy, and making sure each electron counts.

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KEY TAKEAWAY

India's progress should be judged not only by the capacity it installs, but by the capability of the system to deliver energy reliably and convert it into economic value. Efficiency buys time; it does not decarbonise by itself. Tracking energy productivity with the same seriousness as installed capacity will help turn twenty-five years of efficiency progress into a wider national energy transition.

FROM CAPACITY TO CAPABILITY: INDIA'S NEXT TWENTY-FIVE YEARS

Installed capacity shows ambition; delivered energy, and how productively we use it, will show real progress.

Jamshyd N. Godrej

TWO HALVES OF ONE PROBLEM

For the past two decades, India's energy discussion has followed two separate paths. One has focused on using less energy — audits, appliance labels, building codes and industrial benchmarks. The other has focused on producing cleaner energy — capacity targets, auctions, tariffs and project pipelines. Each path has built its own institutions, terminology and stakeholder base. This separation may have been useful for administration, but it is no longer useful for analysis. A unit of energy saved in a foundry in Coimbatore and a unit generated by a solar park in Rajasthan are counted as different achievements, but both affect the same energy system and the same national constraint.

Efficiency reduces the amount of energy a growing economy needs. The grid mix decides the emissions, fuel-import cost and system pressure linked to the remaining demand. Neither can create a clean energy economy on its own. Efficiency without a greener grid only means burning somewhat less fossil fuel. A greener grid without efficiency means building far more capacity than needed, and then struggling to move and manage it. The two are parts of the same problem. India's progress should therefore be judged not only by the capacity it installs, but by the capability of its system to deliver reliable clean energy and turn it into economic value. Moving from capacity to capability is the task of the next twenty-five years.

WHAT EFFICIENCY BUILT, AND WHAT IT CAME TO MEAN

India acted early. The Energy Conservation Act of 2001 and the Bureau of Energy Efficiency came at a time when per-capita energy use was still low and the need for restraint was not obvious to everyone. What followed was not just one programme, but a full framework: appliance standards and labelling for households, an energy conservation building code, mandatory audits for designated consumers and, later, Perform, Achieve and Trade, which gave tradable value to industrial energy savings.

The common result was visibility. A star rating helped a buyer understand the running

"Efficiency, in other words, buys time. It does not decarbonise."

cost of a refrigerator, not just its purchase price. A benchmark made one cement plant comparable with another. An audit converted a vague overhead into measured losses. None of this was glamorous, but it did what appeals and awareness campaigns could not: it made energy performance a number people could act on. In many cases, industry moved ahead of regulation by certifying green buildings and pursuing major energy reduction before the market rewarded it. This showed that the main constraint was not technical capability. It also created the domestic proof that later made regulation easier to accept.

The biggest change over these years was not only in equipment or policy, but in how efficiency was understood. Earlier, efficiency was seen mainly as conservation, or using less. In a country still expanding energy access, this sometimes sounded like restraint. Today, it is better understood as productivity: the economic output generated from each unit of energy consumed. This removes the false choice between growth and efficiency. A company that improves energy productivity does not produce less; it produces more value from the same input. Once framed as competitiveness rather than sacrifice, efficiency moved from the engineering department to the boardroom.

The size of the opportunity is often underestimated. Indian industry has shown that, over a long period, energy use per unit of output can fall very sharply — in some cases by around seventy-five per cent over twenty years. Such improvement rarely comes from one action alone. It usually needs progress on four fronts together: behaviour, which decides whether equipment is used properly; technology, which improves what is technically possible; materials, which affect the energy embedded in the product; and process innovation, which questions whether a manufacturing step is needed at all. Programmes that focus only on one area, usually technology, tend to reach a limit.

Indian cement manufacturing shows what this can achieve. The sector is among the most energy-efficient in the world, not just by Indian standards. Its specific thermal consumption is about 731 kilocalories per kilogram of clinker, and electricity consumption is about 73 kilowatt-hours per tonne, compared with global averages of about 838 and 104. Its clinker factor is also among the lowest globally. Two factors explain much of this progress. First, newer plants were designed with modern dry-process kilns, waste heat recovery and efficient grinding systems from the start, while older plants progressively retrofitted efficient equipment and process improvements to raise performance. Second, regular benchmarking across plants, and later the Perform, Achieve and Trade mechanism, made energy performance a matter of competitive standing.

These lessons are not limited to cement. Steel, aluminium, chemicals, textiles, refining, electronics and data centres face similar choices. The opportunity is especially important now because much of the capacity India will use in 2047 has not yet been built. Cement shows that world-class performance is possible in Indian conditions when plants are designed well from the start and when performance is measured and compared openly.

Productivity also gives efficiency a national importance that conservation alone did not. India's overall primary energy import

dependence has reduced to around 42 per cent, from 47 per cent in FY17. However, crude oil imports still meet nearly 90 per cent of domestic demand, and imported gas meets about half. This exposes industry to global price and geopolitical shocks. Every unit of energy avoided reduces that exposure without needing a new import contract, pipeline or negotiation. That makes efficiency one of India's least contested tools for energy security.

THE GRID IS THE BINDING CONSTRAINT

There is, however, a limit to what efficiency can do. Efficiency reduces the amount of energy an economy uses, but it does not change where that energy comes from. If a plant cuts its consumption by half but still uses power from a fossil-heavy grid, it has genuinely reduced emissions. But the electricity it continues to use is not cleaner than before. Efficiency therefore buys time. By itself, it does not decarbonise the energy system.

That time must be used well, because demand will continue to grow. Urbanisation, affordable cooling, electric transport, data centres and semiconductor manufacturing will all add new electricity demand. Efficiency can reduce the rate of growth, but total energy use is still likely to rise. This does not weaken the case for efficiency. It clarifies its role: efficiency keeps demand within a range that a changing energy system can supply. The main question then becomes whether the grid can deliver cleaner electricity reliably.

India's target of 500 gigawatts of non-fossil capacity by 2030 is ambitious and important. The country also crossed the milestone of having more than half of installed capacity from non-fossil sources in June 2025, five years ahead of schedule. But this is still a capacity target. It tells us what has been built, not whether the grid can absorb that power or deliver it when consumers need it. The gap is already visible. Non-fossil sources account for around 283 gigawatts, or more than half of installed capacity, but provide less than thirty per cent of

actual electricity generation. Some of this is expected, because solar and wind depend on resource availability. Some of it also reflects a power system still designed mainly around dispatchable thermal generation. Capacity that cannot be evacuated, absorbed or stored delivers much less than its nameplate suggests.

Closing this gap will need work that is less visible than adding capacity, but even more important. India will need better management of intermittency and grid stability as inverter-based renewable generation increases. It will need storage so that solar power generated in the afternoon can meet evening demand. It will also need better forecasting, analytics and real-time system operation. Most importantly, generation, transmission, storage and demand must be planned together, not as separate projects.

Another major loss receives too little attention. Aggregate technical and commercial losses have improved to around fifteen per cent, but the national average hides large differences across states. The best-performing states are below seven per cent, while the weakest are above twenty-two per cent. This means a significant share of electricity generated never reaches a paying consumer. It is efficiency lost before the end-user even has a chance to be efficient. It also increases the generation needed to meet demand and weakens the finances of distribution utilities, which are central to the energy transition.

INTELLIGENCE AND DISTRIBUTION: THE UNDER-DISCUSSSED HALF

If the grid is the main constraint, intelligence in the grid is the response. Smart grids are often discussed as a future aspiration, but they are really core infrastructure. Advanced meters, sensors, automated fault detection and dynamic pricing help the network understand what is happening in real time and respond. Without this capability, renewable energy is managed mainly by curtailing supply. With it, variability can be balanced more effectively.

The same infrastructure supports several goals at once. Reliable electrification needs clear information on where losses and outages occur. Electric mobility will put pressure on distribution networks, especially in the evening, unless charging can be shifted and priced intelligently. Time-of-day tariffs can be a powerful lever for behavioural change, but only if the price differential is meaningful enough to incentivise consumers to shift electricity use away from peak periods. Cooling demand will also grow sharply as incomes rise and summers become hotter, but it is one of the more flexible electricity loads if systems can manage it. Demand flexibility is like hidden capacity. It is often cheaper than building new generation and network assets.

Distributed generation also deserves greater attention. Rooftop solar, captive systems and microgrids for industrial clusters produce electricity close to where it is used. This reduces transmission losses, improves resilience and can delay the need for some network upgrades. This is especially relevant because India's distribution companies remain the weakest part of the electricity chain. A stressed utility cannot easily finance modernisation. Every unit generated and used locally is one less unit that the utility has to procure, transmit and bill. Distributed energy cannot replace a strong grid, but it can give the grid time and space to improve.

Policy has started addressing this part of the system, though progress is uneven. Demand-side management regulations, adopted by most State Electricity Regulatory Commissions based on the 2010 model framework and supported by the Bureau of Energy Efficiency, gave discoms a mandate to treat saved energy as a resource. The Revamped Distribution Sector Scheme went further by linking central funding to reductions in aggregate technical and commercial losses and to prepaid smart metering. This makes support dependent on performance, not just spending. The challenge is implementation. In many utilities, demand-side management still means only efficient appliances and time-of-day tariffs. If these regulations are built into the resource

planning that discoms actually use, they can become a source of grid flexibility rather than just a compliance requirement.

BEYOND PROCUREMENT: FLEXIBILITY AND FINANCE

Indian industry has mainly responded by buying renewable power through open access, captive projects and corporate sourcing commitments. This has helped the market grow and is a useful step. But by itself, procurement has limits. It changes who can claim clean energy, but it does not necessarily improve what the grid can deliver. For example, a company may contract solar power generated at noon while its highest demand is at nine in the evening. In such a case, the reporting improves more than the grid's actual performance.

Industry can play a more valuable role by helping the system become flexible. This could include shifting non-critical load away from peak hours, offering interruptible demand when the grid is stressed, investing in storage that supports both plant reliability and grid balancing, and working more closely with distribution utilities. These actions create system value in a way that a procurement contract alone cannot. Indian industry led on efficiency before it was required to do so. A similar leadership role in grid flexibility would be more valuable than another round of clean-power commitments.

Two points should guide this shift. First, design-stage decisions last for decades. Much of India's industrial capacity for 2047 has not yet been built, and a plant's efficiency is largely fixed before construction begins. Once built, those choices can remain locked in for forty years. Second, sequencing matters. Storage, flexible thermal power, green hydrogen and electrification are often presented as competing options. In reality, they are connected. Each works best when deployed in the right order and at the right pace with grid capacity. If introduced in the wrong sequence, they can create stranded assets instead of supporting the transition.

All of this raises one difficult question: who will pay. The investment gap is largest in the very areas where the transition faces the biggest constraints. Renewable generation became bankable because revenues were contracted and the technology was well understood. Grid modernisation, storage and distribution reform are harder to finance. Their benefits are spread across the system, the counterparties are often financially weak utilities, and the returns are not always easy for an individual investor to capture. Capital does not flow to public benefits on policy intent alone.

Bridging this gap will need blended finance, where public and concessional capital take on risks that commercial lenders cannot easily price. It will also need sustained improvement in the financial health and credibility of distribution utilities. Without stronger discoms, concessional finance alone will not be enough. Carbon pricing was expected to help by giving avoided emissions a financial value. The Indian Carbon Market and the Carbon Credit Trading Scheme are important early steps, but they are still developing. Current targets are intensity-based rather than absolute, measurement and verification systems are still maturing, and the power sector — the largest source of emissions and the sector most central to this transition — remains outside their scope.

THE WAY FORWARD

The lesson of the past twenty-five years is not only that India built a successful efficiency programme. It is that visibility changes behaviour at scale. Labels helped households understand consumption. Benchmarks helped firms compare performance. Trading gave value to savings. The next twenty-five years need the same discipline for a more difficult subject: making the performance of the energy system visible, comparable and financially meaningful.

This starts with what India chooses to measure. The country tracks installed capacity closely and celebrates each milestone. But it does not yet track energy productivity — the economic output generated

per unit of energy consumed — with the same seriousness. Energy productivity is a stronger measure of real progress because it improves only when efficiency, generation, transmission and end-use performance improve together. Giving it the same importance as installed capacity would change how projects are assessed, how utilities are judged and how progress towards Viksit Bharat 2047 is measured.

This will require the same institutional patience that shaped India's efficiency movement in its early years. Government, regulators, distribution utilities, industry and financiers each hold part of the solution, but none can deliver it alone. A developed India will not be defined by how many gigawatts it installs. It will be defined by how much economic and human value it creates from each unit of energy produced. The next generation will ask three simple questions: Was the energy clean when it arrived? Did it arrive reliably? And what did the country make of it?

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KEY TAKEAWAY

Energy efficiency delivers its full economic and environmental value only when it moves beyond individual factories and becomes a property of the entire value chain. India's Net Zero transition will ultimately be judged not by how efficient its largest manufacturers become, but by how effectively that same discipline reaches the MSMEs that make up the broader industrial base.

THE EFFICIENCY IMPERATIVE: WHY ENERGY PRODUCTIVITY WILL DEFINE INDIA'S NET ZERO MANUFACTURING JOURNEY

*Before manufacturing can decarbonise, it must first become efficient.
The sequence matters more than the sentiment.*

Kamal Bali

Indian manufacturing has moved through several distinct transformations over the decades: from manual operations to automation, from localized supply chains to global networks, from conventional production systems to increasingly digital enterprises. The transition now underway toward Net Zero is, in many respects, more profound than any of these. Much of the public conversation around it centers on renewable energy, electric mobility, green hydrogen, carbon markets and emerging clean technologies, and these developments will genuinely shape what comes next. But the starting point of that journey lies elsewhere.

Before manufacturing can meaningfully generate cleaner energy, it must first use less of it. Before it invests in new energy systems, it must optimize the ones it already has.

The defining question for the next two decades of Indian manufacturing competitiveness is not how much energy an industry consumes, but how effectively it converts that energy into economic value, and getting the sequence right, efficiency first, decarbonization second, will determine how much value India's Net Zero transition actually delivers..

FROM COST REDUCTION TO GROWTH STRATEGY

For much of its history, energy efficiency was treated narrowly, as a cost-reduction exercise pursued to lower fuel bills and protect margins. That framing understated what efficiency actually does. Every unit of energy a facility saves reduces its operating costs, lowers its emissions, and improves its productivity simultaneously, which is a combination very few other business investments can genuinely claim.

The future industrial energy system will certainly include renewable electricity, storage, green hydrogen, sustainable fuels and electrified processes, but how effective any of these technologies prove to be will depend substantially on the efficiency of the systems they are deployed to serve.

As sustainability expectations rise across global supply chains and capital markets, the manufacturers who succeed will be those able to create more economic value while consuming fewer resources, not as a compliance exercise but as the operating logic of the business itself.

This reframing has direct implications for how manufacturing performance should be measured. Production volume, capacity utilization and unit cost have long been the standard yardsticks of industrial performance.

The more consequential measure going forward is energy productivity: how much economic output a given unit of energy consumption actually generates, and how effectively emissions can be decoupled from growth. India is not starting this transition from a position of weakness. Indian industry has, over the past two decades, demonstrated a genuine capacity to absorb technological change and adopt global best practice at pace.

The task now is less about proving this capability exists and more

about scaling it consistently across the full manufacturing ecosystem, rather than concentrating it in a handful of large, well-resourced facilities

WHY THE REAL OPPORTUNITY SITS IN THE VALUE CHAIN, NOT THE FACTORY

One of the more significant shifts in how manufacturers now think about sustainability is the recognition that emissions do not stop at the factory gate. A facility can optimize its own operations, procure renewable power and improve internal efficiency, and still carry a substantial share of its true carbon footprint embedded in its suppliers, logistics networks, raw materials and product lifecycle.

This changes what energy efficiency actually needs to mean in practice. It can no longer be treated as an initiative individual factories undertake in isolation; it has to become a characteristic of the entire value chain, which requires manufacturers, suppliers, logistics providers, technology partners, financial institutions and policymakers to work toward genuinely shared outcomes rather than optimizing their own segments independently.

Nowhere is this more visible than in India's MSME sector. Large manufacturers have already made real progress on energy management, renewable procurement and sustainability reporting. The deeper opportunity now sits with the thousands of MSMEs that support India's automotive, engineering, infrastructure and electronics industries, and that collectively represent one of the largest untapped pools of efficiency improvement in the economy.

The constraint here is rarely a lack of intent; most MSMEs already understand the commercial value of using less energy. What limits them is access, to the right technology, to implementation expertise, and, most consistently, to financing.

FINANCING AS THE ACTUAL BOTTLENECK

A consistent pattern emerges from engaging with manufacturers across sectors and scales: the technology to improve efficiency generally exists, the business case is frequently sound, and the savings are measurable. What slows implementation, particularly for smaller enterprises, is access to capital rather than any deficit in either technology or commercial logic. This points to the next phase of industrial decarbonization being, in a meaningful sense, a capital allocation problem as much as a technological one.

Financing architecture built specifically around the characteristics of efficiency investment, green finance, transition finance, performance-linked lending, risk-sharing mechanisms, energy service company models and sustainability-linked supply chain financing, can meaningfully reduce the burden smaller enterprises currently face in funding the upfront cost of adoption.

The manufacturers and financial institutions who innovate fastest on how efficiency gets financed will, in practice, determine how quickly efficiency itself gets adopted across the wider ecosystem.

DIGITALISATION AS THE MULTIPLIER

If energy efficiency is the destination, digitalization is what is increasingly making it reachable at scale. Industry 4.0 technologies, connected equipment, advanced sensors, artificial intelligence, digital twins, predictive maintenance and real-time analytics, are giving manufacturers a level of visibility into their own operations that simply did not exist a decade ago.

Inefficiencies that were once invisible are now measurable. Maintenance that was once reactive is now predictive. Resource consumption that once relied on estimation can now be optimized continuously against live operational data. The practical effect is that digitalization and sustainability are converging into a single operational discipline rather than two separate agendas, and this convergence is

producing the increasingly rare combination of higher productivity alongside lower emissions, rather than forcing manufacturers to trade one against the other.

EFFICIENCY AND CLEAN ENERGY ARE STRONGEST TOGETHER

Renewable energy and energy efficiency are frequently discussed as separate agendas, but they deliver their greatest impact only when pursued together. Efficiency reduces how much energy a system needs; renewables decarbonize the energy that remains. Pursued in isolation, each has a meaningfully smaller effect than when combined. A factory that reduces its energy consumption by twenty percent immediately shrinks the scale of renewable generation, storage infrastructure and capital investment required to reach Net Zero. This is precisely why energy efficiency should be treated as the genuine first step in the energy transition rather than a parallel track: only once demand has been optimized does it make economic sense to scale supply-side interventions.

CIRCULARITY AS EFFICIENCY APPLIED TO MATERIALS, NOT JUST OPERATIONS

Most conversations about energy efficiency focus on operational energy, the power consumed while equipment runs. There is a second, less visible dimension that deserves equal weight: the energy embedded in materials themselves. Every material carries an energy footprint from its extraction and processing, and every manufactured product carries embedded carbon accumulated well before it ever reaches a customer.

Circularity, reusing materials, extending product life, remanufacturing components and designing explicitly for recyclability, reduces the need for virgin resource extraction and the energy-intensive processing that comes with it. Volvo Group's own work on green castings and low-carbon materials has demonstrated that this kind of material innovation

can meaningfully reduce emissions while fully maintaining industrial performance, which is the clearest evidence that circularity is not a separate sustainability initiative running alongside energy efficiency. It is energy efficiency applied across the full lifecycle of materials and products, not just the hours a machine spends running.

THE WAY FORWARD

India holds a genuine, time-limited opportunity to lead in sustainable manufacturing, backed by the talent, entrepreneurial capability, policy momentum, digital infrastructure and renewable energy potential the transition requires.

Capturing that opportunity depends on treating energy efficiency not as one initiative among several, but as the organizing principle every other sustainability effort is built around.

Digitalization should be deployed specifically to improve efficiency, not simply to modernize operations for its own sake. Financing architecture should be designed to accelerate efficiency adoption, particularly among MSMEs where capital access, not intent, is the binding constraint. Collaboration across manufacturers, suppliers, logistics providers and policymakers should be structured to scale efficiency across entire value chains rather than isolated factories.

Circularity should be pursued as a deliberate extension of efficiency into materials and product lifecycles, not treated as a separate environmental programme. And clean energy investment should be sequenced to amplify efficiency gains already captured, rather than substitute for the harder work of reducing demand first.

Approached this way, energy efficiency stops being a technical initiative or a sustainability programme confined to a company's operations team. It becomes a national competitiveness strategy.

The manufacturing leaders who define the next decade will not be the ones who consume the most resources, or even the ones who adopt

the most clean energy. They will be the ones who extract the greatest economic value from every unit of energy they use, and who build that discipline not just into their own factories, but across the full value chains they depend on.

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KEY TAKEAWAY

India's next phase of energy efficiency will be defined less by new schemes than by depth of implementation: launching a credible carbon market on the measurement and verification discipline built through PAT, bringing MSMEs into the mainstream with technical handholding and affordable capital, and enforcing building codes at the design stage through States and local bodies. Efficiency is the first fuel. It lowers the cost of every other element of the transition, and it is the foundation on which India's low carbon development pathway will be built.

EFFICIENCY FIRST: BUILDING THE FOUNDATION OF INDIA'S ENERGY TRANSITION

Twenty-five years of institution building — and the agenda that will define the next twenty-five

Krushna Chandra Panigrahy

India's economy is steadily using less energy for every unit of output it produces, and the rate of improvement has run well ahead of the global average. The emissions intensity of India's GDP fell by around 37 per cent between 2005 and 2022, comfortably past the earlier target of 33 to 35 per cent by 2030, and non-fossil sources now account for more than half of installed electricity capacity, a milestone reached nearly five years ahead of schedule. Under the G20 New Delhi Leaders' Declaration, India also stands committed to the collective goal of doubling the rate of energy efficiency improvement by 2030. That is an ambitious undertaking, and it requires the efficiency agenda to move faster, wider and deeper than it has so far. Energy efficiency performance assessment for 2024-25 recorded electricity savings of 356.10 billion units, energy conservation of 65.03 million tonnes of oil equivalent, monetary savings of ₹2.8 lakh crore and 365.76 million tonnes of carbon dioxide avoided across various programmes.

The Bureau of Energy Efficiency marked its 25th Foundation Day on 1 March 2026, and the Confederation of Indian Industry's Energy Efficiency Summit completes its 25th edition this year. The two journeys have run alongside each other. Over this period a set of programmes has been institutionalised that today forms the backbone of India's efficiency architecture: Standards and Labelling for appliances; Perform, Achieve and Trade for energy-intensive industries; the Energy Conservation and Sustainable Building Code

for the built environment; and demand-side management covering distribution companies, municipalities, local bodies and agriculture. Each began as an idea that had to be explained, negotiated and tested. Each is now part of how India does business.

FROM ENERGY INTENSITY TO CARBON INTENSITY

The most significant shift now underway is the move from an energy-intensity approach to a carbon-intensity approach: from Perform, Achieve and Trade to the Carbon Credit Trading Scheme. PAT asked industry to reduce the energy consumed per unit of production. The carbon market asks it to reduce

"Energy efficiency is the first fuel. It is not a separate agenda competing with renewables or low carbon development — it is the layer underneath all of them."

the greenhouse gas emitted per unit of production. The second question is harder, but it is the one the world now asks of Indian goods, and the one India's own net-zero commitment requires it to answer. The transition is already well advanced. Legally binding emission-intensity targets are in force for 490 obligated entities across seven energy-intensive sectors, the Indian Carbon Market portal went live in March 2026, and the first trading cycle for Carbon Credit Certificates is expected later this year.

What deserves emphasis is that India is not starting from scratch. PAT delivered emission reductions of more than 100 million tonnes of carbon dioxide between 2015 and 2024, but its more durable contribution is institutional. The capability to measure, report, monitor and verify — built through accredited energy auditors and verifiers, and through designated consumers who have learnt to keep credible energy accounts — is precisely the foundation a carbon market needs. Markets run on trust, and trust in a carbon market that rests entirely on the integrity of the data. India has also studied closely the experience

of economies that have priced carbon for far longer, including their episodes of over-allocation and price collapse, so that the same mistakes are not repeated.

MAKING EFFICIENCY WORK FOR MSMEs

MSMEs matter to this agenda for a simple reason. They employ the largest numbers, they supply the country's large manufacturers, and they carry a disproportionate share of India's energy cost burden. If their productivity improves and their operating costs fall, India's competitiveness improves with them. Equally, if they are left behind, large parts of the country's supply chains will be left behind too. This is why BEE is implementing ADEETIE — Assistance in Deploying Energy Efficient Technologies in Industries and Establishments — as its flagship programme for the sector, with an outlay of ₹1,000 crore covering 60 industrial clusters across 14 energy-intensive sectors.

The scheme's design goes well beyond a subsidy, and it is the combination of enablers that matters. The first is technical support: investment-grade energy audits and bankable detailed project reports, with the cost reimbursed, so that a small enterprise is not left to work out on its own which technology suits its process. The second is affordable capital: an interest subvention of 5 per cent for micro and small enterprises and 3 per cent for medium enterprises, which changes the arithmetic of a project that would otherwise never clear an internal investment hurdle. The third follows from the first two: once the technology is installed and the required savings are verified, operating costs fall and the enterprise sees the benefit in its own accounts. The objective is straightforward. Energy efficiency should become a genuine competitive tool for MSMEs rather than merely an environmental obligation.

BUILDINGS: DECISIONS MADE AT THE DRAWING BOARD

Much of the India of 2047 is still to be built. That is both the country's

greatest efficiency opportunity and its greatest risk, because a building designed poorly today will consume more energy than it needs to for the next fifty years. BEE has developed the Energy Conservation and Sustainable Building Code, and States are progressively notifying it while Urban Local Bodies incorporate it into their building bylaws. The focus must now shift decisively to implementation and enforcement, because the largest gains are locked in at the design stage: in orientation, envelope, glazing, insulation, daylighting and the sizing of equipment. The code sets three tiers of performance. Baseline compliance delivers energy savings of roughly 25 per cent against conventional practice, the Plus tier about 35 per cent, and the Super tier 50 per cent or more, much of it at little additional cost when the decisions are taken early.

Alongside this sits a question India can no longer treat as secondary. With rising heat and longer summers, air conditioning must be seen as a matter of health and well-being rather than a luxury. Cooling is what allows people to sleep, children to study and workers to stay productive through the hottest months. A building strategy must therefore work on both sides of the equation: reducing the heat load through better design, and improving the efficiency of the equipment that meets the cooling demand that remains. Getting only one of the two right will not be enough.

STANDARDS, LABELLING AND THE SUPER-EFFICIENT AIR CONDITIONER

The Standards and Labelling programme remains the most visible face of energy efficiency in India. The star label has become one of the few technical marks an ordinary household recognises and uses, and the results are substantial. Standards & Labelling performance assessment for 2024-25 recorded electricity savings of 98.40 billion units, energy conservation of 8.46 million tonnes of oil equivalent, monetary savings of ₹63960 crore and 69.86 million tonnes of carbon dioxide emission reduction. The direction of travel is clear. As a category

matures and market penetration grows, it should move from voluntary to mandatory labelling, and the consolidated Appliance Labelling and Compliance Regulations that came into force on 1 January 2026 did exactly that for refrigerators, televisions, deep freezers, LPG stoves, chillers, cooling towers and distribution transformers, in the largest single expansion in the programme's twenty-year history.

The next step is more ambitious. BEE is planning a Super-Efficient Air Conditioner campaign targeting units at the 5-star level and a 5-star-plus-10-per-cent performance category, with the objective of creating a market for substantially higher efficiency without compromising affordability, and of building the technology and manufacturing capability domestically in line with Make in India. The scale makes this urgent. India already adds 10 to 15 million room air conditioners a year, another 130 to 150 million units are expected over the next decade, and air conditioning already contributes 60 to 70 GW to the evening peak. Independent analysis suggests that a sustained efficiency roadmap could reduce peak demand by around 10 GW by 2030 and substantially more thereafter, capacity the country would otherwise have to build, finance and maintain to meet a few hours of summer evening load.

Running alongside this is the Go Electric campaign, covering electric cooking, electric vehicles, and, shortly, heat pumps. Electrifying end uses is among the most effective ways to decarbonise as the grid itself becomes cleaner, and it must be pursued sensibly and responsibly, technology by technology. Nothing in this agenda should be read as a brake on growth. The purpose throughout is to obtain the same service —the same cooled room, the same kilometre travelled — using less energy, and therefore at lower cost.

TRANSPORT: CLEANER VEHICLES AND CLEANER FUEL

In transport, BEE administers the Corporate Average Fuel Efficiency norms, which set a sales-weighted fleet target for each manufacturer

rather than a limit on any single model. The industry is completing the second phase, and the draft CAFE 2027 norms released for consultation set the framework for the five years from April 2027. Their scope is wider than their predecessors'. They are technology-neutral, using petrol-equivalent fuel consumption as a common metric across petrol, diesel, CNG, flex-fuel, hybrid and electric vehicles; they offer volume-based super credits for cleaner vehicles; and, for the first time, they recognise cleaner fuel through carbon neutrality factors for ethanol, biofuels and compressed biogas. Credit banking, trading and pooling give manufacturers a practical path to transition their portfolios without disrupting production or employment. The principle running through it is common to all of BEE's work: firm on direction, realistic on pace.

CLOSING THE FEEDBACK LOOP WITH DATA AND AI

India's efficiency programmes generate an enormous volume of data. Energy audits, compliance filings, verification reports and now carbon market monitoring produce plant-level information of a kind few countries possess. Historically much of it has been used once, for compliance, and then set aside. Closing that feedback loop is a priority. Analysed quickly, this information can tell policymakers which technologies actually deliver savings in Indian operating conditions, which sectors are stalling and why, and where a target is unrealistic rather than merely uncomfortable. BEE is exploring artificial intelligence tools to analyse this data, so that policy remains evolving, practical and implementable, and so that course corrections are made on evidence rather than assumption. The rapid growth of data centres and AI computing as significant new loads makes this capability doubly important.

THE FIRST FUEL: WHY EFFICIENCY UNDERPINS EVERYTHING ELSE

The most important lesson of the last twenty-five years is that energy

efficiency succeeds only when policy, technology, finance, markets and consumer behaviour move together. No programme has ever succeeded on the strength of a regulation alone. Standards and Labelling worked because regulation was matched by manufacturing capability, retail awareness and a consumer willing to pay a little more today for a smaller bill tomorrow. PAT worked because targets were matched by auditor capacity, boardroom attention and a mechanism that put a market value on every tonne of oil equivalent saved. When all five move in step, progress is quick, and that is now the design test for every new programme.

This is why energy efficiency is best understood as the first fuel: the cheapest, cleanest and most immediately available energy any country has. It does not compete with renewables or electrification for capital. It reduces how much of both India needs to buy. Green hydrogen makes the case plainly. Energy is the dominant cost of every kilogram produced, so hydrogen is commercially viable only when it is built on an efficient base. And the efficiency question does not stop at the electrolyser: it runs through purification, compression, storage and every auxiliary load in the plant. Efficiency is what will decide whether Indian hydrogen sells at a world price.

The same arithmetic governs renewables and storage. Waste energy at the point of use and the requirement upstream does not rise gently — it balloons. A system needs 120 kW of solar capacity where 100 kW would have sufficed, or 250 kWh of battery storage where 120 kWh would have done the job. Every additional kilowatt means more material mined, more land occupied, more capital committed and a higher delivered cost of energy. Efficiency at the point of consumption is therefore the cheapest capacity India can add, and the only kind that needs no land, no fuel and no grid connection.

Seen this way, the sequence is a single continuum rather than a contest for priority: efficiency enables the energy transition, which drives renewables and electrification, which deliver carbon reduction,

decarbonisation and, in time, net zero. Efficiency is the foundation at every step. India will not reach its net-zero goal by producing clean energy alone — it will reach it by needing less energy in the first place. BEE's work is not peripheral to that journey. It is the ground on which the journey stands.

IMPLEMENTATION ON THE GROUND: THE ABC APPROACH

Policy is made nationally but energy is consumed locally, which makes State-level implementation the decisive variable. A simple framework — ABC — helps organise this work.

THE ABC APPROACH TO IMPLEMENTATION

A—Achieve. Planning activities and objectives properly, so that intent is translated into a defined set of actions with owners and timelines.

B — Build. Building the tools, team capabilities and technical competencies without which even a well-designed programme cannot be delivered.

C — Collaborate. Working with States, think tanks, industry chambers and associations — never as an afterthought once a scheme has been designed.

Of the three, collaboration is the most important. Achieving and building can be planned; collaboration determines whether the plan survives contact with implementation.

Within this framework, BEE works with States on their State Energy Efficiency Action Plans. All 36 States and Union Territories have now prepared one, which is itself an achievement; the task is to review and update them periodically so that they reflect current technologies, costs and priorities rather than the assumptions of the year in which they were written. The State Energy Efficiency Index, now in its sixth edition and assessing 66 indicators across seven demand sectors, provides the measuring instrument, classifying States as Front Runners, Achievers, Contenders and Aspirants.

The index is most useful when treated not as a ranking but as a map for peer learning. Front Runners are expected to help train and mentor States lower down the scale through structured, collaborative meetings, so that a solution developed in one State — for municipal street lighting, agricultural pump-set replacement or code enforcement by urban local bodies — can be replicated elsewhere without being reinvented. Progress on the ground bears this out: 24 States have notified the building code, 31 have adopted electric mobility policies, and 31 have constituted State-level steering committees on energy transition.

LEARNING FROM THE WORLD, SHARING WITH THE WORLD

India's international engagement is guided by three words: humility, openness and responsibility. Every country, developed or developing, has its areas of strength and its areas still to be worked on, and there is no reason for India to rediscover independently what others have already established at considerable cost. Through bilateral discussions and multilateral forums, India contributes what it does well, studies closely what has worked elsewhere and what has not, and returns to build plans suited to its own circumstances. Adaptation, not adoption, is the operating principle: Indian conditions, consumption patterns and affordability constraints are not those of Europe or North America.

Responsibility runs in the other direction as well. Sri Lanka, Bangladesh and the Maldives are today at the stage of designing appliance standards and labelling programmes that India began building twenty-five years ago, and BEE is actively supporting them, sharing the practical experience of creating testing infrastructure, bringing manufacturers on board and earning consumer recognition for the star label. India's minimum energy performance standards for room air conditioners, tightened from January 2026 with a further revision due in 2028, now stand comparison with the best in the world, and are the more notable for being set against far higher ambient

temperatures. India is at once a learner and a knowledge provider, and should be comfortable in both roles.

THE TASK AHEAD

India already has a comprehensive set of instruments covering appliances, industry, buildings, transport, distribution utilities and agriculture. What the next phase demands is depth rather than novelty: scaling what has demonstrably worked, strengthening the enablers that accelerate adoption, and building an ecosystem in which energy efficiency is the natural economic choice rather than a compliance requirement. That means better access to finance, a deeper pool of skilled manpower, stronger institutional capacity at the local level, and greater confidence among smaller enterprises to invest.

Three priorities will define this phase, and each requires action now. First, the carbon market must be launched and stabilised on the measurement and verification discipline PAT has built — and industry should prepare early, treating carbon accounting with the same rigour it now brings to energy accounting. Second, MSMEs must be brought into the mainstream, which asks large manufacturers to extend efficiency support down their supply chains and financial institutions to treat verified savings as bankable security. Third, implementation must be driven through States and local bodies, with codes enforced at the design stage, developers encouraged to build to the higher performance tiers, and best practices moving freely from Front Runners to States earlier in their journey.

Industry has a decisive part to play in each of these, and CII has shown what industry leadership can achieve. Through the CII Green Business Centre and twenty-five years of the Energy Efficiency Summit, it has built a platform that regulation by itself could never create — bringing manufacturers, technology providers, financiers and policymakers into the same room, benchmarking plants against the best in the world, carrying good practice into clusters and supply chains, and turning compliance into shared ambition. That partnership has been the quiet

strength of the last twenty-five years. The invitation now is to raise it further: for every company to set an efficiency target as seriously as it sets a production target, for every cluster to bring its smaller units along, and for every State to make efficiency a visible measure of its own competitiveness. If India is to double its rate of improvement by 2030, the next twenty-five years must be built on the first fuel — and built together.

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KEY TAKEAWAY

It is no longer about writing new codes; it is about making the ones that already exist stronger and ensuring their country-wide implementation, with strong participation from industry and stronger partnerships to enable the transition. With 86% of India's 2070 building stock yet to be built, enforcement gaps today will be locked in for decades.

INDIA'S ENERGY EFFICIENCY JOURNEY: TWO DECADES OF QUIET TRANSFORMATION

If the last two decades were about building the institutional architecture to prove that efficiency can scale, the next decade should be about stronger cross-sectoral enforcement to drive implementation.

Madhav Pai

Over the past decade, India has made remarkable strides in energy efficiency, with energy efficiency now seen as a powerful driver of resource conservation, economic value generation and emission reduction. Between 2014 and 2024, annual energy savings have risen sharply from just 3.02 Mtoe to 53.6 Mtoe; nearly an 18-fold increase. In 2023-24 alone, these savings were close to INR 2 lakh crore in monetary value, translating into 321 MTCO₂e of avoided emissions. To put that into perspective, that is roughly equivalent to the total annual emissions of a country such as Malaysia.

These data points represent the increasing efficiency measures India is absorbing across sectors. They represent millions of Indian households running cooler homes on less power, industries producing more steel and cement per unit of fuel it burns and cities and villages that are lit by efficient lighting, which once drew double the electricity for half the illumination. These are the compounding results of a robust policy architecture that India has been building patiently since the early 2000s.

The policy architecture rests on several critical pillars. The Bureau of Energy Efficiency (BEE), formed in 2002 under the provisions of The Energy Conservation Act of 2001, created the legal foundations for the

sector. Building on top of that foundation, India has since developed the Standards & Labelling (S&L) programme for appliances, the Energy Conservation Building Code (ECBC) and Eco Niwas Samhita for the built environment and most recently the Perform, Achieve and Trade (PAT) scheme for the energy-intensive industries. And now, India is also transitioning some of its industries from an energy savings model/framework to a carbon-based one, with the launch of the Carbon Credit Trading Scheme (CCTS). India's energy efficiency measures have significantly matured over the last two decades and have evolved into some of the world's largest energy efficiency programmes.

The success of many of these measures, dates to a very specific year: 2009.

2009: THE QUIET BEFORE THE MANDATE

In 2009, India's push for energy efficiency was still finding its ground. But the foundations laid in 2006 had started to push the ecosystem and the market towards alignment. The S&L scheme was launched in 2006 voluntarily, nudging the market to differentiate itself on efficiency rather than an obligation to follow.

"The people most exposed to extreme heat are often the least able to afford mechanical cooling — which means efficiency and access must be designed together, not sequentially."

2009 was the pivot. BEE, in close collaboration with manufacturers, testing labs and other national and state agencies, built the technical and administrative mechanisms to evolve a voluntary scheme into an enforcement. All the groundwork paid off in January 2010, when star labelling became mandatory for ACs, tube lights, refrigerators and distribution transformers. Today, mandatory labelling has expanded well beyond the original 4 appliances. New BEE regulations effective January 2026 pushed the mandatory list to its broadest scope yet, pulling several appliances out of the voluntary bracket into mandatory,

while a wider set of appliances continue to sit under the voluntary list.

States are also now expected to designate an agency to coordinate, regulate, and enforce provisions as directed by the BEE, with over 36 State Designated Agencies supporting EE measures. Appliance and equipment indicator tracked under the Energy Transition Preparedness Initiative's (joint initiative of Prayas, SFC and WRI India) building-sector framework treats promotion of efficient appliances as one of the clearest markers of how prepared a state is for the energy transition ahead, also marking its criticality for India to achieve its net-zero objectives.

CSOs such as CLASP, Prayas, WRI India, etc. played a quiet but persistent role throughout, advocating for greater public participation and consumer voice in how the S&L Programmes were designed, monitored and communicated.

LEDs, FANS AND THE LONG ROAD TO SUPER-EFFICIENT COOLING

Demand aggregation has always been one of India's most successful policy levers. The humble light bulbs are an excellent example. 2015's UJALA Programme solved a classic "chicken and egg" conundrum by using a bulk procurement model to lower retail prices, while ensuring access to energy-efficient lighting to the masses. In a joint effort undertaken by Energy Efficiency Services Limited (EESL) and DISCOMs under the Ministry of Power, the retail price of an LED bulb fell from INR 300-350 in 2014 to INR 70-80 in just 3 years. Across the decade, more than 360 million LED bulbs were distributed as part of the programme, with a parallel Street Lighting National Programme (SLNP) replacing conventional municipal lighting with LEDs across towns and cities.

Ceiling fans and air conditioners, being far more capital-intensive than a bulb, saw a similar but quieter story. EESL's Energy Efficient Fans Programme (EEFP) and its Super-Efficient Air Conditioning

(SEAC) Programme never came close to UJALA's scale. But scale was only one side of success. Both programmes pushed the market toward selling energy-efficient fans and ACs at prices closer to the mainstream, rather than leaving them in a premium niche. For example, star-rated fan models stocked by key market players rose from 87 to 150 within a year of mandatory labelling in 2023.

PAT: TURNING INDUSTRIAL ENERGY EFFICIENCY INTO A MARKET

Perform, Achieve & Trade (PAT), launched in 2012, was one of the novel cap-and-trade regulatory models to target industrial energy efficiency without directing how each carbon-intensive plant should get there. PAT has delivered significant gains: By FY 2022-23, per BEE's own assessments, PAT's completed cycles were still delivering 25.77 million tonnes of oil equivalent in savings and averting 110.66 million tonnes of CO₂ annually. That progress, visible across sectors like cement and aluminium, is now evident in NITI Aayog's 2026 sectoral roadmaps, which signal a shift from narrowly reducing specific energy consumption to cutting overall CO₂ emissions, a goal that will increasingly depend on renewables, alternative fuels, low-carbon technologies and CCUS.

The government now aims to extend the efficiency trading architecture to carbon itself. Since 2025, 9 of PAT's original sectors, including cement, aluminium and textiles, have transitioned into the Carbon Credit Trading Scheme, with a focus on tracking emission intensity and issuing carbon credits instead of Energy Saving Certificates. This shift also lets Indian exporters internalise the EU's carbon border tax domestically rather than paying higher later. PAT enabled not just energy saving for a decade but is also now helping build the carbon trading infrastructure for CCTS.

BUILDING RIGHT THE FIRST TIME

India's building stock is projected to more than double by 2070, from 17.8 to 42.5 billion square meters, with urbanisation expected to

parallelly double. 86% of the building stock that will exist in 2070 is also yet to be built, meaning the majority of efficiency battle in this sector is not only about fixing what already exists but about building right in the first place, and the success of delivery will be decided far more by the choices made in design and building codes today than by any retrofit we do tomorrow.

The last two decades of policy groundwork matter precisely because of the scale ahead. The Energy Conservation Building Code (ECBC) and its residential counterpart, Eco Niwas Samhita, aimed to ensure new construction use less energy by design, but enforcement has lagged intent. State-City coordination on implementation is also a challenge. A 2025 WRI India study's analysis of 10 cities highlighted an interesting finding: out of the 10 cities, 6 cities sit in states that have notified ECBC, yet none enforce it locally, while Pune, Rajkot, Surat and Nagpur were taking steps to advance low-carbon buildings despite no notification of ECBC in Maharashtra and Gujarat at the time of the study.

Policy alone, thus, only goes so far if the industry and the market don't participate. With over 139 signatories, the Decarbonisation Business Charter, launched as part of a consortium with WRI India, AEEE, EcoCollab and Mahindra Lifespaces, has brought developers, material suppliers and financiers together around six priority action areas, from passive design to accelerating building codes, with signatories including Mahindra Lifespaces, JSW Steel and Lodha Group. The task is thus clear: it is no longer about writing new codes; it is about making the ones that already exist stronger and ensuring their country-wide implementation with strong participation from the industry and building even stronger partnerships to enable this transition.

LOOKING AHEAD: THE NEXT DECADE OF INDIA'S EFFICIENCY STORY

If the last two decades were about building the institutional architecture to prove that efficiency can scale, the next decade should be about

stronger cross-sectoral enforcement to drive implementation. Four areas deserve to move from the margins of India's energy efficiency story to the centre of it.

- 1) MSMEs that make up a quarter of the country's energy use;
- 2) Behavioural levers that are still on the table and can unlock massive savings;
- 3) Hospitals whose RTC energy demand goes largely unnoticed; and
- 4) The most important of all, cooling.

MSMEs hold the single largest energy savings potential and remain the backbone of India's Industrial Economy. They account for a quarter of India's energy use, 35% of manufacturing output, 49% of exports and 31% of the country's GDP and yet operate with far less capital or technical capacity to invest in efficiency than large industry. Cluster-level programmes run with BEE, GEF, UNIDO and the World Bank have proven the demand-aggregation model can work here as well, pooling bulk pricing and pairing it with audits and capacity building. ADEETIE, launched in 2025 with a Rs 1,000 crore outlay and interest subvention for Udyam-registered units, is the first scheme built to take that model to genuine scale, initially launching across 60 industrial clusters in 14 energy-intensive sectors. But a supportive financial outlay alone does not go very far. The real challenge MSME clusters face is limited access to a workforce equipped to read an energy audit, size a retrofit, or navigate the subsidy models. Closing that last mile will depend as much on green skilling, training local technicians, auditors and cluster-level stakeholders, as it will on any future policy design.

Enabling energy efficiency through behavioural nudges is an equally important and untapped lever, closely aligning with the Prime Minister's LiFE Mission. WRI India's work with households in Bengaluru shows how efficiently this can move the needle at a lower cost. The study involving 2000 households in Bengaluru introduced

Home Energy Reports (HERs) that included energy-saving tips and social norm comparisons, leading to an average monthly energy consumption reduction of 7% over a year. If implemented city-wide, this could result in an annual reduction of 600 million units of electricity consumption. BRPL's Home Energy Reports Pilot in Delhi also highlighted similar results. Scaling such low-cost, high-trust interventions through state utilities is one of the most cost-effective opportunities still sitting largely untapped.

Running round the clock, with strict indoor climate needs and intensive equipment use, hospitals globally are benchmarked at around 423 kWh per square meter a year, roughly 2-3 times the energy a typical commercial building uses. In India, CII found that nearly 60% of healthcare facilities do not meet even the minimum Energy Performance Index criteria, while India's own Energy Conservation Building Code suggests hospitals could cut energy use by up to 42% through efficiency measures alone.

Closing that gap means looking beyond HVAC and lighting to the medical equipment, which is increasingly driving hospital energy demand, with imaging, diagnostics, sterilisation and cold storage still running on older, energy-intensive technology with little incentive to upgrade. As India's healthcare infrastructure expands to meet a growing and ageing population, building efficiency from the outset remains largely unrealised.

And perhaps the most cross-cutting, cross-sectoral issue of all and the one that deserves treatment as a national infrastructure priority: Cooling. AC penetration is projected to increase from just 10% today to over 80% by 2070, and by then cooling and appliances, and not cooking, will dominate the building energy demand for the first time. As per NITI Aayog's recent estimates, embedding stricter efficiency standards into air conditioning alone could save nearly 700 TWh by 2070, equivalent to Brazil's entire annual electricity consumption, and mitigate approximately 500 million tonnes of CO₂ emissions.

Studies have shown that 323 million people in India, primarily among the rural and urban poor, are at high risk from extreme heat due to a lack of access to cooling. This is also where equity considerations sit most starkly: the people most exposed to extreme heat are often the least able to afford mechanical cooling, which means efficiency and access must be designed together.

The recently launched Keep Cool Innovation Challenge is built around exactly that premise, identifying and supporting affordable, sustainable cooling solutions designed specifically for vulnerable and low-income populations, across three categories: building-level solutions, cold chain, and personalised comfort technologies, helping them reach the market so cooling becomes available to those who need it most, not just those who can already afford it.

THE WORK AHEAD: A MESSAGE TO THE NEXT GENERATION

For the professionals who will carry this work forward, the lesson is far less about any specific technology and more about a way of working. India's efficiency architecture- its standards, codes, policies, schemes and institutions- is largely built. What it needs now is patient, cross-sectoral execution and forging the right partnerships, with a systems thinking approach. India needs more engineers who understand carbon markets as fluently as energy audits, policy professionals who can work comfortably with national ministries as well as with urban local bodies and a generation of passionate professionals who are willing to treat behaviour change, workforce skilling and equity as seriously as megawatts installed and emissions abated.

There is also a new frontier quietly taking shape that the sector cannot afford to miss. Rising electrification and its reliable access, urbanisation, and disposable incomes are reshaping what Indian households can buy and use. Residential electricity consumption has already risen from 256 TWh to 409 TWh over the last decade, growing at 6% CAGR and making it the second-highest consuming

sector after industry. This shift is being led by a rise in demand for a new wave of appliances such as kettles, toasters, air fryers, coolers, etc., especially in Tier 2 and 3 cities. Understanding which appliances drive this demand, and what shapes consumer choice, is only going to matter more. The efficiency agenda must get ahead of this curve now, embedding EE standards into these categories from the start, rather than following the slower path it took to get labelling mandated on ACs and refrigerators

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KEY TAKEAWAY

India's efficiency leadership was built by commercial compulsion, not by mandate. That compulsion is now weakening, at exactly the point where the country needs it most. Rebuilding it — through a credible carbon price, secure municipal contracts, low-carbon public procurement and shared pilot risk — is the central task of the next twenty-five years.

EFFICIENCY WAS NEVER A CHOICE. IT MUST NOT BECOME ONE

Indian cement led the world because efficiency meant survival. That compulsion must now be rebuilt.

Madhavkrishna Singhania

THE SCALE THAT IS COMING

India uses less energy per person than almost any other country, and that will not last. The road to Viksit Bharat 2047 runs through higher incomes, bigger cities, far more manufacturing and much more construction, and every one of these needs energy. Most of the national discussion about this future is a discussion about supply — how fast renewable capacity can be added, how much of it the grid can absorb, and what it will take to keep pace with demand. These are important questions, but they cover only half the problem.

How much new generation India must build depends directly on how efficiently energy is used at the other end: in kilns, furnaces, motors, pumps and fans. A unit not consumed is a unit that need not be generated, transmitted, financed or imported. Efficiency is not an add-on to the energy transition; it decides the size of that transition, and therefore its cost.

Twenty-five years of Indian experience show how efficiency actually gets delivered, and cement is the clearest example. Work done by CII's Green Business Centre for the B20 process during India's G20 Presidency established that the Indian cement industry is the most energy- and carbon-efficient in the world per tonne of cement.

This did not come about through environmental ambition or through

regulation. It came about through commercial compulsion. Energy is the largest controllable cost in cement, and in a market where higher costs could not be passed on, the plant that used less simply survived better. Holding on to this record matters a great deal, because energy efficiency is expected to deliver a very large share of the sector's contribution to India's decarbonisation up to 2047 — the single biggest lever available, not one option among many. That history raises an uncomfortable question for the next twenty-five years. What happens when the compulsion fades, and the gains that remain cost more than they save? The answer will decide whether India's efficiency leadership was a stage in its industrial growth or a permanent feature of it.

HOW THE ADVANTAGE WAS BUILT

Two forces built this advantage, and the first was timing. Indian cement demand picked up after the 1991 liberalisation, and most of the country's capacity has been added since then. Europe, the United States and Japan built much of their infrastructure decades earlier, so they run older plants with older technology. China is the only comparable performer, having built out over a similar period with a head start of a decade or two.

A young asset base is an efficient asset base, and India was fortunate in when it grew. But timing alone explains very little, since many economies have industrialised late without industrialising well. The equipment a country installs matters far less than whether it has a reason to run that equipment well for the next thirty years.

That reason was the second force. The Indian cement industry is less consolidated than most large markets, so competition has been intense, and constant pressure on prices meant that cost control and energy performance were the same job under two different names. In markets that consolidated and gained pricing power, the pressure to chase the last unit of energy eased. Around this compulsion, an institutional structure grew up.

The Perform, Achieve and Trade mechanism gave efficiency a compliance floor and, importantly, a tradable value. Alongside it, sustained plant-level benchmarking gave companies something more useful than a target: a comparison, and with it a clear picture of how far each plant stood from best practice.

Much of this work has been done by CII's Green Business Centre, whose three decades inside cement plants have built the most detailed view of the sector's energy performance available anywhere in the country. Compulsion supplied the motive, while institutions supplied the method and the visibility that made improvement measurable.

WHY THE CURRENT MODEL IS RUNNING OUT OF ROOM

This model is now close to its limit, for a reason that is easily mistaken for good news. Improving is simple when a plant sits well behind best practice, but it is much harder at the frontier, and Indian cement is at the frontier. Perhaps another five to ten per cent of energy efficiency is still available to the sector, and across an industry of this size that is not a small number. But it will not come from the measures that delivered the earlier gains, and it will not be paid for the way those were.

The three levers that brought the sector this far — alternative fuels, waste heat recovery and renewable power — have largely been worked through at the leading plants. Thermal substitution at the best sites has reached levels that would have been considered unattainable in the Indian context not very long ago, and waste heat recovery has moved just as far, with well-configured installations now generating substantially more power per tonne of clinker than the systems installed a decade or two earlier. State policies allowing a higher renewable share in industrial consumption have drawn heavy investment. Each of these, in its time, offered an attractive return, which is exactly why companies took them up without being told to.

Very few of the projects now waiting for sanction can say the same, and proposals that cleared internal hurdle rates comfortably five years ago carry much longer paybacks today. For the leaders, efficiency has quietly stopped paying for itself, and that is the central fact of the present moment.

A carbon price does not make expensive abatement cheap. It makes the value of abatement visible — and visibility is what gets a project appraised, financed and approved.

What is left inside the plant is real, but it is incremental, and it is now more a matter of operating discipline than of new equipment. Power consumed per tonne of cement still responds to holding power factor close to unity, to replacing motors as higher efficiency classes become available, and to the unglamorous work of eliminating idle running across hundreds of drives.

On the thermal side, larger and better-designed preheaters have brought top-stage cyclone outlet temperatures down sharply over the years, a large fuel saving built from many small engineering decisions rather than one breakthrough. The most promising lever left is digital: advanced process control, predictive maintenance and machine-learning optimisation, which are already delivering a measurable gain in productivity and energy performance, and more where implementation is strong. The industry is still only at the beginning of this. Useful as all of it is, it refines a plant that already runs close to its practical limit, and it cannot carry a national decarbonisation agenda on its own.

THE VALUE NOW LIES OUTSIDE THE PLANT BOUNDARY

The conclusion is not that the sector has run out of opportunity, but that the opportunity has moved. The largest gains left to Indian cement are no longer inside the kiln; they lie in the systems the kiln connects to — municipal waste, public procurement, the carbon market and

freight. None of these is within the control of a single company, which is precisely why the next phase cannot be delivered by industry effort alone, however capable that industry has proved to be. All four also need the same thing, which is predictability. Long-life industrial investment follows signals that can be relied on for the life of the asset, and it is the absence of such signals, not any shortage of technology or capital, that holds back progress today.

Municipal waste makes the point most clearly. Leading plants co-process at 35 to 40 per cent thermal substitution, while the national average is understood to be near seven per cent. Closing that gap would do much more than decarbonise cement; it would give urban India a proven and permanent route for waste that otherwise goes to landfill. The constraint is not the kiln but the feedstock — the availability, quality and consistency of processed waste reaching the plant. So far, co-processing has advanced almost entirely on industry investment in feeding systems, storage yards and handling infrastructure.

Urban local bodies, which control most of the country's municipal waste and refuse-derived fuel, have not been able to match that pace, and the reason is structural rather than a lack of intent. Waste-processing contracts are often short, and are subject to re-tendering and to changes in municipal administration. No investor will build durable processing infrastructure against an uncertain contract period, so makeshift processing follows, and poor-quality material follows from that.

The dependence runs both ways, because a plant operating at half substitution cannot absorb a supply break of even a few months. Indore has shown that the alternative works in Indian conditions, and that it can be replicated wherever the enabling conditions hold.

Demand is the second system, and here the diagnosis has changed completely. Low-carbon cement is usually discussed as a technology problem, and it is no longer one. Limestone calcined clay cement, or LC3, has been manufactured and commercially launched in India,

with JK Cement among the early movers, and blended cements have been established for years. The experience of taking LC3 to market is instructive precisely because it was not a technical failure. The chemistry worked, the product was made and it was placed in the market, but the buyer did not follow. There is still no real pull for cement specified on the basis of its carbon content, and no premium attached to it, so building that demand will take sustained work with specifiers, contractors and developers rather than more work in the laboratory. Producers are still right to complete their low-carbon portfolios now, so that the capability is ready when the market turns rather than two years later.

"A carbon price does not make expensive abatement cheap. It makes the value of abatement visible — and visibility is what gets a project appraised, financed and approved."

But the market will not turn on its own. Government infrastructure procurement is large enough to change this, and specifying blended and lower-carbon cements in public tenders would create the demand signal through an administrative decision, without waiting for a single new technology. In this phase, demand-side policy may matter as much as anything happening in a laboratory.

The third system is the price of carbon. The Carbon Credit Trading Scheme, in many ways a natural evolution of the Perform, Achieve and Trade framework, is expected to develop considerably in the coming years, and its importance is easy to underestimate.

The diminishing-returns problem described earlier is, at heart, an accounting problem. Emissions avoided carry no value on a balance sheet today, so projects that reduce them compete poorly for capital against projects that add capacity or output. A credible and reasonably stable carbon price changes that comparison directly. It does not make expensive abatement cheap; it makes the value of abatement visible,

and visibility is what allows a project to be appraised, financed and approved. For an industry already at the efficiency frontier, that may matter more than any single technology now under development.

Two further areas deserve focused national attention, the first being carbon capture, utilisation and storage. It is unavoidable in any serious long-term pathway for cement, because a large share of the sector's emissions comes from calcination itself rather than from fuel, and no amount of efficiency will remove them. What is needed now is pilot-scale demonstration through industry–academia–government partnership, supported by public research funding, rather than a wait for mature technology to arrive from elsewhere.

The second area is freight. Logistics is among the largest cost heads in cement, and its movements are high in volume, repetitive and predictable in routing — exactly the profile needed to anchor early investment in highway charging infrastructure and make electric freight commercially viable well beyond this one sector.

Meanwhile, the industry has begun applying the lesson closest at hand. New capacity is increasingly designed future-ready from the first drawing, with alternative fuel provision, waste heat recovery, renewable tie-ups and digital process control built into the original design, where they cost a fraction of what the same capability costs when retrofitted into a running plant.

THE WAY FORWARD

The next twenty-five years call for a deliberate rebuilding of the compulsion that drove the first twenty-five. Four measures would achieve most of it. First, carbon needs a price that is credible and stable enough to be written into a project appraisal, which makes predictability in the design of the Carbon Credit Trading Scheme as important as its stringency.

Second, municipal waste-processing contracts must run long enough,

and with enough security of tenure, for serious infrastructure to be built against them, backed by financial support to urban local bodies that show performance and not merely intent. Third, public procurement must start specifying blended and lower-carbon cements, turning the government's purchasing scale into a market signal that no producer can create on its own. Fourth, pilot-stage support must extend to carbon capture and to freight electrification, where the technology risk is still too high for any single company to carry on its balance sheet.

Industry's side of the bargain is equally clear. Every new line must be designed for best-in-class power and fuel consumption from the start, and digital capability must be built well before its returns are fully proven, because the learning curve is long and cannot be compressed at the moment it becomes urgent.

Low-carbon products must be kept ready in the portfolio ahead of demand, not in response to it. India's efficiency leadership was built in an era when saving energy was simply the way to stay in business, and the task for the coming decades is to make reducing carbon a compulsion of the same order — visible in the carbon price, in the municipal contract and in the tender document. If that happens, the sector will do more than defend a position it already holds. It will have made efficiency one of the lasting foundations of Indian competitiveness on the road to 2047.

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KEY TAKEAWAY

Across credible pathways to 2050, efficiency remains the cheapest and fastest lever available at every point on the curve. It requires no technological breakthrough, no new import dependency and no new supply chain — and the savings it releases fund the more capital-intensive work that follows.

EFFICIENCY BEGINS WITH ATTENTION

Energy efficiency has never begun with technology. It begins when someone notices what everyone else has stopped noticing — and India's next decade of gains will come from that same discipline.

Meher Pudumjee

BEFORE TECHNOLOGY, OBSERVATION

Energy efficiency is usually introduced as a technology subject. In practice it begins earlier, and with something far less expensive: attention. A steam line that vents, a fan that runs beyond its required duty cycle, a furnace door that stays open a few seconds longer than the process demands — each represents recoverable value, and each becomes visible only when someone is looking closely enough to notice what routine has made invisible. Across industrial operations the sequence is consistent. Observation identifies the opportunity, measurement quantifies it, and technology then delivers the solution.

The principle has a long institutional history. Thermax adopted a commitment to conserving resources and preserving the environment as early as 1980 — well before carbon acquired a market value, before net-zero entered corporate vocabulary, and before efficiency carried an explicit climate rationale. The motivation then was straightforward engineering economics shaped by scarcity: energy already paid for should deliver useful work. That founding logic remains intact, and much of what is now expressed in the language of transition and decarbonisation rests on the same underlying discipline.

The past twenty-five years have added considerable sophistication to that discipline — instrumentation, measurement and verification protocols, sectoral benchmarks, trading mechanisms and dedicated

financing structures. These layers strengthen the practice, and they rest on a foundation that has not changed. Efficiency begins with attention, and technology follows to resolve a problem that a trained professional was alert enough to identify.

A SHARED CONVERSATION, NOT A MANDATE

Efficiency work in India was, for a long time, a private activity. A facility improved its specific energy consumption, recorded the saving, and applied the learning internally, and the knowledge rarely travelled beyond the boundary wall. Its transformation into a shared national conversation is among the most consequential developments in the field.

CII built the platforms that made this shift possible. Benchmarking allowed performance to be compared across similar operations. Structured energy audits made diagnosis rigorous and repeatable. Award platforms and recognition programmes made strong performance visible to the wider industrial community. CII Green Business Centre's sustained efforts in advancing energy efficiency across the country deserve particular recognition for helping make industrial efficiency a shared national priority. A plant head could

"India will use more energy in the years ahead, and that trajectory reflects development working as intended. Efficiency is what will make that growth affordable — and the next decade of gains will come from closer attention to what is already built, measured honestly and acted upon every day."

now locate their own performance relative to sectoral peers, and that visibility created a powerful incentive to improve. This mechanism operates differently from regulation. It combines peer benchmarking with credible measurement, and it has proved durable precisely because it is voluntary, reputational and self-renewing.

The mechanism has an important second-order effect. A plant that publishes a strong result creates an expectation that its peers will match it, and the sectoral benchmark moves upward without a single new regulation being written. Mandates establish a floor of compliance; shared measurement raises the ceiling. India has benefited from both, and it is the second that made the first workable in practice.

POLICY THAT CREATED MARKETS

India's policy architecture for energy efficiency has been effective for a specific and instructive reason: at its strongest, it created markets rather than only issuing rules.

The Energy Conservation Act of 2001 established legal standing and institutional ownership for the subject. The Perform, Achieve and Trade mechanism advanced the design further by attaching a tradable instrument to energy saved beyond target. That single choice transformed the commercial character of efficiency. Energy that had previously dissipated as heat or been absorbed within the cost sheet became visible, countable and tradable. An engineering virtue acquired a market price, and with a price came a constituency inside the enterprise: capital allocation, treasury and finance functions began to engage with efficiency as a value proposition rather than a technical preference.

The method of policy formulation was equally consequential. The framework was developed jointly with industry, drawing on shop-floor evidence assembled by CII over years of audit work, sectoral baselining and operating data on what a well-run plant in a given sector could realistically achieve. Targets were established in consultation with the enterprises that would deliver them. This grounding in measured practice is a principal reason for the high level of industry acceptance the framework has enjoyed. A norm derived from demonstrated performance carries technical authority and commercial credibility. The lesson translates directly into the policy debates ahead: build the evidence base together with those who will implement the rule.

RISING ENERGY USE IS THE PRICE OF GROWTH

Projections of rising energy consumption in India are best understood in developmental terms. For an economy at this stage of industrialisation and urbanisation, increased energy use is a direct indicator of progress.

Higher consumption reflects more homes with reliable cooling, more students able to study after dark, expanded cold chains protecting food and vaccines, more small manufacturers running additional shifts, and more households moving into productive economic activity. A country lifting incomes at scale will require more energy, and that trajectory is entirely consistent with development objectives. The question that matters is how efficiently each additional unit is converted into economic and social value.

Efficiency is what makes that growth affordable — in rupees, in imported fuel, in generation and transmission capacity that would otherwise need to be built, and in emissions intensity. It allows demand to rise without a proportionate rise in the cost of meeting it. Framed this way, efficiency operates as an enabler of national ambition rather than a limit on it. The measure of success is not lower consumption, but greater output, comfort and livelihood generated per unit of energy consumed.

DO THE LEAST GLAMOROUS WORK FIRST

A single operating principle captures much of the accumulated experience of the sector: extract full performance from assets already built before commissioning new capacity.

Efficiency work is inherently understated. A corrected steam trap survey, a rebalanced compressed-air header or a two-degree reduction in flue gas temperature carries no ribbon-cutting moment. New capacity, by contrast, is visible and announceable in a way that optimisation rarely is — which is why the order of investment is so often reversed.

The economics of that sequence are straightforward. Work on installed assets can be executed within the current quarter, using existing teams, and it competes for a fraction of the capital that new capacity requires. New fuels, new process chemistries and new plants remain essential to the longer transition and warrant sustained investment. The point is one of order rather than preference: efficiency delivered first generates the cash flow that funds the more capital-intensive work, and reduces the scale of capacity that must ultimately be built.

PLANTS SPEAK: FROM EVENT TO HABIT

A significant shift over the past decade will shape the decade ahead. Industrial assets now communicate their own performance continuously.

For much of the sector's history, an energy audit was a periodic event. A specialist team arrived, spent a fortnight with instruments and log sheets, produced a report, and departed. Recommendations were implemented, and performance was then reassessed only at the next audit cycle. Efficiency was captured as a periodic snapshot of a system that varies hour by hour.

Continuous monitoring has changed that model. Assets now report themselves, and deviation from expected performance surfaces the same day rather than at the next audit. The basic unit of efficiency work has consequently shifted from the project to the habit, and from a periodic intervention to a daily operating routine. The change is cultural as much as technical. When boiler performance appears on a dashboard reviewed each morning by the plant leadership, the operating discussion moves from whether to invest towards why current performance differs from the previous day.

On current evidence, a substantial share of the gains available to Indian industry over the coming decade will come from closer attention to existing machinery rather than from new machinery alone. Installed equipment across most sectors can deliver more than current operating

practice extracts from it, and continuous monitoring provides the means to close that margin.

TWO UNFINISHED PRIORITIES

Two areas will define the next phase of work: the decarbonisation of industrial heat, and the extension of efficiency into the micro, small and medium enterprise sector. Each is large enough to warrant dedicated national focus, and each calls for a very different kind of response.

The first is industrial heat, where the difficulty is physical rather than organisational. In steel, cement and comparable high-temperature processes, emissions arise from the chemistry and thermodynamics of production itself. These are genuinely hard problems, requiring solutions that are still maturing towards commercial scale and competitive cost — among them green hydrogen, carbon capture and utilisation, alternative binders and process redesign. Efficiency measures reduce the scale of the challenge and create valuable time for these technologies to mature, and they work best when pursued alongside a clear, well-funded technology roadmap for hard-to-abate heat.

The second is unlocking efficiency across the micro, small and medium enterprise sector, where the diagnosis matters more than the technology. Efficient motors, burners, drives and control systems are commercially available, largely manufactured in India, and offer attractive payback periods. The constraint is trust and financing. A smaller enterprise is being asked to commit scarce working capital, plan for installation downtime, and rely on a savings estimate provided by the party that also supplies the equipment. Progress at scale therefore depends on independent measurement and verification, cluster-level aggregation that lowers transaction costs, financing structures designed for smaller balance sheets, and local service providers with established reputations. This is institutional design rather than engineering, and the pathways are well understood.

NEVER WALK PAST A LEAKING VALVE

Three principles separate those who do this work well from those who merely do it. They apply as much to a plant head with thirty years of service as to an engineer in a first posting, and none of them depends on seniority or budget.

The first is to measure honestly, including when the result falls short of expectation. Baselines should be selected on technical merit, comparison periods should be representative, and results should be reported in full. An accurate measurement is more valuable than a favourable estimate, and professional credibility in this field is built on the consistency and integrity of reported numbers.

The second is to examine the whitespace. Engineering training tends to focus optimisation within a single machine, while a large share of the remaining opportunity in Indian industry sits between systems — between the utility block and the process it serves, between production and maintenance schedules, and between the team operating equipment and the function that specified it. These interfaces sit outside any single mandate, and professionals who work confidently across organisational boundaries consistently identify value that specialist analysis within one boundary does not reach.

The third is to begin without waiting for a formal assignment. The most substantial contributions in this field have generally come from professionals who acted on what they observed within their immediate scope of work. The defining attribute is an inability to walk past a leaking valve. It reflects temperament as much as technical skill, and it remains the strongest single indicator of long-term effectiveness in energy efficiency practice.

THE WAY FORWARD

India's energy efficiency practice now has what it needs to move faster: credible measurement, mature institutions, tested policy instruments and a generation of operating experience. The task ahead is to convert

that foundation into system-wide performance. Seven priorities will determine how much of the available opportunity is realised.

1. **Lead with observation.** Every efficiency programme should begin with structured observation of how assets actually operate, before capital is committed. Building this capability across engineering teams is the highest-return investment available, because it determines the quality of every decision that follows.
2. **Widen the conversation.** Benchmarking, audit protocols and recognition platforms should extend into the sectors now driving demand growth — commercial buildings, data centres, cold chains, logistics and municipal systems. Peer comparison and transparent measurement build capability faster than regulation alone, and they should reach every sector where energy is used at scale.
3. **Design policy that creates markets.** The next generation of instruments — carbon credit trading, performance-based energy service contracts and efficiency-linked finance — should follow the design principle that has already proved itself: make saved energy visible, countable and tradable, and build targets on shop-floor evidence gathered alongside the enterprises expected to deliver them.
4. **Sequence capital correctly.** Full performance should be extracted from installed assets before new capacity is commissioned, and capital plans should require an efficiency case before an expansion case. Boards can enforce this without new process, simply by asking what the existing asset base would deliver at design performance before approving new build.
5. **Convert monitoring into habit.** Continuous performance data should be reviewed daily and acted on the same day, with energy performance sitting alongside safety, quality and output in operating reviews. Deviation should carry a named owner and

a closure timeline; in the same way a safety observation does.

6. **Solve for industrial heat and for MSMEs.** Both need dedicated institutional vehicles rather than general programmes: a consortium that pools industry, government and research funding behind demonstration plants for high-temperature processes, and a cluster-based delivery platform that carries verification, financing and service capability to smaller enterprises as a single package.
7. **Build the talent.** Certification, structured mentoring and cross-functional rotation should become standard practice for energy managers, so that honest measurement and system-level thinking are taught deliberately rather than left to individual temperament.

These priorities share a common character. Each can be advanced now, with existing assets, existing teams and instruments already tested in Indian conditions, and each compounds the value of the next. Efficiency will remain the foundation on which the rest of the energy transition is built — the lever that makes rising demand affordable, strengthens industrial competitiveness, and creates the financial and operational headroom for the harder work of decarbonisation.

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KEY TAKEAWAY

India's next energy-efficiency leap will come from making proven efficiency investments business as usual. An opportunity identified in an audit has no economic value until someone takes responsibility for implementing it, measuring the result and sustaining it. The first 25 years built the laws, institutions and professional capacity to discover savings at scale; the next 25 must build the commercial and operational discipline to convert those findings into dependable returns.

FROM REPORTS TO RESULTS: BUILDING INDIA'S ENERGY- PERFORMANCE ECONOMY

India's first 25 years made energy efficiency a profession and a market. The next 25 must make performance continuous, measurable and investable.

Milind Chittawar

An energy-saving opportunity identified in an audit has no economic value until someone takes responsibility for implementing it, measuring it and sustaining it. That distinction is the unfinished business of India's energy efficiency journey. The first 25 years built the law, the institutions and the professional cadre needed to identify savings at scale.

The first 25 years were about discovering savings. The next 25 are about building the discipline to deliver, measure, and sustain them - every single day. Today over 30+ energy efficient technologies can deliver 10 to 25% energy savings with ROI well within 2 years.

FROM PROFESSION TO MARKET

The Energy Conservation Act, 2001 and the establishment of the Bureau of Energy Efficiency in 2002 provided a necessary institutional framework—standards, certified professionals, designated consumers, targets and verification. This helped convert energy management from the work of isolated champions into a recognised profession.

Standards and Labelling, ECBC, PAT and UJALA then broadened participation and made energy performance more visible. CII-GBC supported this transition through benchmarking, awards and peer learning that brought proven plant-level experience into the mainstream.

These measures created significant awareness and accountability. But policy can only open the door; it cannot, by itself, deliver energy efficiency at scale. Accelerated adoption requires compelling business drivers. When management recognises energy efficiency as an investment offering attractive returns, higher productivity and profitability, and a stronger brand through measurable carbon-emission reduction, it moves beyond compliance and becomes a strategic business priority.

At SEE-Tech, this conviction has shaped our work from the beginning: energy saving must stand on a compelling business case. Many opportunities in motors, pumps, fans, compressed air, cooling, steam and process heat need modest capital, can be implemented with limited

"Unless one person or one contract owns the complete outcome, an attractive opportunity can remain permanently under consideration."

disruption, and can recover their investment in months to a few years, depending on site conditions.

The returns then repeat year after year through lower energy bills, higher throughput, improved reliability, reduced maintenance, released electrical capacity and lower emissions. Few decarbonisation measures can match this combination of speed, certainty and continuing cash generation.

The opportunity is becoming richer because proven engineering retrofits can now be combined with demand-based controls and continuous performance monitoring.

In our work, this ranges from IE5 motor retrofits, belt-to-direct-drive conversions, right-sized centrifugal pumps and high-efficiency aerofoil plug fans for AHUs, air washers and exhaust systems, to VFD-based closed-loop automation that continuously matches equipment output to actual demand.

Cooling and thermal opportunities include chiller and cooling-tower optimisation, adiabatic pre-cooling for air-cooled chillers, DX units and VRF systems, conversion of shell-and-tube heat exchangers to plate heat exchangers, normal- and high-temperature heat pumps, steam-pressure recovery through back-pressure turbines, and engineered waste-heat recovery systems.

Compressed-air systems, chilled-water pumps, process utilities and commercial-kitchen ventilation can similarly be transformed from fixed-speed operation to demand-led control.

Equally important is the ability to sustain and prove the results. Smart sub-metering, PLC and VFD integration, IoT gateways, remote monitoring, AI-assisted anomaly detection and digital twins can continuously compare actual performance with agreed baselines and benchmarks, identify deterioration, and report savings in energy, cost and emissions.

The objective is not to install technology for its own sake, but to identify, engineer, implement and verify the combination that offers the strongest lifecycle return. These capabilities are compressing the journey from energy audit to pilot project, verified results and plant-wide or multi-site replication-and adoption is now accelerating at its fastest pace yet.

When supported by sound engineering and transparent measurement, energy efficiency is not a sacrifice for the future or merely a compliance expense; it becomes one of the fastest and most bankable ways to improve profitability, capacity, reliability and carbon performance today.

THE OWNERSHIP GAP

None of these institutional or technological progress resolves the core problem an individual energy-saving opportunity actually faces: an audit report is not an outcome.

Across Indian industry, sound reports routinely remain in drawers while modest, unglamorous projects continue saving energy for years, and the difference is rarely the quality of the underlying engineering. It is whether somebody owned the commissioning and returned to check performance.

Most failures occur in the space between diagnosis and delivery, where capital approval is delayed, responsibilities are split across departments, operating conditions change, the baseline is disputed, or savings simply drift away after handover.

Efficiency also has a visibility problem that renewable energy does not share. A solar plant is a recognisable asset with a rating, a contract and an output meter.

Efficiency is distributed across motors, valves, control loops, pressure settings and operating practices, and its best result is energy that was never consumed, which is inherently harder to see or claim credit for. Accountability for that invisible outcome is scattered besides: operations own the plant, procurement the purchase, finance the capital, sustainability the carbon target, and the consultant only the report.

Today's losses, moreover, are increasingly systemic rather than located in any single piece of equipment. An efficient chiller can still perform poorly inside a badly controlled cooling system; a premium motor can waste energy if the pump, valve and process demand around it are mismatched.

Cooling, compressed air, pumping, ventilation, process heat and controls must be studied as systems that deliver a service, not as equipment evaluated in isolation.

Technical recommendations must also be grounded in the specific climatic and operating conditions of a site rather than in a generic specification sheet: an intervention that performs well in one climate

zone or process can genuinely underperform in another, and the discipline of saying so before a project is signed is what protects long-term credibility in a market still built substantially on trust.

Measurement sits underneath all of this, not as paperwork added after a project concludes, but as part of the business model itself. A clear baseline, agreed variables, calibrated instruments and a transparent measurement-and-verification plan protect both client and service provider.

What cannot be standardised, aggregated and verified will struggle to be financed at scale. Ownership and measurement, not technology, are the binding constraints on how fast India's efficiency market can grow.

FIVE SHIFTS FOR THE NEXT 25 YEARS

- 1. From periodic audits to continuous performance** — every significant asset observable against the service it delivers, not just its last audit reading.
- 2. From energy management to carbon governance** — the same baselines and verification that prove an energy saving increasingly need to support emissions accounting and capital allocation.
- 3. From advice to accountable delivery** — savings treated as a cash flow, backed by standard contracts, robust measurement and verification, and pooled or blended financing.
- 4. Efficiency in sequence with electrification, renewables and flexibility** — reduce avoidable demand first, decarbonise the remaining supply, then operate the combined system intelligently.
- 5. From analysis to intelligence, carefully** — AI-enabled monitoring supporting, not replacing, engineering judgement on the baseline, the sensor and the process.

Analysis, in particular, must evolve into intelligence carefully. AI can detect anomalies, compare similar assets, identify drift, prioritise

actions and learn from verified results. But a dashboard is not an energy-management system, and an algorithm does not absolve the professional of engineering judgement.

The professional must still validate the sensor, understand the process, question the baseline, and protect safety, reliability and production, no matter how sophisticated the analytics layer above it becomes.

MAKING VERIFIED SAVINGS INVESTIBLE

The ESCO model is intended to align engineering incentives with the customer's commercial outcome. Where projects are supported by rigorous measurement and verification, savings exceeding 20 per cent can be delivered without compromising service quality. Yet India's ESCO market remains far below its technical potential.

Trust takes time to build; working capital is expensive for smaller providers; contracts remain largely bespoke; and weak baselines and verification create uncertainty that clients and lenders hesitate to accept.

Grade-1 ESCO accreditation helps establish capability, but cannot by itself make a project financeable. That requires transparent baselines, agreed measurement protocols and independently verifiable evidence of savings - not projections alone.

Across manufacturing, pharmaceuticals, food processing, plastics, metals, automotive and hospitality, the pattern is remarkably consistent: technology is seldom the binding constraint. Durable results come from combining sound engineering with a viable commercial structure, disciplined commissioning, operator ownership and sustained follow-through.

India's efficiency market must therefore progress from accumulating technologies and isolated audit recommendations to delivering repeatable, sector-specific performance solutions with accountable outcomes.

Scalability also demands the right balance between standardisation and site-specific engineering. A practical principle is to standardise about 80 per cent of a solution and configure the remaining 20 per cent for the asset, process and operating conditions. Begin with a paid pilot, agree on the baseline, prove the result and then replicate it across comparable equipment, plants or locations.

This land–prove–multiply model converts scattered projects into investable programmes while preserving the engineering judgement on which real savings depend.

COOLING AND ELECTRIFICATION: THE NEXT EFFICIENCY FRONTIER

Rising temperatures, urbanisation, cold chains, data centres, pharmaceuticals and higher comfort expectations will make cooling one of India's defining loads over the next 25 years. Energy efficiency must therefore be the first cooling resource. Optimising envelope and process demand, ventilation, cooling equipment, heat rejection, pumping, controls, thermal storage and heat recovery as one integrated system can reduce operating costs, install capacity and grid stress while preventing decades of inefficient lock-in.

Electrification must follow the same efficiency-first logic. As renewables expand, efficient and flexible loads can respond to grid conditions and create value beyond direct energy savings. The sequence is clear: eliminate avoidable demand, electrify efficiently, decarbonise the supply and operate the integrated system intelligently.

For MSMEs, cluster programmes can aggregate engineering, procurement, finance and monitoring, converting fragmented opportunities into scalable energy-efficiency projects.

THE WAY FORWARD

Three priorities will determine whether India's efficiency market matures into a genuine performance economy over the next 25 years.

First, measurement and verification discipline must move from a compliance requirement into standard commercial practice, so that savings can be treated as investible cash flow rather than an avoided expense that is difficult to finance.

Financial institutions and ESCOs share this responsibility: standard contracts, robust M&V frameworks and pooled or blended financing would reduce the transaction costs that currently keep efficiency financing bespoke and slow. Second, MSMEs must be brought into the mainstream of this market through cluster-level aggregation, rather than left to negotiate technology and financing decisions individually. Third, as India's carbon market develops, the baselines, instrumentation and verification capability built over 25 years of energy management must be extended, not rebuilt, to support carbon accounting, so that the country's institutional investment in measurement is reused rather than duplicated.

The same evidence that proves an energy saving can support emissions accounting, capital allocation and operational resilience, and energy managers will increasingly need to translate between engineering, finance and climate strategy as this shift takes hold.

By the time India approaches its centenary, energy efficiency should function like an operating system within every serious enterprise: every major asset with a performance baseline, every opportunity with a named owner, a stated value and a timeline, every implemented measure independently verified, and every successful solution ready for replication across the enterprise and its supply chain.

The first 25 years built the architecture - law, institutions, professionals, standards and market mechanisms. The next 25 must convert that architecture into continuous delivery.

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KEY TAKEAWAY

As tariffs fall and carbon intensity influences market access, the economic productivity of every unit of energy will determine how fully Indian industry converts new trade opportunities into durable global success.

ENERGY PRODUCTIVITY: THE COMPETITIVENESS TEST BEHIND INDIA'S TRADE OPENING

New markets are opening. The productivity of every unit of energy will decide how much of them Indian industry wins.

Mukundan R

India's trade landscape is being redrawn. Free trade agreements are opening markets as the country expands manufacturing and deepens its role in global value chains. The opportunity is significant, but lower tariffs work in both directions: exporters gain access abroad while producers face stronger competition at home. Success will therefore depend on cost, quality, delivery, scale and, increasingly, carbon intensity. Among these variables, energy is one of the most important and most within an enterprise's control.

Energy efficiency should therefore be treated as an industrial competitiveness agenda, not only as an environmental commitment. The relevant measure is energy productivity: how much value, output, comfort and resilience are created from every unit consumed.

WHAT REMAINS WHEN TARIFFS FALL AWAY

In newly opened markets, Indian firms compete with established suppliers that have spent decades improving costs, processes and delivery. Small advantages compound: lower production cost, consistent quality, dependable shipments and credible environmental data can decide a contract. Energy is distinctive because it is simultaneously a cost, a productivity driver and an environmental signal. Its performance follows from equipment, process design, operating discipline, maintenance and measurement. Firms cannot control global fuel prices, but they can control how much fuel they

need. Lower energy intensity also protects margins and supports confident pricing through market volatility.

Trade agreements determine who is allowed into a market. They do not determine who succeeds once inside it.

FROM ENERGY SAVING TO ENERGY PRODUCTIVITY

For twenty-five years, efficiency was commonly measured as a reduction from a historical baseline. That made energy visible and built a strong measurement culture. The next step is to align the measure with a growing economy. India's industrial base will

"Efficiency will scale only when a rupee saved can be underwritten with the same confidence as a rupee earned."

consume more energy in absolute terms; progress should therefore be assessed as output per unit of energy – value added, tonnes produced, space cooled or services delivered. A firm that doubles output while increasing energy use by half has clearly improved.

This reframing also changes ownership. Reduction is often a plant-level metric; productivity belongs on the chief executive's and board's agenda alongside labour and capital productivity. The largest gains arise from strategic choices such as process redesign, heat integration, utility reconfiguration, electrification and better instrumentation. The same disciplines that reduce waste – measurement, process control and maintenance – also improve throughput, quality and equipment life.

Nationally, energy productivity supports Viksit Bharat 2047 by enabling output to grow faster than energy demand. It releases capital otherwise required for generation and networks, saves foreign exchange on imported fuel and strengthens energy security.

WHEN CARBON ENTERS THE PRICE OF TRADE

Carbon border measures, including the European Union's Carbon Border Adjustment Mechanism, signal that embedded emissions will increasingly influence trade. Buyers are already asking suppliers for verified data. Deep decarbonisation will require emerging options such as green hydrogen, carbon capture and new process routes. Energy efficiency is available now: proven, cost-effective and capable of reducing costs and emissions together. It also lowers the eventual requirement for clean energy.

Measurement can become a competitive advantage. A firm that can substantiate product-level energy and carbon intensity can differentiate itself, negotiate from evidence and identify improvements precisely. Data collected for the border also serves the boardroom.

MAKING EFFICIENCY BANKABLE

Scaling energy productivity requires finance. The central challenge is not simply the availability of capital, but how returns are evidenced and risk allocated. Efficiency repays investment through avoided cost, which is harder for lenders to observe than sales. Once independently verified, however, savings can be priced as a cash flow rather than treated only as a claim on the promoter's balance sheet. This is especially important for smaller firms.

India needs an infrastructure of confidence: standardised, digital and continuous measurement and verification; familiar contracts; risk-sharing placed with technology providers or energy service companies able to manage performance; and stronger energy-service balance sheets. When avoided energy cost becomes verifiable, contractable and transferable, efficiency can develop as an asset class with its own intermediaries and risk pricing.

THE CLUSTER TEST

The largest opportunity lies among micro, small and medium enterprises that form India's supplier base. Carbon questions directed at major exporters quickly travel down supply chains. Smaller firms need technical guidance, collective purchasing power and workable finance. Procurement must shift from lowest initial price to life-cycle value.

Clusters provide the route to scale. Firms in a foundry, textile or food-processing cluster often use similar systems, allowing diagnostics, technology packages and finance to be replicated. Aggregation turns many small proposals into a financeable portfolio and creates demand large enough to support domestic manufacturing of efficient equipment. India's appliance market has already shown how consolidated demand can reduce costs and make efficient products standard. Industrial clusters can similarly support performance-guarantee enterprises, verified emissions services, shared utilities, waste-heat recovery and digital monitoring—creating skills and employment as well as savings.

EFFICIENCY AS A SYSTEM PROPERTY

As renewable energy grows, the value of electricity varies by time. Facilities that are efficient and flexible—by shifting operations, pre-cooling or charging storage when power is plentiful—reduce peak capacity, ease renewable integration and support distribution utilities. Sensors, controls and analytics make continuous optimisation and remote verification practical. The same digital layer can satisfy lenders, provide carbon data to buyers and enable participation in a flexible grid.

INDIA'S LEADERSHIP OPPORTUNITY

India has strong institutions, skilled professionals, experience in aggregation and a major advantage: much future industrial capacity is still being designed, and efficiency built in is far cheaper than

efficiency retrofitted. Industry must elevate energy to the board agenda and extend discipline to suppliers. Financial institutions must lend against verified savings and cluster portfolios. Policy should reward productivity and flexibility, while industry bodies and technical centres provide standard protocols, diagnostics and skills.

India can demonstrate practical, affordable energy productivity at scale across clusters, small enterprises, cities and a renewable-rich grid—and export this capability to other developing economies.

FROM MARKET ACCESS TO MARKET SUCCESS

The past twenty-five years proved that efficiency works, can be measured and can be institutionalised. The next twenty-five must prove that it pays visibly and bankably across the industrial economy. Three actions are available now: measure energy as productivity and report it to the board; build verification that lenders accept so avoided cost can be financed; and pursue common diagnostics, technology and finance across clusters and supply chains.

Market access creates opportunity; energy productivity creates the competitiveness to convert it. How far Indian industry advances will be decided inside its factories, buildings and grid. Raising the value created from every unit of energy is among the strongest levers available to compete, grow and lead.

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KEY TAKEAWAY

India's best efficiency programmes show that standards and scale can transform markets, driving innovation and competition. Higher efficiency need not mean higher prices: as efficient technologies scale, their costs fall. Effective policy requires long-term, ambitious targets grounded in commercially available technologies and commensurate with the benefits.

INDIA'S NEXT ENERGY EFFICIENCY CHALLENGE: COOLING, FLEXIBILITY AND ELECTRIFICATION

As India's energy demand grows, efficiency must become a core part of how the country plans its grid, shapes markets and builds industry.

Nikit Abhyankar and Amol Phadke

Over the past 25 years, India has built a substantial energy-efficiency policy architecture and delivered several programmes that deserve international attention. The Energy Conservation Act, the Bureau of Energy Efficiency, appliance standards and labelling, the Energy Conservation Building Code, the Perform, Achieve and Trade scheme for industry, and market-transformation initiatives such as the UJALA LED programme all established efficiency as a legitimate field of policy.

But the record is not one of uninterrupted success. Efficiency has usually remained secondary to the more visible task of adding supply, even though saving a unit of energy is frequently cheaper than generating, transmitting and distributing an additional one.

India has shown that strong policy can transform markets; it has not yet made efficiency a systematic part of electricity planning, industrial strategy, building development or consumer decision-making.

That gap matters because India's energy system is entering a very different phase. Electricity demand is growing rapidly, and hundreds of millions of Indians will understandably consume more energy as incomes rise: air conditioning, vehicles, appliances, industrial production and digital infrastructure will all expand dramatically.

At the same time, the grid is becoming increasingly dependent on solar and wind, which makes the timing and shape of demand matter as much as its size.

The objective therefore cannot be to suppress consumption. India needs far more useful energy—more cooling, mobility, industrial output and household services—but it must extract substantially more value from each unit consumed. That is what energy efficiency is for.

WHY MARKETS DO NOT DELIVER ENOUGH EFFICIENCY ON THEIR OWN

One of the persistent puzzles of energy policy is that many efficiency investments are economically attractive, yet consumers and firms routinely fail to make them. The reason is not simply ignorance or irrationality; efficiency suffers from several structural market failures.

Consumers pay close attention to the purchase price of an appliance but far less to the electricity it will consume over ten or fifteen years. Lifetime operating costs are hard to evaluate, while the upfront price difference is immediately visible.

Split incentives compound the problem: a landlord buys the air conditioner while the tenant pays the bill, and a developer chooses cheaper equipment while occupants bear decades of higher operating costs.

Industry faces a different problem. An efficiency investment may have a reasonable payback, but it competes internally with production capacity, product development and working capital. Replacing a motor, boiler or compressor that still works ranks low on management priorities even when the economics are sound.

Finally, consumers do not bear the full system cost of inefficient equipment. A low-efficiency AC bought today may add to peak demand for a decade or more, requiring additional generation, storage,

transmission and distribution capacity. Those costs are spread across the electricity system rather than appearing on the price tag.

These failures explain why policy has mattered so much. Minimum energy performance standards remove the worst products from the market. Labels let consumers compare. Building codes prevent decades of inefficient infrastructure from being locked in. Bulk procurement creates scale, financing softens upfront costs, and long-term standards give manufacturers the confidence to invest in better technology and supply chains.

The lesson of India's best programmes is not that government can pick technologies better than markets; it is that well-designed policy can change the conditions under which markets operate.

UJALA illustrates this well. LEDs were already technically superior to incandescent bulbs, but their upfront price prevented widespread adoption. Bulk procurement created enormous demand, competition drove prices down, quality standards reduced consumer risk, and deployment accelerated. The programme succeeded because it addressed the specific barriers preventing an already attractive technology from scaling.

Other parts of the record are more uneven. Labelling has significantly improved consumer awareness and product efficiency, but minimum standards have often lagged the best available technology. Building codes created an important framework, but implementation and enforcement vary widely across states and cities. Industrial programmes helped institutionalise energy management, but the efficiency potential of Indian industry is far from exhausted.

The lesson is not that these policies failed; it is that creating a programme is different from transforming a market. Nowhere is that distinction becoming more important than in cooling.

COOLING SHOULD BE INDIA'S DEFINING EFFICIENCY PRIORITY FOR THE NEXT DECADE

Air conditioning is rapidly becoming one of the largest new demands on India's electricity system. Cooling is increasingly essential for human health, productivity and basic comfort, and as temperatures and incomes rise, many more Indians will seek access to it. The policy question is whether India can provide that cooling without needlessly multiplying the electricity infrastructure required to deliver it.

India now adds roughly 10–15 million room ACs every year, two to three times the rate of only a few years ago, and could install another 130–150 million units over the coming decade. ACs may already account for as much as 70 GW of peak demand, around a quarter of India's current peak. Without significant efficiency improvements, AC demand could approach 120 GW by 2030 and 180 GW by 2035—nearly a third of projected evening peak demand. By then, a single appliance category in India would draw more power at peak than the entire Japanese grid.

Timing makes cooling especially challenging. India is rapidly expanding solar generation, and afternoon power will increasingly be abundant and cheap. But residential cooling demand stays high well after sunset, precisely when solar output disappears. India will therefore need substantial investment in batteries and other firm resources to shift inexpensive daytime electricity into the evening and night.

Storage, however, should not become an excuse for ignoring demand. A power system that installs inefficient ACs and then builds batteries, power plants and transmission lines to serve their avoidable consumption is solving the problem in the most capital-intensive way possible. Efficiency should come first.

Every kilowatt of peak demand avoided by a more efficient AC is electricity that never has to be generated, stored or transmitted—and in a rapidly expanding power system, that is worth a great deal.

The Government of India's decision to strengthen minimum energy performance standards for room ACs, taking effect in 2028, is therefore an important step. The revision raises minimum efficiency by roughly 25 percent. But it is not yet commensurate with the scale of the challenge.

The next step should be a long-term standards trajectory, announced well in advance and extending through at least 2033, based on technology that is already commercially available. From around 2030, the minimum standard could move to the performance of today's five-star machines, and from around 2033 or so toward the efficiency levels already achieved by the best products sold in India.

Both features matter. A long-term trajectory gives manufacturers and their suppliers time to redesign products, retool factories and build supply chains, rather than scrambling to comply with each revision. Basing it on commercially available technology means the products are ready to be scaled up as standards tighten.

This is not a speculative technology pathway: more than a thousand models already exceed the present five-star threshold, and manufacturers including Blue Star, Daikin and Lloyd sell products with substantially higher efficiencies.

Variable-speed compressors, improved heat exchangers, better motors and sophisticated controls all exist today. The question is not technological feasibility but the speed at which the market adopts what is already available.

A stronger trajectory could cut peak demand by around 10 GW by 2030 and roughly 45 GW by 2035. Avoided generation and grid investment could reach approximately ₹8 lakh crore, and consumers could save as much as ₹2.5 lakh crore in net electricity costs. Efficiency at this scale is not conservation; it is an alternative infrastructure resource.

STRONGER STANDARDS NEED NOT MEAN UNAFFORDABLE APPLIANCES

The most common objection to stronger standards is that they will raise prices and slow access to cooling. That concern deserves to be taken seriously in a country where AC ownership is still expanding rapidly. But history suggests the relationship between efficiency and price is far less straightforward than commonly assumed.

The historical data suggests otherwise. Evidence from India, Japan, and South Korea consistently shows that as efficiency standards rise, prices tend to fall in real terms—as manufacturers scale up production and compete. In India, between 2007 and 2023, AC efficiency improved by roughly 60 percent while inflation-adjusted prices nearly halved.

Efficiency gains initially require better components and engineering, but larger production volumes, supplier competition, design improvements and manufacturing learning offset those costs over time—and standards accelerate that process by expanding the market for better technology.

Interestingly, on manufacturer readiness, the evidence is equally encouraging. Over 1,000 AC models—representing more than 15 percent of available options and a comparable share of market sales—already exceed the current five-star level. Leading manufacturers including Blue Star, Daikin, and Lloyd are offering super-efficient models above ISEER 6.0 at competitive prices.

A high-efficiency AC today may still cost ₹6,000–16,000 more than a basic two- or three-star machine. But electricity savings typically recover that difference within two or three years, after which the consumer keeps saving. Standards alone are not sufficient: bulk procurement, targeted incentives and possibly tax differentiation can help lower the upfront barrier. But the goal of public policy should be

to move the entire market toward higher performance, not to subsidise inefficient equipment indefinitely.

IN A RENEWABLE-DOMINATED GRID, FLEXIBILITY MATTERS AS MUCH AS EFFICIENCY

As solar and wind become dominant, when electricity is used will matter as much as how much is used. The hardest hours on India's grid are increasingly the ones just after sunset, when solar output fades while electricity demand keeps climbing. Meeting that ramp with generation and storage alone is expensive; appliances such as ACs can do part of the work.

They can offer demand response, including peak shaving, without causing consumer discomfort. For example, an AC can briefly cut its power use—by pausing its compressor or raising its set-point by a degree for fifteen minutes. Thanks to thermal inertia, the room temperature barely changes and consumers may not feel any discomfort.

If millions of ACs do this in a coordinated way, the grid gets several gigawatts of peak shaving or fast response during the evening hours. Smart thermostats, connected appliances and thermal storage, supported by well-designed time-of-day pricing, can turn hundreds of millions of ACs from a burden on the evening peak into a resource for managing it.

India should therefore treat efficiency and flexibility as two halves of one strategy: eliminate unnecessary consumption first, then make what remains responsive to the grid.

TURN THE EFFICIENCY CHALLENGE INTO A MANUFACTURING OPPORTUNITY

India's expanding appliance market also creates an industrial opportunity that has not received enough attention. The country

should not aspire merely to assemble more air conditioners; it should aim to become a major global producer of affordable, high-efficiency cooling equipment. That means competitive domestic supply chains for compressors, motors, heat exchangers, power electronics, sensors and controls.

Long-term standards support this objective. Manufacturers are understandably reluctant to invest in new production lines without knowing whether future standards will reward those investments; a transparent five- to ten-year roadmap creates a clear demand signal. Industry, in turn, needs to see efficiency requirements not primarily as compliance costs but as an opportunity to build products capable of competing globally.

"Efficiency and flexibility are two halves of one strategy: eliminate unnecessary consumption first, then make the remaining demand responsive to the grid."

India could have a real advantage here. Most future growth in cooling will occur in emerging economies across Asia, Africa, Latin America and the Middle East—markets that need equipment that is efficient, rugged, repairable and affordable. Designing high-performance appliances for price-sensitive markets could become a distinctive Indian manufacturing capability.

UJALA showed how India's domestic scale can reshape technology costs. Cooling could do the same, but only if policy ambition and industrial strategy reinforce each other.

Although air conditioners have been the focus of this discussion so far, they are not the only case for stronger policy ambition. The same logic—a long-term standards trajectory based on technology that is already commercially available, prices that fall as volumes rise, counting avoided infrastructure as a benefit, and building flexibility into the appliance itself—applies to all other appliances and equipment such as fans, refrigerators, pumps, motors and building equipment.

EFFICIENCY SHOULD ALSO INCLUDE ELECTRIFICATION

The next generation of efficiency policy should also move beyond the idea that efficiency simply means using less electricity. In many applications, electrification is itself a major efficiency gain. Internal-combustion engines discard most of the energy in petrol or diesel as waste heat; electric drivetrains convert a far larger share into motion. In industry, heat pumps, electric boilers and thermal batteries can, in the right applications, deliver the same service with significantly lower primary-energy requirements than fossil-fuel combustion.

Realising that opportunity depends on getting electricity pricing and market access right. Industrial consumers will not switch from coal, oil or gas if tariffs are burdened by cross-subsidies, surcharges or inflexible procurement that make electricity artificially expensive.

Open access, group-captive procurement and other mechanisms that let industries contract directly for low-cost renewable power are therefore important enablers of electrification. States should progressively rationalise cross-subsidies, simplify open-access rules, and ensure that wheeling, banking and other charges reflect the actual costs imposed on the grid rather than acting as barriers to switching.

The case grows stronger as supply becomes more renewable. Solar, wind and storage have very different cost structures from fossil fuels: once built, most of their costs are fixed, with little or no exposure to future fuel prices. India, by contrast, imports most of its oil and much of its gas, leaving transport and industrial energy costs exposed to commodity cycles, geopolitical shocks and exchange-rate swings. Combining efficiency, electrification and low-cost renewable electricity can therefore do more than reduce emissions.

If markets and tariffs let consumers reach that low-cost power, electrification can lower overall energy use, cut costs, and progressively inflation-proof India's industrial and transport energy bills.

THE WAY FORWARD

India's first 25 years of modern efficiency policy built important institutions and delivered notable successes. But efficiency still receives far less strategic attention than supply, and large opportunities remain across buildings, industry and appliances. The next phase should integrate efficiency directly into power-system planning, industrial policy and manufacturing strategy—and for the coming decade, cooling should sit at the centre of that effort.

More efficient ACs can lower peak demand, reduce bills, avoid costly generation and grid investment, and strengthen domestic manufacturing. Flexible demand, better buildings and efficient industrial equipment can multiply those gains.

For the next generation of energy-efficiency and net-zero professionals, the challenge is to think beyond kilowatt-hours saved: how much infrastructure can efficiency avoid, how can policy make better technology the market default, how can flexible demand support a renewable-heavy grid, and how can electrification improve both efficiency and energy security. Those are the questions that will define the next 25 years.

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KEY TAKEAWAY

India's next phase of energy efficiency must move from tactical savings to strategic energy productivity: visible in data, investable in markets, embedded in institutions and owned by leadership.

FROM THE BOILER ROOM TO THE BOARDROOM

India's next energy-efficiency leap must make efficiency its first fuel and productivity its central metric.

Padu S. Padmanabhan

India's energy efficiency journey over the past quarter century has delivered much more than lower electricity consumption or reduced fuel use. It has established a central development principle: economic growth and responsible energy use can produce co-benefits that reinforce each other. Through institutional platforms, regulatory interventions and market driven programmes energy efficiency has moved from the margins into the mainstream of industrial and consumer decision-making.

The central question for the next 25 years is not whether India can save more energy through energy efficiency. It is whether India can extract far greater economic, social and strategic value from every unit of energy it consumes.

As India aspires to become a developed economy by 2047, energy demand will rise with manufacturing growth, urbanisation, cooling needs, digitalisation, mobility, infrastructure and improved living standards. The challenge is therefore not to constrain demand, but to shape and moderate it intelligently. The next phase of energy efficiency must move from conservation to energy productivity as a national economic strategy.

FROM THE BOILER ROOM TO THE BOARDROOM

At the shopfloor level the advent of energy efficiency begins by asking “how” energy is being used. Thus, efficiency measures focus on

reducing consumption against a baseline i.e. reduction in the energy input into a process or a system per unit of useful output. Energy productivity begs a larger question: how much industrial output, comfort, service quality, resilience and competitiveness can be created per unit of energy? In a country where energy access, affordability and reliability remain central to development, this is the more relevant measure. Therefore “what” is the energy used for rather than only “how” energy is used must become a design principle for growth itself.

Energy efficiency at India’s industrial shopfloor and commercial establishments is a time tested practice that has evolved over the past 25 years. Its success has been the result of a number of factors such as: Industrial efficiency spurred the growth of the energy audit and M&V discipline helping large energy-intensive sectors understand and benchmark performance; Appliance labelling programmes helped consumers make informed purchasing decisions; Building codes introduced the idea that comfort and energy use are shaped by design choices.

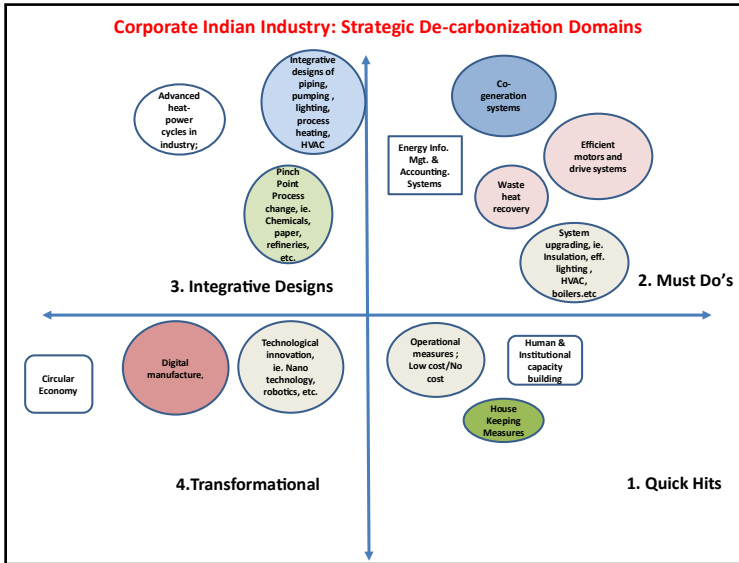
By way of contrast energy productivity requires the assemblage and deployment of a different set of decision-making tools at the boardroom level. It emphasizes structural changes, product diversification and modernization that seek to deliver higher value per unit of energy consumed.

The challenge for corporate India is therefore to expand and transition energy efficiency from the boiler room to the board room decisively by embracing energy productivity as its central metric. This is the next phase of reimagining and redirecting India’s energy efficiency future.

INDUSTRY’S FOUR-QUADRANT EVOLUTION

The industrial sector’s experience offers a useful four-quadrant framework for understanding why the next phase must be more strategic. This is illustrated in Figure 1 below. The first quadrant is “quick hits” or housekeeping measures: the early fuel-efficiency

discipline of saving oil and energy through simple low-cost, no-cost operating improvements. It created awareness and delivered quick gains, but it was essentially tactical.



The second quadrant was the era of the “must-dos”: efficient boilers and furnaces, efficient steam utilization, thermal insulation waste heat recovery, efficient motors and efficient lighting. Large industry has largely covered this ground, although many MSMEs still remain short of full adoption.

The third quadrant is integrated energy-efficiency design, where the greatest future savings may lie: co-generation, pinch point analysis, water-energy nexus, process integration and optimisation that treat a plant as one energy system rather than a series of independent equipment choices. And importantly where the upstream and downstream impacts of an efficiency measure are realised through not only opex but also capex savings.

As an example, consider the oversized chiller system in a typical hotel. Cooling a space such as a room is basically the abstraction of

indoor heat. Changes in illumination technology such as the large-scale use of LEDs that run cold as well as a reduction in other hot spots in a room due to natural ventilation or better insulation, the amount of heat required to be abstracted has come down and so has the cooling load.

The result is savings in capex by using a smaller chiller -and possibly a smaller standby diesel captive plant. Thus, one can reap capex savings and opex through energy savings simultaneously by following an integrative approach.

The fourth quadrant is frontier transformation. Robotics, artificial intelligence, digital twins, circular economy models and drawdown technologies can reduce both energy use and emissions at a scale large enough to influence India's decarbonisation trajectory.

The progression matters because the first two quadrants could be driven largely by plant-level action; the next two demand leadership decisions on capital allocation, product strategy, technology pathways, value chains and long-term competitiveness.

This is the practical meaning of moving from the boiler room to the boardroom. To achieve this at scale and speed requires reimagining efficiency as discussed briefly in subsequent sections.

REIMAGINING ENERGY EFFICIENCY

Scaling visible savings to investable savings

The first change required to achieve scale is conceptual. What is not measured is rarely valued; what is not valued is rarely financed; and what is not financed cannot scale.

India has made strong progress in measuring equipment performance and benchmarking industrial energy use, but future efficiency opportunities will be more distributed and less obvious. A motor replacement in an MSME, better building controls, efficient cooling

in a commercial complex, demand response in a cluster, or flexible industrial load management may each be modest in isolation.

Through bundling they can reduce costs, ameliorate risks and make them bankable. But their value must be made visible through credible measurement, digital monitoring, transparent baselines and trusted verification.

From isolated programmes to integrated energy markets

Historically, electricity systems have been planned around meeting demand, with efficiency treated as a reduction in sales or a social obligation. Therefore, of the early efficiency movement understandably relied on programmes, mandates and demonstration projects. These were necessary to create confidence and prove technical feasibility.

The next phase must create markets in which efficiency competes for capital, receives a value for verified performance and is aggregated across sectors. Market creation requires a shift in how utilities and DISCOMs view demand.

Efficient and flexible demand can reduce peak stress, improve load factors, support renewable absorption and reduce the need for expensive capacity additions. This is the emerging logic behind integrated energy networks (IEN):

"Energy efficiency must move from the boiler room to the boardroom: from technical action to strategic energy productivity."

supply and demand must be planned and coupled symmetrically. The IEN or 'sector coupling' as it is also referred to, is the convergence of four system elements: customer engagement with energy resources and providers; dramatic emissions reductions in generation through renewables and energy efficiency including carbon capture; application of AI and digitalisation technologies, and, end-use electrification.

Thus, rooftop solar, battery storage, efficient electrical appliances,

demand response, electric vehicles, industrial load shifting and building management systems are not separate domains. They are interdependent components of a more resilient integrated energy system spanning both sides of the energy equation.

Drawdown technology choices

The drawdown technologies will redefine EE. What do I mean by that? Drawdown technologies are those that dramatically reduce and reverse CO₂ emissions. Over the next decade, I would expect energy efficiency in heavy industry to move beyond incremental improvements in equipment efficiency toward digitally optimized, electrified, low-temperature, and process-integrated production. Technology will play a larger role in the next phase, but technology alone will not deliver the transition.

Digital monitoring, artificial intelligence, advanced analytics and automation can make efficiency more granular and responsive. They can detect wastage, optimise systems, predict maintenance needs, manage loads and create better baselines for savings.

EE technologies will feature across all end use sectors – buildings, industry, transports, domestic, agriculture and so on. The list is long. For e.g. In buildings it could be “smart” glass -electrochromic glass that changes colour according to the time of day, that saves heating, cooling and lighting.

In transport, besides EV and hybrid in vehicles, new designs and technology upgrades would help drawdown. The most important emerging technologies will often reduce both energy use and emissions simultaneously. Some of the key drawdown technologies in industry are:

Green Steel: Hydrogen based direct reduction of iron ore; Eliminates the need for use of coal or coke; reduces energy intensity of the reduction process; AI enabled process optimization & digital twins

continuously optimizes temp, fuel, O₂, raw materials like iron ore & scrap in ways that conventional process controls cannot .

Cement: Low temperature electrification for clinker production; utilizes advanced microwave and plasma heating; reduces substantially the heat requirement in conventional clinker production, reduces fossil fuel use and replaces it with low carbon electricity. Advanced grinding technology – high efficiency roller mills combined with AI enabled process control reduces substantially power requirements for grinding, better comminution and real time optimization.

Aluminium: Inert anode aluminium smelting; Inert anode cells replace conventional carbon anode cells, reduces electricity consumption and eliminates direct CO₂ emissions due to non-use of carbon anodes. AI digital optimization of electrolytic cells and machine learning control of alumina feed, voltage, temperature and anode -cathode distance can reduce energy consumption across cells.

Pulp & Paper: Advanced drying technologies: heat pump drying, impulse drying, infra-red & microwave assisted drying can eliminate steam drying. AI and digital twins coordinate and optimizes boilers, turbines, evaporators, digesters, paper machines, etc.

ENERGY PRODUCTIVITY AND VIKSIT BHARAT 2047

The framing of Viksit Bharat 2047 gives energy efficiency a new strategic relevance. A developed India will require reliable electricity, competitive industry, comfortable and productive cities, strong MSMEs, lower import vulnerability and a credible decarbonisation pathway. These goals cannot be pursued separately. Energy productivity connects them: allowing India to grow without locking itself into preventable inefficiencies, enabling renewable energy to deliver greater value, improving investment quality by reducing lifecycle costs, strengthening industrial competitiveness as global value chains become more carbon-conscious, and making

development more affordable for citizens and enterprises.

CII Green Business Centre's 25-year journey sits within this larger national movement. The broader significance of such platforms lies not only in promoting efficient technologies, but in convening industry, policymakers, financiers, experts and institutions around practical pathways. The most important task ahead is to move efficiency from the boiler room to the boardroom: from a technical recommendation owned by plant teams to a boardroom, regulatory and investment priority that shapes competitiveness, profitability and sustainability together.

THE WAY FORWARD: MAKING EFFICIENCY INDIA'S FIRST FUEL

India's first 25 years of energy efficiency created institutions, awareness, standards and successful programmes. The next 25 years must convert that foundation into a productivity movement. Energy efficiency must become India's first fuel: a primary national resource to be planned, financed and governed with the same seriousness as conventional supply.

If the past 25 years proved that India could make energy efficiency credible, the next 25 must prove that India can make it transformative. The country's development ambition does not reduce the importance of efficiency; it makes efficiency indispensable. For Viksit Bharat 2047, the defining question will not be how much energy India consumes, but how much value, competitiveness, comfort and resilience India creates from every unit of energy.

The transition from the boiler room to the boardroom depends on capital allocation, technology choices, value-chain decisions and institutional commitment.

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KEY TAKEAWAY

Cement has taken equipment-level efficiency close to its physical limit. The next quarter-century of gains will come from the ecosystem around the plant: reliability as an efficiency lever in its own right, digital tools aimed at defined process problems, waste supplied as a properly characterised raw material, and policy and procurement signals that turn low-carbon capability into real demand.

FROM EQUIPMENT TO ECOSYSTEM: CEMENT'S NEXT EFFICIENCY FRONTIER

India's most efficient industrial sector has taken equipment-level gains close to their limit. The next chapter depends on reliability, circularity and the wider ecosystem beyond the factory gate.

Raj Narayanan E R

Twenty-five years ago, energy efficiency in Indian manufacturing was an engineering brief. An engineer was asked to cut the power or fuel consumed on a line, performance was measured against a target, and the project was closed. That framing served industry well, nowhere more visibly than in cement: Indian plants today rank among the most energy-efficient in the world, ahead of comparable plants in Europe, Japan and Korea. But a discipline built to capture equipment-level gains eventually meets a harder question — what happens once the equipment has been optimised as far as physics and available technology allow?

Efficiency has already moved once, from a shop-floor task to a subject of leadership attention. It must move again, from optimising individual machines to optimising the ecosystem in which they operate: the digital systems that run them, the resource flows that feed them, and the institutions that supply and price those inputs.

This matters well beyond cement. India is adding industrial capacity at a pace few economies can match, and the efficiency model built into that capacity now will shape competitiveness, energy security and decarbonisation for decades. Cement, having reached the limit of what conventional measures can deliver, shows what must come next.

FROM EQUIPMENT PROJECTS TO A LEADERSHIP DISCIPLINE

What counts as an efficiency intervention has itself shifted over the last decade. Twenty years ago, it meant an equipment-level project: a more efficient motor, a better-insulated line, a discrete upgrade with a start and a finish. Today the conversation takes place at the level of manufacturing philosophy, operational discipline and digital capability, and is treated as central to competitiveness. The distinction is not cosmetic.

An equipment project asks how one machine can consume less. A systems discipline asks how an entire production chain, and the ecosystem feeding it, can be reorganised to draw more value from every unit of energy and material consumed.

Renewable power, waste heat recovery, alternative fuels and digital monitoring are no longer separate initiatives bolted on to a conventional plant. They are parts of one interdependent system, where a gain in reliability in one place produces a gain in energy efficiency in another, and where the binding constraint is not any single piece of hardware but the quality of the system's design and operation.

Two developments show how far this view has travelled. The first is renewable energy, which entered mainstream planning only five or six years ago.

Early on the constraint was availability: renewable power could support operations for about sixteen hours a day, after which the plant fell back on the grid. The ambition today is round-the-clock supply, and closing that gap is not merely a matter of adding capacity. It calls for storage, long-term contracts, access to interstate transmission so that power generated in one state can be used at a plant in another, and a far more sophisticated balancing of demand across the grid, the company's own renewable plants and power from alternative fuels.

Electrification of process heat is the natural extension of this

thinking. UltraTech's collaboration with Coolbrook of Finland uses the RotoDynamic Heater to deliver process heat of the order of 1,400 degrees Celsius from electricity rather than fossil combustion, and is being advanced through pilot trials with the intent of extending it into core cement-making processes.

"A plant that runs reliably around the clock extracts more genuine efficiency from its equipment than one that runs the same equipment intermittently."

The second is waste heat recovery. A cement plant is built around the kiln, a large rotating furnace in which limestone is burnt at close to 1,450 degrees Celsius. The gases leaving it are extremely hot, and waste heat recovery captures that heat to generate power instead of releasing it. Recent gains have come not from new equipment but from a better understanding of the process and improved reliability of the recovery system. No additional energy is created; the plant simply captures more of what previously escaped. Both examples make the same point: the binding constraint has shifted from the hardware to the discipline applied around it.

WHY RELIABILITY, NOT JUST TECHNOLOGY, IS THE NEW EFFICIENCY LEVER

Reliability has become one of the most significant remaining levers for energy efficiency, more so today than incremental equipment upgrades. Efficiency is a function of how well an asset is used over the hours it runs.

A plant that operates reliably around the clock draws more genuine efficiency from its equipment than one running the same equipment intermittently over sixteen hours. Digital tools have been central to this gain — not as technology for its own sake, but as the meeting point of deep domain knowledge, tools that reveal patterns conventional monitoring cannot see, and the infrastructure to connect the two at scale.

The source of those tools has also shifted. Kilns, motors and control systems still come from established equipment providers, while the digital layer increasingly originates in the start-up ecosystem, which brings fresh tools and fresh problem framings to the shop floor. The gains come when the two are brought together: value emerges where domain knowledge and digital tools are applied to a specifically identified problem, and the sector's experience now offers a clear template for making that combination work.

WASTE AS RAW MATERIAL: THE SHIFT FROM DISPOSAL TO CIRCULARITY

A second frontier lies in how industry relates to waste. Alternative fuels are waste materials — from other industries and from cities — burnt in the kiln in place of coal. They were once seen as a disposal service: cement manufacturing was a convenient destination for material that had nowhere else to go, a solution offered to other sectors rather than an input to manufacturing. That relationship has matured. The position now taking hold treats such waste as a raw material in its own right, whose value depends on how carefully it is separated, sized and chemically tested before it reaches the kiln.

The technical reality explains why this matters. The thermal substitution rate is the share of a plant's fuel requirement met by alternative fuels rather than coal. At around five per cent, a plant tolerates wide variation in what it receives. As the rate rises towards the levels advanced Indian plants now target, that tolerance narrows sharply. Consistent burning calls for the quality discipline the coal supply chain built over decades — particle size, moisture and feed rate tracked with precision — extended to alternative fuels. Digital technology helps here too, giving far better insight into how waste streams behave inside the kiln, how fuel mix and injection point affect burning, and where the process can be adjusted to handle a variable input cleanly.

This is a system-level opportunity, and it depends on capability at

three points. First, a policy framework that brings waste classification and approval requirements into a single, streamlined pathway. Second, waste management companies willing to move up the value chain into processing and segregation, supported by business models that make such investment viable. Third, application knowledge within the user industries, since even well-processed waste delivers full value only when the receiving plant knows how to blend, size and burn it. Municipal solid waste offers the largest headroom: as collection, segregation and treatment capacity expands, the volume and consistency available to industry will rise with it.

Geography matters as much as quality. Moving waste over long distances can consume much of the carbon that substitution is meant to save, so frameworks encouraging alternative fuel use will deliver most when they account for logistics and reward the shortest practical route from source to kiln. So does moisture. Waste carrying thirty-five to forty per cent moisture is largely water being carried across the country at the cost of fuel and carbon, and then dried at the receiving plant. Drying and size reduction close to the point of collection would release that value, at far lower cost than each plant doing the same work independently.

The energy used for such drying is itself open to improvement. The RotoDynamic Heater's first application at an UltraTech unit is precisely this — replacing fossil-fuel heat used to dry alternative fuels with electrically generated heat — showing how circularity and energy decarbonisation reinforce one another.

Liquid and hazardous waste streams — chemical residues from pharmaceutical, refinery and other process industries — offer substantial substitution potential, and one enabling step will unlock most of it: a clear specification and reliable chemical composition accompanying every consignment. With that information in hand, a manufacturer can judge how the material will behave in the kiln, what it will do to product quality and how to handle it safely.

Making characterisation and disclosure a routine part of transfer is a straightforward reform, and it would open up a large volume of material that industry is both willing and technically able to absorb.

WHERE THE NEXT GAINS WILL COME FROM

Any sector at leading efficiency levels faces a natural question: will further investment cost more and return less? Reliability improvements compound rather than plateau, and continue to offer meaningful returns even in an already efficient operation. A plant that improves uptime captures gains a purely technology-focused view would miss, because the measure that matters — energy consumed per unit of genuinely productive output — keeps shifting as reliability improves. Renewable energy shows a similar pattern: as the cost per unit falls through higher renewable use and better transmission access, the economics of switching keeps improving rather than flattening out.

The record of the past quarter-century points the same way. Gains have come from technology improvement and product innovation together, not either alone, or the industry's energy mix has been reshaped as a result. The diminishing returns question is therefore misframed when asked only of individual technologies. Returns do diminish within a given approach. But new approaches — reliability, circularity, digital optimisation, product reformulation — keep opening fresh headroom even in sectors that appear to have exhausted the obvious opportunities.

UltraTech's work with the Institute for Carbon Management at the University of California, Los Angeles, is headroom of exactly this kind. The ZeroCAL process converts limestone electrochemically into calcium hydroxide, avoiding almost all the carbon dioxide otherwise released when limestone decomposes in the kiln, and the product can replace limestone in the existing process.

A demonstration plant is being developed at one of the company's integrated units. The hydrogen and oxygen produced along the way can be used within the plant, and a wider range of limestone grades

becomes usable, strengthening raw-material security alongside decarbonisation.

BUILDING DEMAND FOR LOW-CARBON PRODUCTS

Efficiency and decarbonisation are related but not identical, and cement's progress on carbon intensity — the carbon dioxide emitted per tonne of cement — shows where the two diverge. That figure has fallen substantially through operational efficiency, circularity, renewable power and reformulated products that use less clinker. Clinker, produced when limestone is burnt in the kiln, is the single largest source of emissions in cement making. Blending it with fly ash from power plants or slag from steel plants lowers the carbon content of the final product, and most cement produced in India today is already a blended variety, well ahead of what the market considered standard a generation ago.

The search for new blending materials continues alongside. UltraTech has entered into a consortium with EnviCore, Queens Carbon and NeoCrete to develop and evaluate a new generation of supplementary cementitious materials — drawn from waste streams, from limestone and sand, and from activated pozzolans — with the specific objective of reducing clinker content further in commercially usable products.

This progress has been led largely from the supply side. Manufacturers have invested heavily in making the lower-carbon option available at scale, and the next stage of gains will come as demand-side signals develop to match that capability. The direction is encouraging. Buyers are increasingly expected to look less at the technical classification printed on the bag and more at how the cement performs in concrete, which brings carbon intensity naturally into procurement conversations.

Government procurement preferences, building codes that account for embodied carbon — the emissions locked into a building's materials

before it is occupied — and the carbon markets now taking shape each offer a lever to convert a supply-side achievement into genuine demand. Once a credible price signal is in place, industry can respond quickly, because the capability to produce lower-carbon products in volume already exists.

THE WAY FORWARD

The lesson extends well beyond cement. The foundation that carried India's first quarter-century of industrial energy efficiency — equipment-level projects, plant-by-plant upgrades, efficiency measured as reduced utility consumption — delivered substantial gains, and cement's global standing is proof of what it achieved. The next quarter-century will build on that foundation with a wider set of capabilities: reliability engineering that treats uptime as an efficiency lever; digital tools aimed at clearly defined process problems; circular resource flows that draw as much on upstream waste management and coherent policy as on the receiving industry; and market mechanisms that convert low-carbon capability into priced demand.

Partnerships of this kind are already taking shape. Under the Department of Science and Technology's national programme of cement-sector carbon capture and utilisation testbeds, UltraTech is the industry partner for one of five selected projects, with IIT Madras and BITS Pilani, K K Birla Goa Campus, as knowledge partners.

The three-year project will establish a one-tonne-per-day capture and mineralisation pilot integrated with a working plant, associated with the company's Reddipalayam operation in Tamil Nadu, with UltraTech meeting a quarter of the cost.

None of these levers sits entirely within any single company's control, and that is precisely the opportunity. The next stage of India's efficiency journey depends less on any individual plant achieving a better number than on the ecosystem around every plant — waste management companies, digital start-ups, policymakers and buyers

— building the capability and the incentives to meet manufacturing halfway.

For an economy adding capacity at India's scale, embedding this view now, while the capacity is still being built, will do more for competitiveness, energy security and decarbonisation than any further round of equipment-level optimisation. The task is clear: build the policy, market and institutional scaffolding around industry as deliberately as industry has built efficiency into its own operations. That is where the next twenty-five years of gains will be found.

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KEY TAKEAWAY

India's next phase of energy efficiency must move beyond individual savings projects to system-level value: lower peak demand, improved grid flexibility, reduced import exposure, higher industrial productivity and better quality of growth.

ENERGY EFFICIENCY AS THE FIRST FUEL

Powering India's electrification journey with productivity, resilience and system value.

Ravichandran Purushothaman

EFFICIENCY: INDIA'S FIRST FUEL

Twenty-five years ago, energy efficiency in India was often treated as a shop-floor discipline: important, technical, and largely confined to engineers responsible for boilers, motors, compressors, chillers and process lines. Its value was understood in terms of reduced consumption, improved equipment performance and lower operating cost.

Today, that framing is no longer sufficient. Energy efficiency now sits at the intersection of national energy security, industrial competitiveness, climate commitment and the quality of India's growth. It is no longer merely a question of how much energy can be saved; it is a question of how much economic value, productive output, comfort and resilience India can create from every unit of energy consumed.

Every unit of energy that does not need to be generated, imported, transported or transmitted is cleaner, faster and cheaper than any unit added through new supply. For a country that is still building the bulk of its long-term energy infrastructure, this is not only an environmental principle; it is sound economics.

It reduces pressure on capital investment, eases stress on distribution networks, lowers fuel-import exposure and allows scarce investment to be directed towards productive growth. In this sense, efficiency is India's first fuel because it creates capacity before capacity has to be built.

TWENTY-FIVE YEARS, BUILT DELIBERATELY

India's energy-efficiency journey did not happen by accident. It was built deliberately through legislation, institutions, market mechanisms, standards and industry collaboration. The strength of the first 25 years lies precisely in this combination. Policy created direction, regulation created discipline, standards created visibility and industry platforms created confidence. Together, they helped shift energy efficiency from isolated good practice to a recognisable national agenda.

That architecture was created through a sequence of mutually reinforcing instruments. The Energy Conservation Act and the Bureau of Energy Efficiency gave the country an institutional backbone; the Perform, Achieve and Trade scheme brought measurement and targets into large energy-consuming sectors; standards and labelling made product performance visible to consumers; and the Energy

"As Danfoss Group CEO Kim Fausing puts it, the greenest energy is the one we don't use. And as the world races toward net zero, one truth is becoming unavoidable: there is no net zero without energy efficiency."

Conservation Building Code began embedding efficiency into the way commercial buildings are designed, constructed and cooled.

Industry platforms, including the CII Energy Efficiency Summit, complemented these measures by turning compliance into collaboration and technical practice into shared learning.

FROM REGULATION TO MOVEMENT

Regulation gave India's efficiency journey its foundation, but regulation alone cannot create a movement. The deeper achievement of the past 25 years has been the creation of a community around energy performance. Platforms such as the CII Energy Efficiency Council, the Energy Efficiency Summit, best-practice exchanges,

technology sessions, start-up showcases and recognition programmes helped build the human infrastructure that sits behind every improvement in efficiency. Engineers, plant heads, facility managers, technology providers, CXOs and policymakers were able to compare performance, learn from peers and raise expectations across sectors.

This institutional ecosystem mattered because efficiency improves fastest when it becomes visible. A plant manager who can compare performance with the best in the sector has a reason to act. A chief executive who sees energy productivity linked to competitiveness has a reason to invest.

A policymaker who sees measurable outcomes has a reason to strengthen programmes. The transformation of sectors such as cement, paper, power plants and sugar was therefore not sporadic. It reflected a wider culture of benchmarking, recognition and disciplined improvement, supported by platforms that made performance comparable and excellence aspirational.

A COMMUNITY ACROSS EVERY SECTOR

The awards and peer-learning ecosystem did for industry what formal regulation could not do on its own: it created momentum beyond compliance. It brought into view sectors and applications where efficiency was previously hidden inside operating costs, maintenance decisions or procurement choices.

The result was a broader understanding that energy efficiency is not confined to a few large designated consumers. It is embedded in processes, buildings, cooling systems, data infrastructure, cold chains and the everyday decisions that determine how Indian industry grows.

This widening of the efficiency conversation can be seen across sectors. In process industries, the focus has moved from equipment-level improvements to more systematic, process-integrated efficiency. In buildings, facility management, smart HVAC and automation have

become central to operational performance. In data centres, cooling and energy-use benchmarks are becoming increasingly important as digital infrastructure expands. In cold chains, what was once treated as a backend operating cost is now recognised as a discipline involving refrigerants, compressors, controls and reliable thermal performance.

THE NEXT FRONTIER: EFFICIENCY MEETS ELECTRIFICATION

The next 25 years will look different from the last 25 because India's energy system is entering a new phase. Electrification is accelerating across mobility, heating, cooling, industrial motors, data centres and emerging areas such as green hydrogen. This is essential for decarbonisation, but electrification by itself is not decarbonisation.

If new electric loads are inefficient, poorly managed or added without regard to grid conditions, emissions are merely shifted upstream and costs are transferred to already stressed distribution infrastructure. The central challenge is therefore not whether India electrifies, but how intelligently it electrifies.

Efficiency and electrification must be designed together. The technologies that reduce consumption at the asset level can also make demand more flexible at the system level. Variable frequency drives, efficient motors, heat pumps, waste-heat recovery, district energy, smart cooling and connected controls are not only efficiency measures; they are tools for managing load, reducing peaks and improving the utilisation of renewable power. This is where the future agenda becomes larger than conservation. Efficiency must become a system property.

Several technologies illustrate why the next phase must be framed carefully. Variable frequency drives and efficient motors can reduce avoidable electricity use and make industrial loads more responsive. Heat pumps can improve the productivity of electrified heating and cooling where suitable applications exist.

Waste-heat recovery, district energy and smart connected cooling can reduce pressure on new supply, lower peak demand and improve system efficiency. These technologies are not merely equipment choices; they are part of the infrastructure of a more flexible and productive energy system.

The technologies that make electrification efficient are the same ones that make the grid resilient. India has an advantage because much of the future energy infrastructure is still being built. It can design flexibility, intelligence and high efficiency into new demand from the beginning, rather than paying later to retrofit inefficient assets and strained networks.

This is especially important as comfort demand, cold-chain requirements, digital infrastructure and manufacturing loads expand. The question for the next phase is whether India can avoid locking in avoidable demand while still delivering abundant energy services.

FIVE PRIORITIES TO UNLOCK INDIA'S POTENTIAL

To unlock the next phase of India's efficiency potential, action must move beyond isolated projects and into a coordinated national agenda. Five priorities stand out because they determine whether efficiency becomes visible, investable, scalable and valuable to the wider energy system.

1. **Align policy around energy productivity.** Efficiency codes, renewable-energy integration, electrification plans and grid mandates must reinforce one another. Efficiency cannot remain in a separate administrative compartment while transport, cooling, buildings, industry and power-sector planning move forward independently. A converged policy framework will ensure that every major energy decision also considers demand reduction, flexible load and productive use of electricity.
2. **Make savings bankable.** Energy efficiency often pays for

itself, but savings alone do not automatically attract capital. The next phase must convert avoided consumption into credible investment opportunities through stronger measurement, risk allocation, aggregation, standardised contracts, ESCO models, green finance and performance-linked structures. The objective is to make efficiency projects compete for capital at scale.

3. **Localise critical technologies.** India must build deeper domestic capability in drives, heat pumps, controls, compressors, power electronics and thermal systems. As manufacturing expands, localisation should not merely reduce import dependence; it should create technologies that are suited to Indian operating conditions, cost structures, service networks and maintenance realities. This will make adoption faster and more resilient.
4. **Keep standards ahead of the market.** Standards and labels are powerful because they make efficiency visible to buyers, designers, manufacturers and regulators. Their value depends on remaining current as technology improves and markets mature. Minimum performance standards should continue to set the floor, while higher-performance tiers encourage ambition, innovation and consumer recognition.
5. **Build the skills ecosystem.** The next generation of efficiency will require engineers, auditors, facility managers and entrepreneurs who can work across power electronics, digital controls, thermal systems, data analytics and grid interaction. Without adequate skills, even proven technologies remain underused. Skilling must therefore become a central part of India's efficiency strategy, not an afterthought.

Efficiency and electrification must stop being two conversations and become one national strategy for productive, resilient and clean growth.

DIGITAL INTELLIGENCE FOR THE NEXT EFFICIENCY FRONTIER

The next phase of energy efficiency will require a stronger digital foundation. The progress of the past 25 years was built on measurement, audits, benchmarking, standards and disciplined implementation. These remain essential, but they are no longer enough for an energy system that is becoming more electrified, decentralised and data-rich.

As demand patterns become more complex, efficiency will increasingly depend on the ability to see performance continuously, diagnose losses quickly and optimise energy use in real time.

This is where AI, digital twins and connected controls can add value. A digital twin of a plant, building or cold-chain network can test improvement pathways before capital is committed. AI-enabled maintenance can identify performance drift before it becomes waste.

Intelligent controls can manage loads dynamically rather than relying only on periodic audits or manual intervention. Used well, these tools can make efficiency more visible, measurable and bankable, while also helping the power system manage flexible demand and renewable-energy integration.

The opportunity for India is not to treat digitalisation as a separate technology layer, but to embed it into the core efficiency agenda. Energy-as-a-service models, AI-enabled ESCOs and digital platforms can convert dispersed savings into more reliable investment propositions.

For industry, this means moving from episodic efficiency improvements to continuous energy productivity. For Viksit Bharat, it means building growth on systems that are efficient by design, responsive in operation and competitive over time.

THE WAY FORWARD

India now has an opportunity to make energy efficiency a central pillar of national growth strategy. The first 25 years proved that efficiency can be measured, regulated, benchmarked and delivered through institutions.

The next 25 years must go further. Efficiency must move from the margins of project design to the centre of industrial planning, infrastructure investment, power-sector reform and enterprise competitiveness. It must be treated not as a supporting programme, but as a core economic capability for a country that aims to grow rapidly, electrify widely and decarbonise responsibly.

The call to action is clear. Policymakers must align standards, building codes, industrial programmes and grid planning around energy productivity.

Industry must view efficient energy use as a boardroom issue linked to margins, reliability and market access. Financial institutions must help convert measured savings into investable opportunities. Technology providers must localise solutions, strengthen service ecosystems and build confidence among users. Utilities must become digital, demand-responsive and capable of using efficiency as a resource for grid flexibility.

If these actions come together, energy efficiency will cease to be seen as a cost-saving exercise. It will become one of the foundations on which India builds a competitive, secure, resilient and low-carbon economy. That is the impact the next 25 years must deliver.

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KEY TAKEAWAY

A statute that cannot standardise inputs can still standardise outputs. The Energy Conservation Act must address key issues related to structure, staffing, budgets and standardised reporting to empower and hold the State Designated Agencies accountable as they are meant to deliver and mainstream energy efficiency at the sub-national level.

FROM NATIONAL AMBITION TO STATE-LEVEL DELIVERY: THE NEXT CHAPTER OF ENERGY EFFICIENCY IN INDIA

The next 25 years of energy efficiency will not be won by building one strong institution at the Centre, but by building the capacity to deliver in every state.

Satish Kumar

Twenty-four of India's 36 states and union territories scored below 30 out of 100 on the government's own energy efficiency index in 2020. In 2023, the number was 24. In 2024 it was 24 again. That flat line, more than any ranking of the leaders, is what the next quarter-century of energy efficiency in India has to change.

India's Energy Conservation Act was enacted in 2001, and the Bureau of Energy Efficiency was established soon after. Over the following two decades, India built an energy-efficiency architecture that compares well with much richer countries: Standards and Labelling changed the appliance market, the Perform, Achieve and Trade (PAT) scheme embedded efficiency in the management systems of large energy-intensive industries, Energy Conservation Building Codes set a framework for new buildings, and EESL showed what aggregation and public procurement could achieve at scale.

Those are real achievements. They also share a feature that is easy to miss: almost all of them were designed at the Centre and could be driven from the Centre.

THE NEXT PHASE CANNOT WORK THAT WAY.

Efficient buildings are sanctioned and built in cities. Agricultural demand is managed through state policy and distribution companies. MSME clusters differ from state to state. Electric mobility depends on state transport policy, tariffs and charging infrastructure. Municipal water pumping and street lighting reside with urban local bodies.

Demand response depends on State Electricity Regulatory Commissions and DISCOMs, and even industrial decarbonisation increasingly needs coordination between national programmes and state industrial policy.

India's energy transition, in short, is becoming a state subject in practice even where it is not one in law. State institutional capacity, data, finance and accountability are now the binding constraint.

"Better data would do more than improve benchmarking. It would help states find investment opportunities, design targeted programmes, evaluate savings and make a stronger case to their own finance departments — and it would separate policies that have been announced from interventions that are actually changing energy use."

Energy efficiency is also not a single-sector intervention. It cuts across buildings, industry, agriculture, transport, electricity distribution, municipal services and household consumption, each with its own department, budget and regulatory process.

A state agency has to work across all of them, not act as a delivery arm for centrally sponsored schemes.

And no two states face the same problem. A state built on heavy industry needs a different strategy from one whose demand is dominated by agriculture, buildings or transport, and a small state's mix looks nothing like a large one's.

THE FEDERAL BARGAIN IN THE ENERGY CONSERVATION ACT

The Energy Conservation Act anticipated a two-tier structure: BEE at the national level, and State Designated Agencies, or SDAs, coordinating, regulating and enforcing the Act within states.

The two institutions were built very differently. BEE was created as a statutory body, with a Governing Council, defined functions, funding arrangements, accounts, audit and reporting obligations.

The SDA appears in a single clause. Section 15(d) of the Energy Conservation Act permits a State Government, in consultation with BEE, to designate an agency to coordinate, regulate and enforce the Act within the state. Nothing else is prescribed: not structure, not minimum staffing, not the qualifications of whoever leads it, not even that the agency be dedicated to the job.

The result is an institutional landscape that reflects Indian federalism accurately. BEE's listing shows 36 SDAs: sixteen renewable energy development agencies, seven electrical inspectorates, six electricity distribution companies, five state power departments, and two stand-alone agencies.

That diversity is not the problem, and it was largely unavoidable. Electricity is on the Concurrent List, but state public services are not. Parliament could confer the function; it could not dictate the vehicle. The fair criticism is a different one.

Having necessarily left structure to the states, the Act went on to prescribe nothing else — no minimum output, no annual report, no audit, no duty to lay anything before a state legislature. A statute that cannot standardise inputs can still standardise outputs. This one did neither. So the questions worth asking are whether SDAs consistently have a designated administrative head, technical staff, a predictable budget, access to energy data, authority across departments and the ability to run programmes.

On those measures, the picture is far more uneven than the organisation charts suggest.

The clearest illustration is Andhra Pradesh and Kerala, the only two states with a dedicated, stand-alone SDA rather than one folded into a renewable energy agency or a power department. Across nearly every edition of the State Energy Efficiency Index since 2018, APSECM and Kerala's Energy Management Centre have finished in or near the top band; in SEEI 2025 they placed first and second overall.

Two cases do not establish cause — states that already care about efficiency may be the ones that set up dedicated agencies — but the pattern has now held for eight years.

Under its financial-assistance programme for State Designated Agencies, BEE has had to fund manpower, demonstrations, capacity building and contributions to State Energy Conservation Funds — that is, to pay for the basic institutional capacity of a statutory state agency.

Programme support has a legitimate role in getting an institution started. Sustained reliance on it weakens institutionalisation, because the core statutory functions never enter the state's own administrative structure and budget.

The Energy Conservation (Amendment) Act, 2022 tried to address part of this problem. Section 15A requires an SDA to prepare its annual budget and forward it to the State Government, which "shall include" it in the annual state budget; the amended Section 16 explicitly provides that the State Energy Conservation Fund may be utilised to meet the expenses of the designated agency in discharging its functions.

These are important changes, though they do not prescribe how much a state must provide.

The implementation and institutionalisation indicators show that progress has been made, but much work remains. SEEI 2025 reports that nine States had secured approval for their SDA budgets for FY

2025 - 26, while only seven had allocated budgets for implementing their State Energy Efficiency Action Plans during FY 2024 - 25.

WHAT EIGHT YEARS OF SEEI REVEAL

When BEE and the Alliance for an Energy Efficient Economy launched the State Energy Efficiency Preparedness Index in 2018, the aim was simply to compare states on readiness. Seven editions later it has become something more useful: the best available window into how India's state energy institutions actually function.

The framework has changed in almost every edition. Indicator counts have run 63, 97, 68, 50, 65, 66 and 67. The peer-grouping variable moved from Total Primary Energy Supply to Total Final Energy Consumption, a better measure for tracking efficiency, and the number of groups changed with it. Raw scores cannot be compared across editions.

The pattern underneath is harder to miss. In 2020, 24 states and union territories were classified as Aspirants, scoring below 30. The number fell to 19 in 2021-22, returned to 24 in 2023 and again in 2024, then dropped to 18 in SEEI 2025. Front Runners rose, though not steadily, from two in 2020 to nine in 2025.

This suggests two Indias when it comes to state energy efficiency - a group of states that has gradually prioritised energy efficiency activities and implementation capability, and a long tail where progress remains much slower.

There is a second pattern, and it is the more revealing one. Every time the Index has tightened, the top of the table has thinned.

In 2019, using 97 indicators — the most any edition has deployed — no state reached the Front Runner band at all; Haryana, Kerala and Karnataka topped out as Achievers, a year after five states had been named Front Runners. SEEI 2024 deliberately weighted implementation more heavily, and Front Runners fell from seven to

five. Neither was a collapse in energy efficiency. Both showed that announcing a policy is easier than running one and proving it.

That has turned the Index into an annual audit of the state delivery system, which is not what it was designed to be. The Energy Conservation Act asks for nothing of the kind. There is no statutory SDA annual report to match BEE's own reporting duty, and basic questions about staffing, programme expenditure, enforcement and even energy data can be surprisingly hard to answer.

FROM BENCHMARKING TO STATE ENERGY PLANNING

Across the SEEAPs submitted to BEE, states use FY 2019-20 as a common baseline and FY 2030-31 as the planning horizon, estimating business-as-usual demand and identifying opportunities under moderate and ambitious efficiency scenarios.

The plans generally prioritise sectors by energy consumption, economic contribution, carbon intensity and state-specific priorities, according to BEE's State Energy Efficiency Action Plans (SEEAPs) methodology and state-level planning documents.

The value here is not the precision of every number, and the plans say as much themselves. Data for PAT industries and electricity sales are relatively strong; data for MSME clusters, agricultural pump stocks and municipal services often rest on surveys or secondary estimates.

The investment figures use standardised assumptions and should be read as indications of market potential rather than project pipelines.

For the first time, every state can ask a different question. Not "which BEE programme should we implement?" but "where does our state actually use energy, where will demand grow, and which interventions matter most for our economy?" That shift should shape the next generation of state policy.

The SEEAP exercise provides the analytical basis for that differentiation. But planning cannot become another end in itself.

That progression deserves attention - 36 plans, 18 states reporting implementation status, 7 with reported budget allocation for implementation.

The next challenge, then, is not another round of planning but converting the plans already prepared into funded programmes with named implementing agencies, timelines and measurable savings.

WHY IMPLEMENTATION DEPENDS ON STATES

Buildings show the Centre-state-local chain most clearly. SEEI data record steady progress on ECBC 2017 notification: 20 states in SEEI 2023, 24 in 2024, 27 in 2025. Incorporation into building bye-laws or the relevant legal framework has trailed at 16, 20 and 21.

The gap has held at four to six states for three consecutive editions, and it is not closing.

A code notified by a State Government does not save energy — savings occur when the requirements enter building regulations, architects and engineers design to them, officials check compliance, and completed buildings perform as intended.

This matters more as India moves from ECBC 2017 to the Energy Conservation and Sustainable Building Code and the updated Eco Niwas Samhita: the policy cycle cannot keep restarting each time a new code arrives while implementation of the last one remains incomplete.

The same chain runs through every other sector. In agriculture, Telangana reports full compliance with the five-star pump requirement for new agricultural connections, and Maharashtra reports substantial adoption of efficient and solar pumps under PM-KUSUM.

In transport, 27 states offer consumer incentives for private EVs and 23 mandate charging infrastructure in commercial buildings. Yet only 13 states had a DSM action plan approved by their electricity regulator in SEEI 2025, even though 31 reported demand-response policies of some kind.

Each state's portfolio has to reflect its economic structure, fuel mix, urbanisation, industrial base, agricultural demand, climate, DISCOM finances and institutional capacity. State-level implementation is therefore not an administrative matter.

It runs directly into economic development, public finance, electricity reform and urban governance, and will move fastest when folded into those agendas rather than run alongside them.

BUILDING THE DATA INFRASTRUCTURE FOR ENERGY EFFICIENCY

One further constraint will matter more with time. India has good national energy statistics and extensive administrative data across the CEA, the petroleum and statistics ministries and the DISCOMs.

What it lacks is a routinely published, reconciled state-level account of where that energy is actually used. Energy Statistics India 2025 carries state-wise tables on coal, lignite and hydrocarbon reserves, renewable potential and installed generation capacity. Every consumption table in the volume is national.

The Index has had to build state-level TFEC estimates from several central sources — proof both that state energy accounts are possible within reasonable uncertainty bounds, and that the underlying data architecture remains fragmented.

A state cannot manage its energy productivity if it cannot answer four basic questions. How much energy do we consume? Which sectors consume it? Which fuels do they use? And how is that changing?

The recently released MoSPI Expert Committee Report on Energy Statistics recognises the need for granular state-level end-use databases and for identifying state nodal offices. Those offices already exist. There are 36 of them, and they have been assembling precisely this data for the Index since 2018. The sensible course is to build on the SDA rather than add another layer — provided the role arrives with the technical capacity and funding to carry it.

The United States offers a useful benchmark. Its Energy Information Administration runs the State Energy Data System, or SEDS, publishing comparable state-level estimates of energy production, consumption, prices and emissions by source and sector going back to 1960, with a published methodology that states plainly which series are estimated rather than surveyed.

Notably, Washington does not ask fifty states to build their own accounts. The federal statistical agency builds them.

India need not copy the American system, but the division of labour is worth copying. The Centre, through MoSPI and BEE, should construct state energy balances from central administrative sources on a common methodology; SEEI's TFEC series is already a working prototype. States should supply what only they can: returns from designated consumers, and DISCOM sales data mapped to economic activity rather than tariff category.

LESSONS FROM OTHER NATIONS

The United States does not have 50 identical state energy offices. It has energy offices sitting variously inside environment departments, standalone energy departments and public benefit corporations. What Washington standardises is not structure but obligation.

Most states rely on a utility delivering savings under an Energy Efficiency Resource Standard: a regulator-set, ratepayer-funded obligation to achieve verified savings. But the lynchpin is the state

regulator's power to create that funding stream and enforce the obligation, not the utility itself.

Some states hand delivery to a third party altogether — Efficiency Vermont is a non-profit working under contract to the state commission, funded from a charge on customer bills.

China offers a harder-edged model. Provincial governments carry binding energy-intensity and total-consumption targets cascaded from the Five-Year Plan and differentiated by province, with progress published in periodic red, yellow and green ratings and performance folded into the evaluation of local officials. The incentive mechanism is neither transferable nor desirable in India.

The principle behind it is worth keeping: national ambition means little until it becomes measurable sub-national responsibility, with something following when it is not met.

The Chinese literature is candid that the system has generated its own problems, unreliable provincial data among them — a reminder that consequences without independent verification are not the answer either.

The European Union works in layers: a binding target set in law, a negotiated contribution for each member state, delivery left to national institutions of widely differing design, and reporting back in a common format as a legal requirement.

Most member states place the savings obligation on energy distributors rather than on government, which is closer to a DISCOM-run scheme than an SDA-run one.

India already has most of the pieces these systems rely on — national institutions, independent regulatory commissions, public tariff proceedings that any consumer can join, strong digital infrastructure and an annual benchmarking exercise. What is missing is the link between measurement and consequence. A poor SEEI score today

triggers no corrective plan, no additional technical assistance, no conversation with the State Finance Department and no fiscal or regulatory result. That is where the Index should go next.

The Index should not become a punitive instrument — its value lies in making differences visible and creating a common language for improvement. But measurement has more impact when linked to a structured response: states falling behind should receive targeted support and be expected to prepare time-bound improvement plans, while states performing well should have more flexibility to innovate and share their approaches.

FROM STATE ENERGY EFFICIENCY INDEX TO STATE ENERGY PRODUCTIVITY

The first generation of the Index measured preparedness. Subsequent editions increasingly measured policy and implementation. The next generation should move towards outcomes and accountability.

That does not necessarily require more indicators. It may require fewer and harder ones.

The pattern is already visible in what BEE and AEEE have collected. Thirty-six states have an action plan. Thirty-one have a steering committee. Twenty-seven have notified a building code. All of those cost little and need no dedicated cadre.

Thirteen have a DSM plan approved by their regulator. Nine have an approved SDA budget. Seven have money allocated against their action plan. States have done what does not require money or staff, and not what does. SEEI 2025, for the first time since the enactment of the EC Act, scores states on enforcement — whether they prepare Annual Inspection Plans and complete compliance inspections under ss. 13A, 14 and 15 of the EC Act.

The objective should not be to make all 36 SDAs look alike; that would run against both federal logic and practical experience. It

should be a minimum set of capabilities every state system possesses — predictable finance, professional staff, credible data, quantified targets, working relationships with the relevant departments and regulators, and transparent reporting of results.

The State Energy Conservation Fund can evolve from funding demonstration projects into a platform for mobilising private capital, through revolving funds, partial-risk guarantees and project aggregation for MSME, municipal and public-sector work — a direction SEEI 2025 itself signals. SEEAPs, in parallel, should stop being one-time documents running to 2031 and become living energy-productivity strategies, with their sectoral priorities written into state budgets, DISCOM demand-side plans, industrial policy, urban development and climate action plans. That also repositions efficiency within the development agenda.

Energy productivity is about producing more economic value, strengthening energy security and building more resilient infrastructure, not simply about consuming less. A state that treats it as part of a growth strategy will sustain investment far longer than one that treats it as a compliance obligation.

Technology is now the easier part — efficient motors, pumps, chillers, buildings, vehicles and appliances are all widely available. What determines whether they are deployed at scale is the quality of institutions, regulation, finance, data and delivery.

THE WAY FORWARD

India's first 25 years of institutionalised energy efficiency created the national architecture; the next 25 will test whether it can work through India's federal system.

India is urbanising fast. New classes of load — data centres, cooling and EV charging — are growing quickly, and manufacturing is expected to expand. Electricity is taking a larger share of final energy

use, and a grid carrying much higher shares of variable renewable power will place growing value on when electricity is consumed, not only how much. Electric vehicles, storage, smart meters and demand response will increasingly tie efficiency to power-system flexibility.

These shifts will play out differently across states. Maharashtra's strategy should not look like Assam's; Tamil Nadu's industrial and renewable mix is not Uttar Pradesh's; Punjab's agricultural electricity problem is not Delhi's buildings and transport one.

The hill states and the smaller union territories will have different priorities again. National policy should work with those differences rather than flatten them.

Rank	States	TFEC (Mtoe)	Category
1	Maharashtra	39.32	Front Runner
2	Gujarat	37.09	Contender
3	Uttar Pradesh	35.63	Contender
4	Tamil Nadu	24.93	Front Runner
5	Odisha	23.88	Achiever
6	Karnataka	23.16	Front Runner

Sequencing matters, and the table above suggests where to begin: not simply with the largest consumers, but where large consumption meets weak delivery.

Karnataka, Maharashtra and Tamil Nadu are already Front Runners. Gujarat and Uttar Pradesh, second and third by consumption, remain Contenders, while Orissa lags further behind.

Concentrating technical support, finance and data assistance where those two conditions overlap would produce the largest absolute savings for the least effort, and the approach can then extend in phases according to each state's energy profile, institutional capacity and readiness.

The Centre should retain its role in setting standards, developing

national markets, establishing common methodologies and providing technical support, while States assume greater responsibility for implementation and measure energy productivity. SEEI can reinforce this division of roles by creating a common basis for measurement and accountability without prescribing a uniform institutional structure.

India does not need 36 identical SDAs. It needs 36 states and union territories that can understand their own energy use, set priorities suited to their economies, finance implementation, measure what works and answer for the outcomes.

Technology is now the easier part -- efficient motors, pumps, chillers, buildings, vehicles and appliances are all widely available. What determines whether they are deployed at scale is the quality of institutions, regulation, finance, data and delivery.

The next 25 years of energy efficiency will not be won by building one strong institution at the Centre, but by building the capacity to deliver in every state.

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KEY TAKEAWAY

India's next phase of energy efficiency must move from isolated savings to energy productivity. That means making efficiency visible to users, bankable for investors, scalable through institutions and valuable to the wider power system.

ENERGY PRODUCTIVITY: INDIA'S NEXT GROWTH FRONTIER

The next phase of efficiency must make energy a source of productivity, competitiveness and resilience.

Saurabh Kumar

India's next stage of development will be shaped not only by how much energy the country can produce, import or generate, but by how productively that energy is used. Manufacturing growth, urbanisation, rising incomes and the expansion of modern services will all increase demand for electricity and fuels. Meeting that demand through additional supply will remain necessary, but it will not be sufficient. The deeper economic challenge is to ensure that every unit of energy consumed delivers higher industrial output, better urban comfort, stronger enterprise productivity and lower exposure to volatility.

This is the productivity case for energy efficiency. It moves the subject beyond the narrow language of savings and conservation into the wider domain of competitiveness, energy security, investment quality, power-system resilience and decarbonisation.

An efficient economy is not one that merely consumes less. It converts energy into value with less waste, lower risk and greater resilience. For India, that distinction will become increasingly important as the country pursues the ambition of Viksit Bharat 2047.

The first 25 years of India's energy-efficiency effort created the conditions for this broader understanding. Standards and labelling made product performance visible to consumers. Building codes introduced efficiency into design and construction. Industrial

programmes brought measurement, benchmarking and targets into large energy-consuming sectors. These instruments established energy efficiency as a matter of public policy and industrial practice, rather than as a voluntary technical improvement pursued only by a few early adopters.

That foundation remains valuable, but its limits are now clearer. Regulation can define minimum performance and create discipline, but it cannot by itself deliver the pace,

"Energy efficiency and renewable energy are not parallel agendas; efficiency makes the power system more capable of using renewable energy well. "

investment and market depth required for the next phase of growth. As millions of new appliances, buildings, machines and industrial processes enter the economy, their efficiency will influence peak demand, utility finances, fuel import exposure, consumer affordability and the cost structure of Indian industry.

The issue is no longer simply whether energy can be saved; it is whether India can raise the productivity of energy across the economy.

FROM COMPLIANCE TO PRODUCTIVE VALUE

The shift from compliance to productive value begins with visibility. Efficiency must be seen, measured and valued by consumers, businesses, financiers and public institutions. Existing labels have helped consumers distinguish performance levels, but the next generation of products will require stronger signals in categories where demand growth will shape the power system. Air conditioners, refrigerators, fans and lighting are not merely household goods at India's scale; their aggregate performance affects electricity demand, distribution planning, peak load and household expenditure. A differentiated super-efficient category can create an aspirational tier that manufacturers can design for, public procurement can support, and consumers can recognise.

Such market creation does not weaken regulation; it gives regulation a wider economic purpose. Minimum standards set the floor, but higher performance needs demand signals strong enough to justify investment by manufacturers and adoption by consumers.

Public procurement can create this early demand by choosing super-efficient technologies in government buildings, institutions and programmes. In doing so, it reduces uncertainty, supports scale and communicates that efficiency is not a marginal preference but a standard of modern infrastructure.

The same principle applies to buildings and industry, where efficiency becomes powerful only when it carries economic value. A high-performing building should have commercial meaning for owners, developers, occupants and utilities, whether through tariff structures, development incentives or market recognition. Industrial efficiency targets, similarly, should be viewed less as compliance obligations and more as instruments of productivity.

For a chief executive, energy efficiency matters when it improves margins, asset reliability, supply-chain resilience and the ability to compete in markets where carbon and resource productivity increasingly shape investment choices.

Once efficiency is understood in this way, the next question is how to move from individual adoption to market scale. India's experience with large-scale LED procurement offers a useful illustration. Its significance was not only that lamps were replaced, but that a dispersed opportunity was converted into a mass-market proposition through aggregation, bulk procurement, lower transaction costs, warranty support and a clear consumer offer.

The broader insight is that efficiency scales when the user sees a simple benefit, and the market sees predictable demand.

FROM VISIBLE SAVINGS TO INVESTABLE SAVINGS

Energy efficiency often fails to scale because the asset is less visible than the savings. A solar panel can be seen and financed as a physical system that generates electricity. An efficient chiller, motor, pump or process improvement produces value by avoiding consumption. That value is real, but it is harder to measure, package and finance. The first requirement is therefore visibility: users must be able to understand the benefit, institutions must be able to aggregate demand, and financiers must be able to trust the savings.

Visibility, however, is only the beginning. Once efficiency is converted into a market proposition, finance becomes unavoidable. Unlike renewable energy projects, many efficiency investments are dispersed across thousands of facilities, involve smaller ticket sizes, depend on operating behaviour and generate returns through avoided costs rather than an explicit revenue stream. This structure makes lenders cautious even when the underlying economics are sound.

The financing challenge is therefore not simply a shortage of capital. It is a problem of risk allocation. Energy efficiency needs mechanisms that can absorb performance risk, payment risk and aggregation risk in ways that individual project owners cannot. Equity-backed platforms, guarantee structures, standardised contracts and specialised intermediaries can convert a scattered universe of projects into a credible pipeline for investment.

This is particularly relevant for public institutions, municipalities and state-level assets, where savings potential may be substantial, but counterparties may not always offer the balance-sheet strength that private finance expects. Technical assistance is also part of bankability. Projects must be identified, designed, measured and standardised before capital can flow at scale. Finance that remains available only in principle does little for the energy system; the real challenge is to create investable efficiency.

THE MSME TEST

The question of bankability becomes sharper when the discussion moves from large enterprises to MSMEs. India's small and medium enterprises are central to employment, manufacturing and regional industrial ecosystems, yet they often operate with limited capital, thin margins and low tolerance for operational disruption. For them, an efficiency technology is not adopted merely because it promises savings; it must be proven in comparable conditions, supported by trusted suppliers and financed without placing the full risk of experimentation on the enterprise.

This makes MSME efficiency a delivery challenge as much as a technology challenge. Cluster-based approaches are more appropriate than isolated interventions because they allow awareness, demonstrations, supplier networks and financing mechanisms to be built around common processes and sectoral needs. Repeated engagement within clusters can reduce uncertainty, while pilots can show whether a technology performs under specific operating conditions.

Heat pumps illustrate the broader point. In industrial processes requiring low-grade heat, the technology may offer a route to greater efficiency and electrification, but many MSMEs may not know whether it suits their production systems. Even when the proposition is understood, adoption requires confidence that the equipment will perform, that servicing will be available and that the financial risk is manageable. The pathway is therefore sequential: awareness, demonstration, aggregation and risk-sharing.

Commercial finance alone cannot build this pathway. Public budgets, philanthropic capital and industry platforms can fund the enabling architecture that private investors usually will not: demonstrations, capacity building, technical validation and first-loss or guarantee instruments. Such support should not be understood as subsidy for inefficient enterprises. It is an investment in reducing the market

failures that prevent productive technologies from spreading across India's industrial base.

EFFICIENCY AS A SYSTEM PROPERTY

The MSME challenge also reveals a wider limitation in how efficiency is often approached. If every intervention is treated as a separate project, the transaction burden remains too high and the pace remains too slow.

The next phase must view efficiency as a system property, extending from appliances and factories to distribution networks, demand patterns and the integration of renewable electricity.

Industrial electrification is central to this wider view. Where suitable low-grade heat applications can move from fossil fuels to electricity, the benefits are not confined to a plant boundary.

They can influence fuel import dependence, power demand, emissions, utility planning and the future shape of industrial energy use. But these benefits will be recognised only when electrification is presented in system terms, not merely as equipment substitution.

At this stage, the role of DISCOMs becomes central. A power system that must serve rising demand, integrate renewable energy and support new forms of electrified industrial load cannot rely on analogue distribution management.

Digital utilities can identify losses, understand demand patterns, enable flexibility and support more efficient use of infrastructure. Digitisation is not simply an operational improvement; it is the foundation on which a modern demand-side efficiency system will rest.

Artificial intelligence belongs within this same discussion. Much attention is given to the electricity consumption of AI and data centres, but the more strategic question is how digital intelligence can optimise demand, reduce losses and improve decisions at the distribution level.

AI will be useful for energy efficiency only if the grid produces reliable data and if utilities have the institutional capacity to act on that information.

Grid flexibility completes this logic. Counting renewable capacity is not enough if the system cannot absorb, balance and use clean electricity productively. Efficient demand, digital networks and flexible loads reduce the cost of integration and strengthen energy security. In this sense, energy efficiency and renewable energy are not parallel agendas; efficiency makes the power system more capable of using renewable energy well.

This is the larger economic point. A country that uses energy productively can grow with lower exposure to fuel volatility, lower stress on infrastructure and greater room to decarbonise. For India, this has direct relevance to Viksit Bharat 2047.

Manufacturing competitiveness, urban comfort, MSME productivity, resilient utilities, investment quality and climate goals will increasingly depend on the same underlying capability: the ability to convert energy into value with minimal waste.

THE WAY FORWARD: BUILDING AN ENERGY-PRODUCTIVITY ECONOMY

The argument for the next 25 years is clear. India must retain the policy instruments that have served it well, but it must now use them to build deeper markets, stronger institutions and more investable models of efficiency. Minimum standards should continue to set the floor, while super-efficient products, efficient buildings and productive industrial systems create the next level of performance. Public procurement, credible labelling and stronger demand signals can make efficiency visible and valuable to households, businesses and public institutions.

The way forward must also recognise that technology adoption will not happen at scale unless savings become bankable. Energy efficiency

projects need aggregation, standardised contracts, risk guarantees, equity-backed delivery platforms and technical assistance that can convert dispersed opportunities into investment-ready pipelines. This is especially important for MSMEs, where confidence, supplier credibility, demonstrations and risk-sharing are often more decisive than the technology itself.

At the same time, India must treat efficiency as a system capability. Industrial electrification, digital DISCOMs, AI-enabled demand management and grid flexibility are not separate agendas. They are part of the same transition from energy conservation to energy productivity.

A more digital and flexible power system will allow efficient demand to support renewable-energy integration, reduce system stress and improve the resilience of future growth.

The call to action, therefore, is to place energy productivity at the centre of India's economic strategy. Policymakers must design markets that reward higher performance. Industry must treat efficient energy use as a competitiveness advantage.

Financial institutions must help make savings investable. Technology providers and industry platforms must build confidence in new solutions, especially for MSMEs. Utilities must become digital, demand-responsive and capable of supporting a more electrified and renewable-rich economy.

If these actions come together, energy efficiency will no longer be a programme that follows growth. It will become one of the foundations on which India builds growth that is competitive, secure, resilient and low carbon.

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KEY TAKEAWAY

India has demonstrated that significant improvements in building energy performance are achievable. The next challenge is to make high performance the norm — across new construction as well as the existing building stock — rather than an attribute of a limited number of leading projects.

GREEN BUILDINGS AND THE NEXT FRONTIER OF ENERGY EFFICIENCY

From efficient components to intelligent, low-carbon and grid-responsive buildings.

Shekar Reddy C

India's approach to energy efficiency in buildings has changed fundamentally over the past two decades. What began largely as an effort to reduce electricity consumption through more efficient equipment has evolved into a broader pursuit of high-performance buildings that use less energy, integrate renewable power, manage demand intelligently and remain resilient to a changing climate. The next phase of this transition will require the built environment to move beyond individual technologies and operate as an integrated energy system.

The scale of the opportunity is significant. Buildings and construction account for approximately 32% of global energy use and 34% of global carbon dioxide emissions. Global electricity demand from buildings also continues to rise, with building electricity use increasing by more than 600 TWh in 2024 and accounting for nearly 60% of global electricity-demand growth. In India, buildings account for more than 30% of national electricity consumption, while a substantial share of the building stock that will exist in the coming decades is yet to be constructed.

At the same time, India's power system is undergoing a structural shift. Renewable energy capacity has grown rapidly, reaching nearly 300 GW by mid-2026. This creates an opportunity that extends beyond conventional energy efficiency. Buildings can increasingly be

designed to reduce demand, generate and store clean energy, manage peak loads and respond intelligently to the availability of renewable electricity.

The transition, therefore, is no longer simply about making buildings consume less electricity. It is about creating buildings that deliver the required services — thermal comfort, lighting, indoor air quality and productivity — with the lowest practical energy, resource and carbon intensity.

FROM COMPONENT EFFICIENCY TO WHOLE-BUILDING PERFORMANCE

The transformation in India's building sector can be seen clearly in the performance of individual building components.

In the early 2000s, the energy performance of HVAC systems, lighting, building envelopes and equipment was considerably lower than what is achievable today. Lighting Power Density (LPD), for instance, was typically in the range of 1.3–1.5 W/ft² in 2003. High-performance buildings today can achieve LPD levels of approximately 0.3–0.4 W/ft². Similarly, the Coefficient of Performance (COP) of small water-cooled chillers was around 2.9–3.1 in 2003. High-efficiency water-cooled chillers available today can achieve COP levels above 7–8 under Indian climatic conditions.

The improvement is not limited to equipment. Building envelopes, including glazing, walls and roofs, have also become significantly more efficient. Buildings designed to current codes and standards, including ASHRAE 90.1 and India's ECBC and ECSBC frameworks, can deliver substantially better energy performance than buildings constructed under conventional practices a decade or more ago.

The significance of this progression goes beyond improvements in individual technologies. Green building principles, energy codes and performance standards have progressively changed the market

itself. IGBC's development of rating systems specific to different building typologies has helped establish new benchmarks and encouraged building owners, designers and developers to view energy performance as an integral part of building design rather than an optional enhancement.

The larger shift has been from asking whether an individual component is efficient to asking whether the building as a whole performs efficiently

CODES HAVE CHANGED THE DEFINITION OF EFFICIENCY

The evolution of building energy efficiency in India can broadly be understood in three stages.

During the 2000–2010 period, the emphasis was largely on improving individual systems: efficient HVAC equipment, fans, pumps and motors, variable frequency drives, high-performance glazing,

"The next frontier of building efficiency is not better equipment alone; it is the ability of the entire building to continuously optimise energy, comfort, carbon and cost as one system."

insulation, daylighting and basic controls. The introduction of the Energy Conservation Building Code (ECBC) in 2007 represented a significant shift because it established minimum performance requirements across the building envelope, HVAC, lighting and electrical systems.

The following decade moved the conversation towards integrated building performance. Energy modelling, commissioning, sub-metering, Measurement and Verification, and increasingly sophisticated Building Management Systems enabled building owners to understand performance at the system and whole-building level.

ECBC 2017 strengthened this approach through three performance levels — ECBC, ECBC+ and SuperECBC — corresponding broadly to approximately 25%, 35% and 50% or greater energy savings against a conventional baseline. The introduction of the Energy Conservation and Sustainable Building Code (ECSBC) 2024 represents a further evolution towards holistic performance, bringing energy efficiency, renewable energy and operational performance into a more integrated framework.

The metrics used to evaluate buildings are changing accordingly.

TABLE: Evolution of Building Energy-Performance Metrics

Phase	Primary objective	Representative metrics
2000	Reduce energy use	kWh; equipment efficiency
2010	Optimise whole-building performance	EPI; COP; kW/TR; LPD; U-value
2020 onwards	Decarbonise and manage demand	Renewable-energy fraction; peak kW; kgCO ₂ e/m ² ; Net Zero

The objective is no longer simply to minimise annual electricity consumption. Building performance increasingly needs to be understood through a combination of Energy Performance Index (EPI), COP, kW/TR, LPD, U-value, peak demand intensity, renewable-energy contribution and carbon intensity.

This also changes the economics of efficiency.

Earlier efficiency investments were often evaluated primarily through simple payback: how quickly would an efficient lamp, motor or chiller recover its additional cost through electricity savings? Building owners today are increasingly considering life-cycle cost, maintenance, peak-demand reduction, resilience, carbon exposure and access to green finance.

The relevant question is consequently shifting from “What is the lowest first cost?” to “What delivers the strongest whole-life performance?”

INDIA'S OPPORTUNITY IS LARGE — AND TIME-BOUND

India illustrates both the scale and complexity of the building-energy transition.

Urbanisation, increasing floor area, rising appliance ownership and growing demand for thermal comfort are driving energy consumption upwards. At the same time, the green building movement has moved from a niche segment towards mainstream adoption.

The scale of this transformation is visible in the growth of the green building ecosystem. India's registered green built-up footprint has expanded from approximately 20,000 sq. ft. in 2003 to more than 16.33 billion sq. ft. across over 20,000 projects by August 2026.

The energy system serving these buildings is changing at the same time. India's renewable-energy capacity has increased from 76.38 GW in 2014 to nearly 289 GW by mid-2026. The combination of a rapidly expanding building stock and a progressively cleaner electricity system creates an important strategic opportunity.

Buildings can increasingly be designed around a different sequence:

Avoid unnecessary demand → reduce loads → improve system efficiency → electrify appropriate end uses → integrate renewable energy → manage demand → optimise performance continuously.

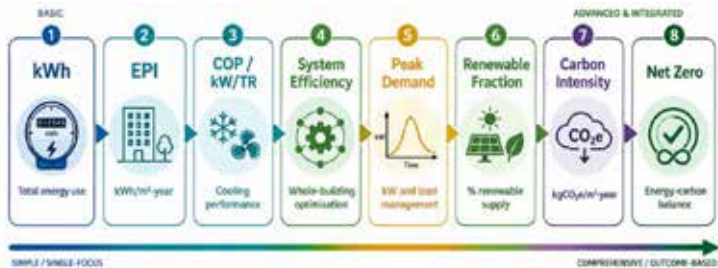
The sequence matters.

A building that first reduces its energy requirement needs less renewable generation, less storage capacity and lower electrical infrastructure capacity to achieve the same level of decarbonisation.

Recent high-performance office building data indicates operational

EPIs approximately 38–52% lower than older BEE five-star reference values, demonstrating how significantly performance benchmarks have advanced.

Cooling performance provides another illustration. Since kW/TR is inversely related to COP, increasing chiller COP from 3 to 6 approximately halves the compressor input required for the same cooling output. ECSBC 2024 further strengthens performance requirements, including tighter LPD and envelope performance parameters across higher-performance tiers.



Evolution of Building Performance Metrics

COOLING WILL BE THE DEFINING TEST

If energy efficiency is the foundation of India's building transition, cooling is likely to be its defining test.

Rising incomes, increasing urban temperatures, expanding floor area and growing expectations for thermal comfort are driving cooling demand rapidly. The India Cooling Action Plan projects that building-sector cooling demand could increase nearly eleven-fold between 2017–18 and 2037–38, while electricity consumption for space cooling in buildings could rise from approximately 135 TWh to nearly 584 TWh over the same period.

This makes cooling more than a building-level efficiency issue. It is becoming a national power-system challenge, with implications for

generation capacity, transmission and distribution infrastructure and peak demand.

The response cannot be limited to installing more efficient chillers.

Cooling performance depends on the interaction between the building envelope, heat gains, chillers, pumps, fans, cooling towers, distribution systems, controls and occupancy patterns. Variable-speed systems, smart controls and advanced analytics can enable cooling output to respond to actual occupancy and thermal demand instead of predetermined schedules.

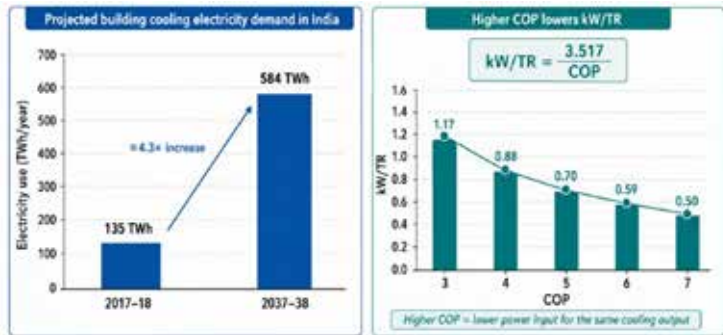
Thermal storage and demand-response strategies can further shift cooling loads away from periods of grid stress. Renewable electricity can reduce associated emissions, while lower-global-warming-potential refrigerants can address direct climate impacts.

This represents a fundamental change in the cooling paradigm:

The objective is no longer simply to add cooling capacity. It is to reduce heat gain, optimise cooling demand, improve system efficiency, manage when cooling occurs and deliver low-carbon thermal comfort.

District Cooling Systems have already demonstrated their potential in landmark projects, while emerging models such as Cooling-as-a-Service can potentially improve asset utilisation and reduce the need for oversized cooling infrastructure.

The opportunity is particularly significant because better cooling efficiency delivers benefits beyond energy savings. It reduces peak demand, lowers infrastructure requirements, improves operating costs and makes buildings better prepared for rising temperatures.



Building Cooling Electricity Demand and Relationship Between COP and kW/TR

THE BUILDING MUST BE TREATED AS AN ENERGY SYSTEM

The next stage of efficiency requires a broader definition of building performance.

As electricity generation becomes progressively cleaner, the relative importance of emissions embodied in construction materials will increase. Cement, steel, glass and aluminium carry substantial energy and carbon footprints before a building is occupied. Material efficiency, durability, reuse, responsible procurement and lower-carbon materials will therefore become increasingly important components of whole-life building performance.

At the same time, energy efficiency cannot be separated from occupant experience.

Earlier approaches often reduced the question of comfort to maintaining a fixed indoor temperature. Current thinking increasingly considers adaptive comfort, ventilation quality, daylight, indoor air quality and occupant control.

The objective is not to minimise energy consumption at any cost.

It is to deliver the required building service with the lowest practical energy, resource and carbon impact.

That distinction matters. A building that consumes less energy but compromises indoor air quality or occupant productivity cannot be considered a high-performance building in the broader sense.

DIGITALISATION CAN MAKE PERFORMANCE PERSISTENT

One of the biggest gaps in building efficiency is not necessarily design capability. It is the persistence of performance after occupancy.

A building can be designed to perform efficiently and still consume significantly more energy than expected because of poor commissioning, inappropriate operating schedules, equipment degradation, sensor errors or inadequate maintenance.

Digitalisation is beginning to change this.

Modern Building Management Systems, IoT sensors, fault detection and diagnostics, advanced analytics and digital twins can provide continuous visibility into building performance. They can identify conditions such as simultaneous heating and cooling, sensor drift, excessive static pressure, inefficient schedules and abnormal equipment behaviour that periodic energy audits may not capture.

This creates a transition from designing for efficiency to continuously managing for performance.

It also creates an opportunity for existing buildings. Significant improvements can often be achieved through controls optimisation, commissioning, operational tuning and targeted system upgrades without undertaking complete building retrofits.

Artificial intelligence can take this further by identifying patterns across large volumes of operational data and continuously optimising building systems against occupancy, weather, energy prices, grid

conditions and equipment performance.

For the building sector, this could represent one of the most important developments of the next decade.

The intelligent building will not simply know how much energy it is consuming. It will increasingly be capable of determining why it is consuming that energy and what should change in response.

FROM ENERGY EFFICIENCY TO NET-ZERO PERFORMANCE

The transition towards Net Zero is therefore not a choice between energy efficiency and renewable energy.

The two are most effective when sequenced correctly.

Efficiency reduces the amount of energy a building requires. Electrification shifts appropriate end uses away from direct fossil-fuel consumption. Renewable energy reduces the carbon intensity of the electricity that remains. Storage and demand response enable buildings to manage when energy is consumed.

Whole-life carbon adds another dimension by recognising that building performance begins before occupation and continues through construction, operation, maintenance, refurbishment and eventual end-of-life.

Projects that integrate these dimensions are already demonstrating what is possible. A Net Zero Carbon project undertaken by L&T, for instance, has achieved very high levels of energy efficiency alongside its carbon objective, illustrating the relationship between energy performance and whole-life decarbonisation.

The lesson is clear: Net Zero cannot be achieved by adding renewable energy to an inefficient building. The strongest outcomes come from reducing demand first and then decarbonising the energy and materials required to deliver the remaining building services.

THE STRATEGIC ROLE OF GREEN BUILDING RATING SYSTEMS

This evolution also highlights the importance of green building rating systems.

Rating systems have played a critical role in moving energy efficiency from an aspirational concept to a measurable performance objective. By establishing benchmarks, encouraging integrated design and recognising performance across different building typologies, they have helped create a market for technologies and practices that were once considered advanced.

The next phase will require rating systems to go further.

The emphasis will increasingly need to shift towards actual operational performance, whole-life carbon, grid interaction, AI-enabled optimisation, resilience and the ability of buildings to perform under changing climatic and energy-system conditions.

For IGBC, this represents an opportunity to support the market through the next stage of its evolution — from green buildings to high-performance, intelligent and resilient buildings.



Building Performance Metrics — From Energy Use to Net-Zero Outcomes

THE WAY FORWARD

India's building-energy transition will be shaped by how effectively efficiency, electrification, renewable energy, digitalisation and resilience are integrated rather than pursued as separate agendas.

The way ahead can be defined through five priorities.

First, avoid unnecessary demand. Passive design, climate-responsive architecture, efficient envelopes, daylighting and appropriate orientation should remain the first line of defence against energy consumption.

Second, maximise system efficiency. HVAC, lighting, pumps, fans and other building systems should be designed and operated around high-performance benchmarks, with commissioning and continuous optimisation treated as integral to performance rather than post-completion activities.

Third, improve the existing building stock. India's future efficiency gains cannot come only from new construction. Existing buildings will require systematic interventions across HVAC systems, controls, envelopes, commissioning, renewable-energy procurement and operational practices.

Fourth, measure actual performance. EPI, peak demand, renewable-energy fraction, carbon intensity, water consumption and indoor-environment quality should increasingly be assessed using operational data rather than design assumptions alone.

Fifth, make buildings intelligent and resilient. AI-based controls, digital twins, predictive analytics, storage and demand-response capabilities can enable buildings to respond to occupancy, weather, heat waves, grid conditions and variable renewable-energy availability.

India has a particularly valuable opportunity because much of its future building stock is yet to be constructed. The country can avoid locking

in inefficient assets while simultaneously improving the buildings that already exist.

Over the next five to ten years, IGBC can play an important role in accelerating this transition by enabling projects to incorporate AI-based optimisation across both design and operations, strengthening operational performance benchmarks and encouraging buildings to move from static efficiency towards continuous performance management.

The most successful buildings of the next decade will not depend on a single green technology. Their advantage will come from how effectively passive design, efficient systems, clean electricity, intelligent controls, low-carbon materials and healthy, resilient indoor environments work together as one measurable performance strategy.

The paradigm shift is therefore already underway.

The question is no longer whether buildings can become more energy efficient. It is whether India can make high-performance buildings the standard for its next generation of growth.

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KEY TAKEAWAY

AI's role in energy efficiency is not confined to any one sector. It spans generation, industry, logistics, agriculture and measurement, and it is the cumulative effect across all of them that makes the emissions reduction set out earlier achievable. What unites them is visibility: AI is valuable only when it converts hidden operating losses into verified performance gains that industry, utilities and financiers can trust.

AUTOMATION, AI AND INDIA'S NEXT ENERGY EFFICIENCY FRONTIER

Digitalisation and automation are the means; higher economic value from every unit of energy is the goal.

Tejpreet S Chopra

India's energy story has always been measured in scale: megawatts added, households connected, factories powered and renewable capacity commissioned. That story remains essential to India's development. Yet the next phase of growth will be judged by a harder measure. India will need to ask not only how much energy it can supply, but how much economic output, industrial competitiveness, comfort, resilience and decarbonisation value it can extract from every unit of energy consumed.

The central challenge for the next 25 years is therefore not energy conservation in the narrow sense. It is energy productivity. Efficiency must move from being a compliance obligation or a collection of projects to becoming operating infrastructure for a modern economy.

That shift will be carried by digitalisation and automation: instrumented plants, connected assets, automated controls and artificial intelligence applied across electricity, industry, transport, agriculture, buildings and measurement systems. These are not adjacent technologies borrowed from another sector.

They are becoming the working machinery of energy efficiency itself, and the frontier now lies in deploying them at industrial scale rather than demonstrating them at pilot scale.

The size of the prize is best understood in numbers. On internationally

reported estimates, India's energy-related carbon dioxide emissions stood at close to 2.8 billion tonnes in 2023, at a carbon intensity of roughly 730 grams per kilowatt hour against a global average of about 480. These figures describe the scale of the opportunity. Applied with discipline, artificial intelligence offers a credible pathway to reduce these emissions substantially, potentially by half, within a decade.

It is not a technology add-on, but the connective intelligence that determines whether renewables, storage, grids and industry deliver on their promise.

FROM ACCESS TO INTELLIGENCE

India's energy-efficiency journey over the past 25 years can be understood in three distinct stages. The first was about access. Little more than two decades ago, hundreds of millions of Indians did not have reliable electricity at all; the priority then was simply putting capacity

"AI should become an efficiency layer across India's entire energy stack, not merely a collection of technology pilots."

on the ground, any capacity, so that homes had light and factories had power. Clean energy was, understandably, a secondary concern.

The second stage, roughly the last five to ten years, has been about transition. India has seen an extraordinary build-out of solar, wind, storage, transmission, smart meters and cleaner technologies, alongside a much deeper national awareness of what sustainable growth actually requires.

Capacity, however, is only half the story. Alongside the push for power came an institutional architecture: energy conservation legislation, a dedicated national agency, appliance standards and labelling that changed what manufacturers could sell, building energy codes, and target-based industrial programmes that turned savings into tradable obligations for the most energy-intensive plants.

These instruments established the habit of measuring energy use, benchmarking it and holding it to a standard. That foundation is the reason efficiency in India is now a discipline rather than an aspiration.

The third stage, now beginning, will be about intelligence, and intelligence is not free. Data centres consumed roughly 415 TWh of electricity in 2024, about 1.5 percent of global supply, and the International Energy Agency expects that to more than double by 2030, approaching Japan's total annual consumption. The technology that promises to make energy more productive is itself among the fastest-growing sources of demand for it.

That paradox sharpens the argument. India's task shifts from generating more energy to extracting more economic value from every unit it already generates, and this shift from capacity to value will define the next 25 years as clearly as electrification defined the last.

MAKING EFFICIENCY VISIBLE AND VALUABLE

Efficiency has always suffered from a problem of visibility. Losses hide inside processes that appear to be running normally, and what cannot be seen is rarely valued, prioritised or funded. The first contribution of intelligence, therefore, is not automation but observation: continuous, verifiable measurement that replaces assumed performance with observed performance across generation, industry, transport, agriculture and reporting itself.

That visibility shows up across the value chain. In generation, sharper forecasting and optimised battery charging make renewable output more predictable, matching every megawatt of wind and solar more precisely to demand. In industry, optimising kiln fuel mix, oxygen levels and clinker production in cement, or furnace control, yield and temperature in steel, lowers energy consumed per tonne, while predictive maintenance identifies a failing fan, pump, compressor or mill before it stops.

Greater process stability, higher yield and less rework cut emissions further and make lower-carbon operating recipes viable. In transport and logistics, route optimisation, vehicle loading, scheduling and fleet maintenance each carry direct energy consequences; in agriculture and water, satellite imagery, weather data, soil sensors and irrigation systems can be combined to cut waste at scale. Underpinning all of it is measurement itself, where meters, fuel systems, logistics records and ERP data allow carbon intensity to be tracked consistently, so that progress is verified rather than assumed.

FROM PILOTS TO PRODUCTION

Enthusiasm for AI is not the constraint; disciplined deployment is. Much of India's AI-in-energy-efficiency activity today remains at the pilot stage, and moving beyond that will require a few deliberate shifts.

The first is measuring outcomes rather than intentions. The gap between industries narrows when targets are clear and comparable: a 5 percent reduction in energy per tonne, a 20 percent cut in unplanned downtime, a 50 percent reduction in inspection time. Stated as targets rather than results, figures of this order give boards something to approve and plant teams something to be held to.

The second is redesigning workflows around the technology rather than layering AI onto unchanged processes, since sensors, computer vision and energy forecasting deliver full value only when the workflow is rebuilt to use them.

The third is building a genuine data foundation, because the SCADA, MES and ERP systems already installed across Indian industry generate enormous volumes of data, too little of which is structured, standardised or shared.

The fourth is a discipline of learning and expanding, taking a proven use case from one plant and propagating it across

an industry, as CII has done in cement by turning one company's operational learning into a shared playbook. The fifth is training the people who will use these tools, from operators to engineers. The sixth is trust, earned through evidence that AI-generated recommendations are reliable enough to act on.

Underlying all of this are three broader shifts: from isolated pilots to full-scale deployment; from scattered data collection to trusted, shareable industrial data sets; and from a mindset of AI replacing people to one of AI working alongside them. None of these happen automatically, and none are primarily technical.

Each depends on an institution deciding to measure, standardise and share, and on someone willing to underwrite the result. That is where deployment stops being an engineering question and becomes a financing one.

BANKABILITY BEYOND CAPITAL AVAILABILITY

The barriers standing in the way are specific rather than abstract, and most of them reduce to a single question: can a projected saving be measured, verified and underwritten with enough confidence for someone to finance it? Where the answer is no, efficiency remains an engineering opportunity that never becomes an investment, however compelling the technology behind it.

Indian factories typically operate machines of different ages, makes and control architectures, many never designed to communicate with one another.

Connecting this fragmented physical layer to a reliable digital one is an engineering challenge that precedes any attempt at optimisation, and the data that emerges is often poorly labelled, inconsistently structured and expensive to clean. Cost is only part of the problem, and not always the largest part. Survey evidence on smaller enterprises finds that unclear business purpose and knowledge gaps outrank price as

adoption barriers, with system integration close behind, and that only around one in ten has integrated AI meaningfully. Many organisations lack a defined business objective, cannot articulate a confident return on investment, and face shortages in AI, IoT and cybersecurity skills. Add organisational resistance to change, the difficulty of moving from pilot to production, and a still-evolving regulatory and ethical framework, and the barrier is clearly not technology alone. It is the absence of a trusted operating model that converts efficiency potential into bankable savings.

This is most acute for India's micro, small and medium enterprises, which face every one of these barriers with far less capital and technical depth to absorb them. A government-commissioned research effort involving the World Economic Forum, the Ministry of MSME, MeitY and the Principal Scientific Adviser's office examined precisely how to bring AI to this base, and one answer is instructive.

Machine learning models originally built for large companies on the cloud can now be compressed onto a small, secure, palm-sized device, addressing data security, privacy and sovereignty concerns directly, without requiring MSMEs to send their data anywhere at all.

Solving adoption for India's smallest enterprises is often less about inventing new algorithms than about redesigning how existing intelligence is delivered, securely and affordably.

Alongside edge computing, shared service platforms, cluster-level aggregation and industry-led templates can turn advanced intelligence into a practical productivity tool, though delivering them at scale needs sustained coordination between government, industry institutions and technology providers.

POLICY AS AN ENABLER OF SCALE

Government has a distinct and necessary role, and four priorities stand out. The first is trusted, interoperable data infrastructure across

manufacturing, energy, agriculture, healthcare and transport, with standardised formats and open interfaces; this alone would do more for AI-enabled efficiency than almost any single subsidy.

The second is genuinely affordable compute for smaller enterprises, building on the work underway through the IndiaAI Mission.

The third is public procurement that moves at a pace suited to the technology.

The fourth is regulation that is sector-specific and risk-based rather than a single blanket framework, supported by sustained investment in workforce training and in the links between universities, startups and industry.

It is also worth learning selectively from other economies. The United States combines industry, research and university ecosystems more effectively than most. The European Union has done substantial work on risk-based legal frameworks, even as some argue it has erred towards over-regulation.

China has pursued a state-led model that aligns AI policy tightly with industrial strategy. India need not replicate any of these wholesale, but it should be deliberate about what to avoid: over-regulating early-stage experimentation, imposing compliance burdens that smaller firms cannot absorb, allowing untested AI into safety-critical systems, and becoming dependent on frontier models built elsewhere rather than developing sovereign capability at home.

EFFICIENCY AS A SYSTEM PROPERTY

Five areas deserve particular focus. Renewable generation becomes more usable when AI sharpens forecasting and helps operators schedule capacity.

Grids become more efficient when AI identifies overloading, predicts faults and optimises power flows, though credible quantification of

the gain remains scarce, and that is itself part of the problem: until grid-level benefits are measured to a common standard, they cannot be procured, priced or financed. Storage becomes more intelligent when charging and discharging respond to demand, renewable availability, pricing and grid conditions, a capability that matters more as large data centres come online. Industrial productivity improves across cement, steel, automotive and chemicals through predictive maintenance, process optimisation, energy baselining, waste-heat recovery and real-time carbon monitoring.

And transport, one of the largest global opportunities for emissions reduction, gains most from system-wide efficiency rather than vehicle-level improvements alone.

System value is where these gains compound. Efficiency that is measurable and responsive becomes flexibility, and flexibility allows a grid with a rising renewable share to stay stable without over-building capacity.

For distribution utilities, that means better load shaping and lower peak procurement costs; for industry, power that is cheaper and more predictable; for the country, reduced exposure to imported fuel and a stronger foundation for affordable comfort in cities that are urbanising quickly. Efficiency, understood this way, is not a subtraction from growth but an input to energy security.

PEOPLE, SKILLS AND PRODUCTIVE ADOPTION

No honest conversation about AI and energy efficiency can avoid the question of jobs. There will be genuine displacement, as routine, repetitive tasks are automated.

But displacement is only one part of a three-part picture that also includes augmentation, where AI makes existing workers more capable, and creation, where new categories of work emerge around designing, operating, supervising and integrating these systems. The

more useful frame is not AI versus workers, but AI plus workers.

This matters enormously given the scale of India's MSME sector. On the Ministry of MSME's own figures, it accounts for a little over 30 percent of GDP, more than a third of manufacturing output and close to half of India's exports, with well over six crore enterprises now formally registered. Bringing AI to this base, responsibly and affordably, is arguably the single most consequential workforce decision India will make in this transition.

It requires funding continuous reskilling, supporting worker transitions, incentivising augmentation rather than pure automation, and protecting the human-centred work of trust, judgement, empathy and leadership that AI cannot replace.

The competition ahead will not be between humans and machines, but between organisations that learn to combine the two and those that do not.

THE WAY FORWARD

The way forward is clear. Policymakers must treat the data and compute priorities set out above as infrastructure decisions rather than technology pilots, and calibrate regulation to support responsible experimentation while protecting safety-critical systems.

Industry leadership must stop treating AI-enabled efficiency as a demonstration activity and start treating it as core operating infrastructure, with measurable outcomes and executive ownership.

Financial institutions, technology providers and anchor industries must make savings investable, especially for MSMEs, by aggregating demand, standardising measurement and reducing performance risk. Educational and industry institutions must invest at scale in training the workforce that will operate alongside these systems.

And utilities and industrial operators must build the data foundations,

without which no amount of AI ambition translates into results, while valuing efficiency not only as demand reduction but as flexibility that strengthens renewable integration and grid resilience.

For Viksit Bharat 2047, this is a competitiveness agenda as much as a climate agenda. India cannot afford an energy transition that only adds capacity while allowing productivity losses to remain invisible. The next 25 years must therefore make efficiency visible, bankable, scalable and systemic.

This is an extraordinary moment to be working in energy. The pace of advancement in AI now compresses into weeks what once took years, and the compounding effect of that pace, applied to something as foundational as energy, is difficult to overstate.

India does not command the capital resources of the West, but it holds something equally valuable: scale of talent, depth of engineering capability, and a hard-earned understanding of what energy scarcity means, built over 25 years of expanding access before expanding cleanliness.

Bringing that capability together with the intelligence layer now available is India's opportunity not merely to adopt this transition, but to lead it, and to define what an energy-productive economy looks like for the rest of the world.

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KEY TAKEAWAY

India's energy efficiency success was built by making products consume less, and that method has been extraordinarily effective. It is now insufficient on its own, because the stock of installed equipment is growing far faster than any labelling cycle can improve efficiency. The next twenty-five years depend on shifting from product efficiency to system efficiency — building codes that cut cooling load at source, standards and skills that protect efficiency in operation, digital intelligence in place of exhausted electro-mechanical gains, a retirement policy for ageing equipment, and coverage extended to cold rooms and data centres. The method that worked remains valid; the canvas must widen.

BEYOND THE MACHINE: INDIA'S NEXT EFFICIENCY FRONTIER

Two decades of labelling transformed the Indian appliance; the harder task now lies outside it.

Thiagarajan B

India will add more cooling capacity in the next two decades than it has added in its entire history. Rising incomes, a warming climate and the rapid expansion of commercial floor space are converging to make cooling one of the fastest-growing electricity loads in the country. This matters well beyond comfort. Cooling now sits at the intersection of India's growth ambitions, its energy security, the stability of its grid and its decarbonisation commitments. How efficiently the country cools itself will shape household electricity costs, the competitiveness of Indian manufacturing and the credibility of the road to Viksit Bharat 2047.

The encouraging part is that India already knows how to do this. Over twenty-five years it has built one of the most credible energy efficiency architectures in the developing world, and it has done so by making individual products consume less.

The difficulty is that this method, however successful, is running into its own limits. The next quarter century will not be won inside the appliance. It will be won in the building that surrounds it, in the vast stock of equipment already running, in how that equipment is operated, and in the skills of those who design and service it. The task now is to move from product efficiency to system efficiency.

HOW THE FOUNDATION WAS BUILT

The foundation was legal before it was technical. The Energy Conservation Act, 2001, through Sections 14(a), (b) and (c), empowered the government and the Bureau of Energy Efficiency to set Minimum Energy Performance Standards, to make star ratings mandatory for notified equipment, and to prohibit the manufacture, sale or import of appliances falling below the line.

That statutory backing is what separated the Indian effort from a well-intentioned voluntary campaign. It also settled a question that markets rarely settle on their own. Efficiency had until then been difficult to demonstrate and harder still to verify, and a legally backed rating supported by defined test methods replaced claims that no buyer could check with a rating that could be tested and trusted.

Manufacturers gained a credible way to bring real performance to market, and consumers gained a single dependable symbol in place of competing assurances. The design that followed was deliberately simple: a minimum standard as the floor, and a comparative label from 1 Star to 5 Star layered on top.

Simplicity was the source of its power. A buyer could suddenly compare not merely the price of two products that looked identical, but their lifetime electricity consumption and running cost. A ceiling fan running eight hours a day reveals nothing about its efficiency on the day of purchase; over a year, the difference between a poorly rated and a highly rated model appears unmistakably in the bill.

A label of that kind, however, only works if the expertise behind it is credible, and much of that credibility was built by institutions working steadily alongside the regulator.

The CII-Green Business Centre has been among the most consistent of them. Energy efficiency there has never been a standalone activity; it has run as one of several connected workstreams, alongside green buildings, green product rating and green company rating, with each

strengthening the others. The Centre's distinctive contribution has been subject matter expertise of a kind that is difficult to build and easy to underestimate — energy modelling, measurement protocols, audit methodologies, the accreditation of professionals qualified to apply them, and recognition programmes that gave industry both the tools to improve and a reason to want to.

Advocacy on standards and labels was carried largely by industry associations, with the

"Efficiency policy in India has been a policy of flow, when the problem has become one of stock."

Centre supporting implementation on the ground, where such programmes are ultimately won or lost. Sustained engagement with academia, research institutions, industry and international agencies ensured that Indian practice was benchmarked against the best available globally, rather than against its own earlier performance.

The results compounded quietly. By 2025 the Standards and Labelling programme covered 38 appliance and equipment categories. Cumulatively, 58 crore star-labelled appliances have been produced, with estimated savings of 89.80 billion kWh.

Room air conditioners were prioritised early, both for their volume and because cooling accounts for roughly 50 to 60 per cent of a typical residential electricity bill. Getting that one product right meant getting the single largest lever in the Indian home right.

That programme evolved in careful stages. Star labelling for fixed-speed machines was introduced in 2006 and made mandatory in 2009, and has been upgraded three times since, the most recent cycle running to 31 December 2025. Inverter air conditioners entered voluntarily in 2015 and became mandatory in 2018.

The framework is now technology-agnostic, applying a common standard to fixed-speed and inverter machines alike — a quiet but consequential decision, since it obliged manufacturers to compete on

delivered efficiency rather than on the technology named on the box.

The measurement method matured alongside. India moved from the Coefficient of Performance, which captures a single test point, to the Indian Seasonal Energy Efficiency Ratio, based on ISO 16358 but adapted through temperature bins running from 24°C to 43°C that cover more than 99 per cent of average Indian temperatures.

The significance of that adaptation is easily missed. The international ISO 16358-1 method uses outdoor bins spanning only 21°C to 35°C, while Japan and South Korea test between 24°C and 38°C. Because India rates its machines against a hotter and more demanding profile, the Indian standard is roughly 18 per cent more stringent than the ISO method.

A MARKET THAT CHOSE EFFICIENCY

What distinguishes the Indian experience is that the market moved further than regulation compelled it to. Roughly 70 to 75 per cent of buyers choose 3 Star air conditioners and about 20 per cent choose 5 Star, while 1 Star sales are negligible. It is a pattern of consumer preference that few other markets operating minimum performance standards have achieved, and it reflects both the clarity of the label and the readiness of Indian buyers to weigh running cost alongside price.

The technology mix shifted just as decisively: inverter air conditioners accounted for less than 1 per cent of room air conditioner sales in 2015, rose to about 76 per cent by 2022 and reached roughly 86 per cent in 2024.

Efficiency levels climbed steadily behind that shift. The 3 Star threshold moved from 2.7 in the 2009-11 cycle to 4.3 in 2026, and under the thresholds effective from 1 January 2026 to 31 December 2028, split air conditioners must deliver 4.3 ISEER for 3 Star and 5.6 ISEER for 5 Star. Over two decades the cumulative effect has been striking: an air conditioner today is estimated to consume only about

a fifth of the power a comparable machine consumed twenty years ago. Three constituencies gained at once — manufacturers found a legitimate basis for differentiation and a reason to invest in better compressors, motors, heat exchangers and controls; the electricity sector saw lower peak demand and reduced pressure to add capacity; and emissions were lower than they would otherwise have been. A demanding domestic standard also proved an export asset, since products built to it travel easily into international markets.

Policy widened the frame in 2019 with the India Cooling Action Plan, launched by the Ministry of Environment, Forest and Climate Change with the Ozone Cell as nodal agency. It set a twenty-year integrated approach across space cooling, refrigeration, cold chain, servicing, refrigerants, manufacturing and research, with targets for 2037-38 that include a 20 to 25 per cent reduction in cooling demand, a 25 to 30 per cent reduction in refrigerant demand, a 25 to 40 per cent reduction in cooling energy requirements, the training of one lakh servicing technicians, and — significantly for the decades ahead — the recognition of cooling as a national research and development priority.

Labelling extended accordingly — chillers move to upgraded requirements from 1 July 2026, with the Eco-Niwas Samhita linking chiller selection to star ratings; deep freezers became mandatory from February 2023 and were upgraded from January 2026; and variable refrigerant flow systems will be voluntary from January 2027 and mandatory four years later.

WHY THE PRESENT MODEL NO LONGER SUFFICES

The difficulty with the product-by-product method is arithmetic rather than intent. Each labelling cycle improves efficiency by roughly 10 per cent, suggesting a cumulative gain of around 20 per cent by 2030. Over the same period the installed population of cooling equipment is expected to grow four to five times, with room air conditioner

volumes alone projected to reach 23 to 30 million units a year by 2030 under growth scenarios of 10 to 14 per cent. On these trends, cooling load on the grid could rise by 300 to 400 per cent while efficiency improvements offset only about 20 per cent of that increase. The gap is not marginal, and tightening the label further cannot close a gap of that shape.

Part of the reason is that India has no retirement policy for cooling equipment. Unlike automobiles, air conditioners and cold chain assets have no defined end of life. Old machines are repaired repeatedly, sold onward into secondary markets or simply shifted from one room to another, and they continue drawing power at levels the market abandoned a decade ago.

Every efficiency standard applies only to the product being sold today, while the far larger population already installed stays outside its reach. Efficiency policy in India has been a policy of flow, when the problem has become one of stock.

The technical headroom is narrowing too. Compressors and motors have been refined to a point where further electro-mechanical gains are incremental and expensive. Meanwhile the largest determinant of cooling energy lies outside the machine altogether. Building envelope design decides how much heat enters a space in the first place, and design has not so far been the principal focus of efficiency effort in India.

That makes it the largest opportunity still available. Orientation, glazing, insulation and shading determine how much heat a 5 Star machine is asked to remove, and gains secured at the design stage carry through the entire life of the building without any further intervention.

A further share of designed efficiency is realised only when systems are maintained well. Variable refrigerant flow systems, chillers and cooling towers perform close to their rated levels when serviced to

standard, and drift away from them when servicing is irregular. Air balancing and water balancing are disciplines still maturing in India, and the gains available from getting them right are considerable — even air distribution across zones, fresh air quantities calculated correctly for the space, tight ducting and clean coils together account for a meaningful share of what a building actually consumes.

Efficiency certified on a test bench must survive fifteen years of operation, and strengthening the practices and capabilities that allow it to do so is among the clearest opportunities open to the sector.

Coverage is also still catching up with the market. Data centre cooling is emerging as a major new load that could eventually rival residential air conditioning in scale, and standards and technical capability for this segment are still being built, which makes early engagement valuable.

Cold chain remains significantly underpenetrated, with consequences reaching well past energy into food security, food inflation and farmer incomes, while a significant share of existing cold storage was built to an earlier generation of technology and offers substantial scope for improvement. Labelling today covers deep freezers but not cold rooms, leaving a large and growing load outside the framework for the present.

THE NEXT FRONTIER OF EFFICIENCY

If electro-mechanical engineering is approaching its limits, the next significant gains will come from digital and artificial intelligence technologies — inverters, controllers and sensors that continuously optimise compressor speed and refrigerant flow against the actual load in a space, rather than running equipment at a fixed design point. This is as much a talent question as a technology one. Air conditioning and heat transfer engineers now need digital competency layered onto their core discipline.

Looking ahead, research and development teams across the cooling industry are likely to require a far greater share of digital electronics and controls expertise alongside traditional heat and mass transfer engineering.

Hardware innovation has not exhausted itself entirely. Heat exchanger design remains productive, with aluminium microchannel and flat aluminium tube designs offering gains in both performance and material use, and green product initiatives such as CII GreenPro and GreenCo have shown that material content can fall even as efficiency rises. But the decisive lever is the building.

Codes governing envelope performance, orientation, glazing and insulation will do more for national cooling energy than another round of appliance tightening, because they reduce the load before any equipment is asked to remove it.

There is also a more fundamental question for industry and the research community to take up together. The objective is human comfort, not a particular number on a thermostat.

If comfort can be delivered at 26 to 26.5°C through better humidity control rather than by defaulting to 24°C, the implications across millions of installations would be substantial. This remains an open scientific question with direct energy consequences, and it deserves sustained institutional research rather than occasional advocacy.

Refrigerants present a trade-off with no clean answer as yet, since efficiency and environmental friendliness pull in opposite directions. Water is environmentally ideal but cannot cool effectively in these applications; R22 is efficient but ozone-depleting; several alternatives carry flammability or other penalties. Balancing near-zero global warming potential, ozone safety and efficiency in a single molecule remains unresolved, as does making evaporative cooling commercially viable at scale.

The wider task is to make both cooling and heating affordable and environmentally sound, since extreme heat and extreme cold each carry mortality risk, and no viable alternative to vapour compression exists at scale today.

Two emerging loads will demand research of their own. Data centres are driving work on liquid cooling and on chips designed to tolerate higher operating temperatures, and India, which intends to host a significant share of the world's digital infrastructure, has a direct interest in participating in that research rather than importing its conclusions later.

Cold chain requires a distinctly Indian line of enquiry, since not all produce needs the same cooling intensity and better harvesting, grading and sorting at the farm level could remove considerable energy use before any refrigeration is switched on.

THE WAY FORWARD

Public policy has fewer direct levers here than is often assumed, and the discipline lies in choosing two or three and pursuing them seriously. Equipment standards and building codes are the two that have consistently delivered, and they deserve the bulk of institutional energy. Linking cooling to renewable energy by mandate would be very difficult to implement and is better left to the electricity system to resolve.

A carbon price may become appropriate once the market matures, with Singapore offering a useful reference, but direct taxation of consumption is not a viable instrument at this stage.

Two decisions on the labelling framework itself deserve early debate. The first, and the more contentious, is whether India should adopt Minimum Energy Performance Standards more broadly and more firmly across categories, using a five-year horizon — by 2031 — to assess whether industry and the manufacturing base are ready.

The second is simpler: labelling should not stop at 5 Star. Permitting 6 Star, 7 Star or higher ratings would give manufacturers a continuing reason to innovate beyond today's ceiling, instead of clustering at the top of a scale that has run out of room.

Three gaps should be closed without waiting for consensus. Operations and maintenance need enforceable standards and far greater investment in service capability, so that rated efficiency survives in the field; the India Cooling Action Plan's target of one lakh certified technicians should be treated as a floor rather than an aspiration. Cold rooms should be brought within the labelling framework alongside deep freezers. And end-of-life policy for cooling equipment — how ageing, inefficient machines are retired rather than recirculated — needs to move from discussion to design.

The talent pipeline needs equal attention. Energy efficiency has yet to find a place in most undergraduate engineering curricula, though some master's programmes cover it, with notable work on air conditioning at IIT Bombay. Bringing the subject into the mainstream of engineering education is among the highest-return investments available, given how much of the coming agenda rests on design and service capability. Awareness-building can begin earlier still. A generation that understands what a star label means, why a building's orientation matters and why a well-maintained machine outperforms a neglected one will make better decisions as consumers, as engineers and as policymakers.

The animating principle should remain what it has always been: sustainable habitats and efficient industry delivered without adding cost to the consumer or to the enterprise. Sustainability that raises cost is adopted slowly and reluctantly; sustainability that is cost-neutral spreads on its own momentum, which is precisely what the labelling programme demonstrated. Industry, regulators and research institutions now need to commit to a shared agenda for the coming decade — standards that reach the whole cooling system rather than its components, codes that make

efficient buildings the default, a service ecosystem capable of protecting efficiency in use, and a research base equal to the open questions on comfort, refrigerants and cold chain. India built one of the world's most demanding cooling standards by being deliberate and patient. The same method, applied now to a far wider canvas and with far greater urgency, is what will carry the country to 2047.

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KEY TAKEAWAY

India's first twenty-five years of energy efficiency proved that efficient technology could be made affordable and mainstream at national scale. The next twenty-five years will be defined by how far that discipline travels down the value chain: deeper electrification, renewables matched with storage, and financing built around how small enterprises actually invest. Bring the MSME backbone fully into this transition, and India gains both a more competitive industrial base and a faster route to its energy goals.

THE BACKBONE QUESTION: TAKING EFFICIENCY TO EVERY TIER OF INDIAN MANUFACTURING

Large industry has made its transition. The next quarter-century belongs to the Tier 2 and Tier 3 enterprises that carry the manufacturing base.

Vikram Sitaram Kasbekar

India's energy efficiency journey over the past twenty-five years is usually measured by the technologies that entered the market. Seen from the shop floor, the more telling measure is how quickly an entire industrial base learned to absorb change. The automotive sector illustrates this best. From a starting point in India before 2000, when two-stroke engines ran with very limited emission control, Indian industry moved through BS2 in 2005, BS3 in 2010 and BS4 in 2017, then skipped a stage entirely and adopted BS6 in 2020, retooling products, processes and thousands of supplier units along the way. Industrial energy use travelled a parallel road, from furnace oil to diesel, then LPG and propane, then natural gas and biogas, and now toward blended hydrogen and flex fuels. Each transition demanded new equipment, new skills and fresh investment, and each was completed at a pace few industrial economies have matched.

That proven capability now faces a different kind of test. India's manufacturing base does not end with its largest companies. It runs several tiers deep into foundries, component manufacturers and small ancillary units, and it is these Tier 2 and Tier 3 enterprises, the MSMEs, that are truly the backbone of Indian industry. Large manufacturers and their Tier 1 partners have largely made their transition, financing efficiency investments from their own balance sheets. The decisive question for the next twenty-five years is whether the same progress

can be carried the full length of the value chain, to enterprises that are every bit as commercially minded but work with far less capital to commit upfront. Efficiency, in other words, must shift from being a property of the individual plant to a property of the value chain as a whole.

WHAT THE PAST TWENTY-FIVE YEARS ACTUALLY BUILT

The last two and a half decades were not merely a sequence of technology upgrades. What was built, often without being named as such, was a national capacity for absorption. Energy-efficient motors, blowers, electronic controls, LED lighting and appliance star-rating programmes spread quickly because India developed the institutional muscle to aggregate demand, standardise performance and communicate value to a price-sensitive market. Life-cycle costing moved from a niche engineering concept to a routine basis for investment, applied as readily to industrial equipment as to a household purchase. Manufacturing meanwhile moved from Industry 3.0 automation to Industry 4.0's data-driven optimisation, with Industry 5.0, human-centred automation combined with robotics, artificial intelligence and the Internet of Things, already on the horizon.

Several defining moments stand out. India built indigenous solar module manufacturing capability, including bifacial and high-efficiency modules, expanding domestic module capacity from 2.3 GW in 2014 to around 172 GW by March 2026. Industry has chosen to move ahead of the national timeline rather than wait for it: while the country's net-zero commitment is set for 2070, a growing number of companies have voluntarily targeted Scope 1 and Scope 2 neutrality by 2030. The green grid and the green factory have moved from concept to active programme. Life-cycle assessment has taken hold, with companies now declaring the global-warming impact of their products and processes upfront. That willingness to be measured is itself a marker of how far Indian industry has travelled.

Policy has been a strong enabler throughout. The steady expansion of renewable energy policy has helped enormously, and rooftop solar is now progressing well across industrial and residential segments. Open access, wheeling and interstate transfer frameworks have opened up genuine choice for industrial consumers, with several states designing and administering these provisions in a notably industry-friendly manner. Continued harmonisation across states will give industry even greater confidence to plan long-term renewable investments. The widening of the designated consumer base under the energy conservation framework, from process plants to a much wider set of sectors, has brought many more enterprises into a structured, measurable efficiency regime.

WHY THE NEXT PHASE ASKS A BROADER QUESTION

The model that served India well for two decades was built around discrete, identifiable interventions: upgrade this motor, meet this rating, improve this process. The next phase asks something broader. As electrification accelerates, particularly across two- and three-wheelers and increasingly four-wheelers, the locus of energy consumption is shifting from fuel tanks to the electricity grid. Millions of vehicles charging in residential and commercial spaces represent a different kind of load altogether. Renewable energy and storage, once framed largely as environmental choices, are becoming operational essentials for a grid carrying this new demand.

This is where a significant opportunity becomes visible. India's grid now draws more than half its installed capacity from non-fossil sources, having crossed 300 GW in July 2026, over 54 per cent of a total installed base of about 552 GW, and more than sixty per cent of the way to the 500 GW target set for 2030, well ahead of schedule. Solar has been the single largest contributor, rising in module manufacturing from 2.3 GW in 2014 to around 172 GW by March 2026. Non-fossil sources now make up more than half of installed capacity while contributing

close to thirty per cent of actual generation, a gap that simply reflects the daily rhythm of solar and wind. Substantial headroom therefore already exists within the capacity India has built, and capturing it is a storage and system-design opportunity rather than a generation challenge. Sodium-ion batteries, solid-state batteries approaching commercial maturity, and the repurposing of retired electric-vehicle batteries for stationary storage all point the same way: the next gains will come not from generating more renewable power, but from using what is already generated, whenever it is needed.

Storage brings a further benefit that sits outside the traditional definition of efficiency. In housing societies, condominiums and commercial complexes, battery storage combined with smart circuits allows loads to be started and operated sequentially, with peak demand met from stored energy. The sanctioned connected load can then be reduced substantially, lowering capital cost and easing the burden on distribution infrastructure. This is efficiency in its truest sense: the same service delivered by a smaller system, freeing up grid capacity for others.

FUEL TRANSITION AS A CONTINUUM, NOT A FINISH LINE

One of the more instructive aspects of India's energy journey is how rarely it has reached an endpoint. Hydrogen is no longer a distant aspiration: India commissioned its first project blending hydrogen into a city gas distribution network at Indore in 2022, beginning at 2 per cent and later scaling to 5 per cent in the piped natural gas network, while the National Green Hydrogen Mission of production 5 million metric tonnes (MMT) of green hydrogen per year by 2030. Institutions including IIT Madras are working on how much further that ratio can go. Oil companies already produce grey hydrogen in abundance, and the Mission's intent is to progressively replace it with green hydrogen as electrolyser costs move toward commercial viability. India has taken a good lead here, and point-to-point applications such as buses

and trains are already demonstrating what is possible.

The same logic applies to biofuels, and flex fuel deserves recognition as a genuinely green fuel. For the 2026-27 ethanol supply year, 72 lakh tonnes of Food Corporation of India rice have been reserved for ethanol distilleries, up from 52 lakh tonnes, with a further 55 lakh tonnes of fully broken rice offered through open market e-auction. Revised guidelines prioritise old and broken rice, converting low-value surplus into an industrial raw material while easing storage pressure on record central pool stocks. Feedstock has been diversified across sugarcane juice, molasses, maize, damaged foodgrains and surplus rice, reducing dependence on any single crop and cushioning the programme against weather-driven variability. The wider lesson is that fuel decarbonisation is best planned as a sequence of overlapping transitions rather than a single technology bet.

BEYOND THE FACTORY GATE: THE SUPPLY CHAIN AS THE NEW FRONTIER

Efficiency can no longer be treated as something a company does to its own operations alone; it is a property of the entire value chain in which that company participates. The automotive sector shows this clearly, given how deeply its supply chains extend into foundries, component manufacturers and ancillary units. Encouragingly, the extension is already underway. Large manufacturers have worked with supply chain partners, particularly foundries, to secure long-term green energy contracts, built on straightforward commercial logic: clean energy adoption lowers the supplier's costs while advancing the buyer's decarbonisation commitments. It is a genuine win-win, and replicating it more widely is what will lift India's industrial energy productivity at scale.

Electrification of process heat offers a parallel illustration. Heat pumps, long used for lower-temperature duties, are now being applied to higher-temperature industrial processes, including paint-shop applications in the range of 140 degrees Celsius, developed

with an Indian technology provider working alongside IIT Madras. The significance lies not in the temperature threshold but in the demonstration that electrification can reach deeper into core manufacturing processes when technology providers, academia and industry collaborate deliberately.

"It is the Tier 2 and Tier 3 enterprises, the MSMEs that are truly the backbone of Indian industry, where the greatest opportunity now lies."

It helps to be clear about where the remaining effort sits. Scope 1 and Scope 2 are largely within a company's own control, addressed through internal efficiency, the shift from direct burning to electrical alternatives, and the sourcing of renewable energy. This calls for a 360-degree view that looks beyond the main process lines to canteens, utilities and support facilities. Once that ground is covered, the net-zero challenge rests mainly with Scope 3, which comes from two directions: tailpipe emissions, where electric vehicles are the best available option today, supported by flex fuels through the transition; and thermal energy use, particularly hot water generation and process heating, which will progressively shift to cleaner sources. Solid-state batteries and other emerging technologies will shape the pace, and the picture will become clearer over the coming decade. The direction is already unambiguous.

THE MSME TEST

The most consequential part of extending efficiency down the value chain is supporting it at the level of small and medium suppliers. Tier 1 partners are generally well placed to finance their own investments. It is the Tier 2 and Tier 3 enterprises, the MSMEs that are truly the backbone of Indian industry, where the greatest opportunity now lies. These enterprises are not indifferent to efficiency; they are sharply commercial by nature. An investment promising an internal rate of return in the region of twenty-five per cent is one most small business owners would take up without hesitation. What they need

is education and awareness alongside access to initial capital, and, equally important, the assurance of consistent business, because a steady order book is what gives a small enterprise the confidence to commit capital. As larger industries continue to invest alongside their partners, this will happen.

The opportunity, then, is to design support that works with this commercial logic. Risk-sharing and early-capital mechanisms calibrated to how small suppliers actually make investment decisions, combined with sustained education and demonstration, will convert awareness into action quickly. Existing schemes provide a strong foundation; sharpening their design around the capital question is what will accelerate adoption across the tens of thousands of enterprises that together account for a very large share of industrial energy use.

BUILDING THE INSTITUTIONS THAT MAKE SCALE POSSIBLE

None of these shifts can be achieved through individual corporate initiative alone. They require institutions capable of aggregating demand, sharing knowledge and de-risking early adoption across an entire industry. This is precisely the role CII has played and continues to play, through industry-wide collaboration, idea exchange, benchmarking and the diffusion of innovative technologies. Forums such as the Energy Efficiency Summit are valuable because companies openly share operating detail with one another, recognising that better energy utilisation benefits industry and society at large rather than any single participant. Individual companies have run smaller versions of the same exercise, convening supply chain partners around World Environment Day each June to share the improvements they have made; a national platform multiplies that effect many times over. The evolving relationship between academia and industry, moving toward time-bound, industry-relevant research with professors participating as active professional partners, is shortening the distance between promising technology and commercial deployment. Flow batteries,

a long-duration storage technology now advanced partly through institute-linked start-ups, show how such collaboration brings emerging technologies within industrial reach.

THE HUMAN DIMENSION OF EFFICIENCY

A system-level view would be incomplete without recognising that behaviour, not just technology, determines outcomes. Habits formed early prove more durable than interventions introduced later, which is why instilling an understanding of resource use, waste segregation and conservation from school age, reinforced through college, matters as much as any industrial measure. India's own experience with municipal waste management is encouraging: cities that have organised systematic segregation and processing, Indore being the most cited example, show what a disciplined "reduce, reuse, recycle" approach can achieve. Food waste in large urban centres is a significant opportunity of the same kind; better organised collection could convert what is presently discarded into meaningful volumes of biomass and biogas. The underlying principle, extracting more value from every unit of resource consumed, applies as much to a household or a city as to a factory.

THE WAY FORWARD

Taken together, these threads point to a coherent proposition for the next twenty-five years. The first quarter-century proved that efficient technology could be made affordable and mainstream at national scale. The next must extend that same discipline across the full length of India's industrial value chains: deepening electrification into higher-temperature processes, matching renewable generation with the storage needed to use it fully, and ensuring the smallest enterprises in every supply chain move forward alongside the largest.

The stakes are considerable. A manufacturing base competing globally will increasingly be judged on its energy productivity; a grid absorbing millions of electrified vehicles will depend on storage-enabled

renewable use; and an economy building toward Viksit Bharat 2047 will draw much of its strength from an MSME base that is well financed and well supported through this transition. Energy efficiency, in this framing, is no longer a compliance obligation or even a sustainability commitment. It is a direct determinant of industrial competitiveness, energy security and the pace at which India can grow.

The technologies for this next phase, storage, electrification and blended fuels, are largely visible today. What remains to be built is the institutional and financial architecture that carries them to every tier of India's industrial base. That architecture, more than any single technology, will shape what India's energy efficiency journey looks like twenty-five years from now.

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ABOUT CONFEDERATION OF INDIAN INDUSTRY:

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society through advisory and consultative processes.

For more than 130 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. With its extensive network across the country and the world, CII serves as a reference point for Indian industry and the international business community.

In the journey of India's economic resurgence, CII facilitates the multifaceted contributions of the Indian Industry, charting a path towards a prosperous and sustainable future. With this backdrop, CII has identified "Accelerating Competitiveness: Growth, Resilience, Inclusion, Sustainability, Trust" as its theme for 2026-27, prioritising five key pillars. During the year, CII will align its policy advocacy, institutional initiatives, partnerships, and outreach to support Indian industry in strengthening these five interconnected pillars of competitiveness.

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ABOUT CII GREEN BUSINESS CENTRE:

The CII – Sohrabji Godrej Green Business Centre (CII – GBC) is CII's Developmental Institute for Green Practices and Businesses, focused on offering world-class advisory services dedicated to the conservation of natural resources. Its mission is to help India emerge as a global leader in green business by 2030.

The Green Business Centre in Hyderabad, Telangana, is housed in one of the greenest buildings in the world. Established in 2004, the Green Business Centre was inaugurated by His Excellency, the late Dr. A. P. J. Abdul Kalam, the then President of India, on 14 July 2004.

The Centre promotes sustainable practices and supports businesses through a comprehensive range of services, including Green Buildings (IGBC), Energy Transition Services, GreenPro Certification, GreenCo Rating System, Green Entrepreneurship Council (GEC), Council on Green Mobility, Green Cooling Council, Solar Vendor Rating Program (VRP) and more.

The Green Business Centre has registered over 20,000 green building projects (through the Indian Green Building Council - IGBC), certified 15,800+ GreenPro products, conducted 2,600+ energy audits globally, registered 1,600+ manufacturing facilities under GreenCo, and engaged with 300+ cleantech startups across India, Sweden, Australia, Ethiopia, Bangladesh & Japan.

CII GBC with all its councils has contributed to reducing 55 million tons of CO₂ emissions, saving 198 billion litres of water and 65 billion kWh of energy annually.

Learn more by logging on to - <https://greenbusinesscentre.com/>

ABOUT CII ENERGY EFFICIENCY COUNCIL:

The CII Energy Efficiency Council, part of the CII–Godrej Green Business Centre, has been driving energy efficiency and low-carbon transformation across Indian industry for over three decades. It works with industry and government to accelerate the adoption of energy efficient technologies, renewable energy, decarbonization solutions and sustainable business practices.

With experience across 20+ industrial sectors, CII Energy Efficiency has undertaken 2,600+ energy audits, trained 100,000+ professionals and facilitated 3.5 billion+ in annual recurring energy savings. Its work spans energy audits, technology adoption, net-zero and decarbonization, resource efficiency and policy advocacy, supporting industry in becoming more competitive, resilient and sustainable.

Learn more by logging on to -<https://energy.greenbusinesscentre.com/>

The CII Green Business Centre has convened India's energy efficiency community at a single table across twenty-five editions of its Summit — turning individual champions into a profession, and a profession into one of the world's largest energy-efficiency markets. To mark this milestone, CII-GBC brought together leaders who built this movement from its earliest days: policymakers, industrialists, regulators and institution-builders who shaped India's energy-efficiency agenda at the national level. The Energy Efficiency Imperative Book gathers their distinct perspectives on what worked, what remains unfinished, and what India's next twenty-five years of energy security, industrial competitiveness, and decarbonisation will demand.

