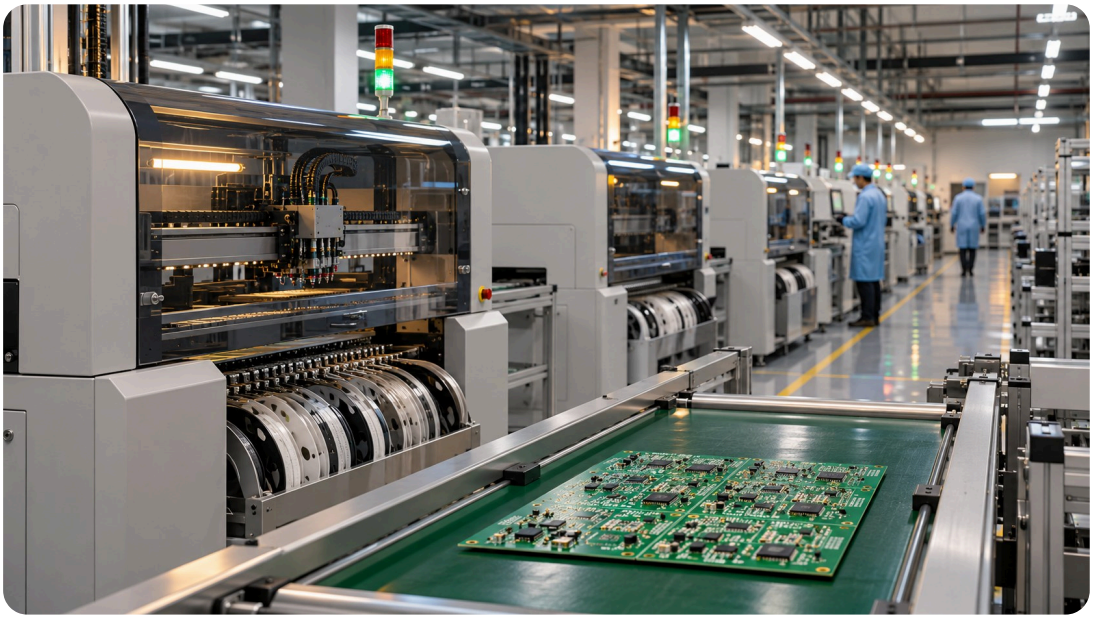
TOPTIER ENERGY SERVICES PVT LTD · INDUSTRIAL ENERGY ADVISORY

How India’s Electronics Manufacturers Can Cut Energy Costs and Carbon Emissions



Original AI-generated illustration of an unbranded SMT factory.

The power bill keeps running after the last board leaves the line

The final circuit board clears inspection. The production counter stops. The electricity meter keeps moving. A reflow oven is still hot, the air compressor is holding pressure, and the HVAC system is conditioning a floor that will sit idle until the next shift. Each load

has a reason to run. The question is whether it needs to run at the same setting for every minute the factory is open.

For leaders in India's electronics manufacturing services (EMS) industry, that question connects three decisions that often sit in different departments. The plant head controls process settings and yield. Procurement negotiates power and buys components. Finance decides which projects receive capital. If those teams work from the same load profile and product data, they can decide where to cut energy use, how much renewable electricity to buy, and which emissions need supplier action.

How an electronics assembly plant uses energy

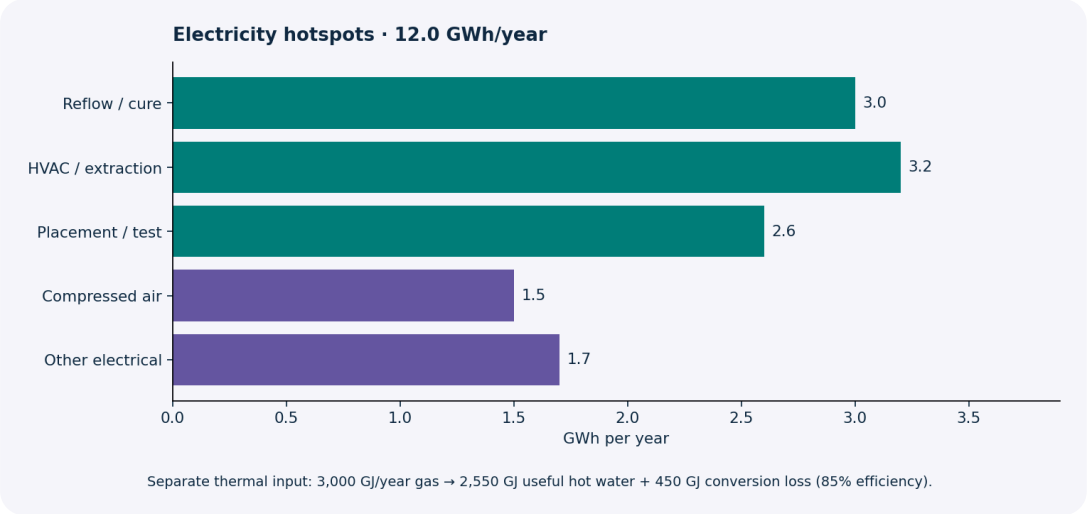
Assembly begins with incoming inspection and controlled storage of bare printed circuit boards, integrated circuits, passive components, connectors and solder paste. Moisture-sensitive parts may require dry cabinets or controlled baking. In a surface-mount technology (SMT) line, a stencil printer deposits solder paste, a pick-and-place machine positions components, and a conveyor carries the board through a reflow oven. A qualified temperature profile melts the solder and forms joints. Inspection may use optical imaging or X-ray, depending on the product and joint geometry. Through-hole components can add selective or wave soldering. Some products also require cleaning, conformal coating, curing, enclosure assembly, programming, functional testing and burn-in. See assembly process guidance [1].



Typical assembly flow. Optional steps depend on the product and approved process.

An EMS assembly floor has a different load profile from a semiconductor wafer fabrication plant or a bare-board etching and plating operation. In-house moulding, cable or harness fabrication, battery assembly or wet cleaning can change the profile materially. Map those processes separately before applying any assumptions. A factory running two shifts may also operate dry storage, cooling and selected test loads around the clock. Measure weekends, changeovers and restart ramps before proposing a shutdown schedule.

The first measurement campaign should cover reflow and cure equipment, HVAC and extraction, compressed air, and product test. Record oven state, product family, line occupancy, first-pass yield and utility readings on the same time base. Track both kWh per good board for similar products and kWh per populated panel or standard line-hour where the product mix varies. A factory that adds complex double-sided boards can consume more electricity even while the process becomes more efficient. Normalising for mix prevents a misleading before-and-after comparison.



Hypothetical EMS plant energy balance. Gas and electricity are shown separately.

Energy input	Useful service	Losses to measure	Operating emissions
12,000 MWh delivered electricity	Qualified solder joints, cooling, pressure, component handling and testing	Standby loads, heat exhausted from ovens, compressor leakage and overconditioning. No split assumed.	8,100 tCO_2/yr location-based baseline
3,000 GJ gas input	2,550 GJ useful hot water at assumed 85% efficiency	450 GJ flue and conversion losses	168.3 tCO_2/yr gas combustion

Distinguish useful heat transfer to boards and approved process air from standby and excess exhaust losses. Ventilation remains a safety and quality control. The engineering opportunity lies in validating airflow, scheduling and control settings against the approved design and working conditions. Keep extraction interlocked and qualify any recipe, nitrogen supply or idle-mode change with Quality and EHS before deployment.

Where Scope 1, Scope 2 and Scope 3 emissions come from

Scope 1. Screen fuel used by on-site standby generators, gas-fired heat, controlled vehicles and HVAC refrigerant leakage. Gas heat may serve a wash line or low-temperature hot-water load at some sites. A heat pump can fit a stable, low-temperature demand with a usable heat source. Check the required delivery temperature, part-load performance, electrical capacity and redundancy. Electric resistance heating has a simpler installation in some cases, but operating cost depends on the tariff and conversion efficiency. Track top-ups by refrigerant type and check low-GWP replacement compatibility and service capability. Assess on-site wastewater emissions where the treatment process warrants it. An electric reflow oven draws purchased electricity and belongs in Scope 2.



GHG Protocol boundaries applied to an EMS plant.

Scope 2. Account for purchased electricity and any purchased steam, heat or cooling. Location-based electricity emissions use an appropriate grid-average factor. Market-based emissions reflect eligible contracts and instruments, with an appropriate factor hierarchy for unmatched purchases. Obtain evidence of exclusive attribute ownership and retirement or cancellation where required. Confirm vintage, market boundary and supplier documentation. If

another party retains or sells the attributes, the factory cannot claim them. The two reported totals answer different questions and should be shown independently. GHG Protocol consulted on Scope 2 revisions in 2025–26. Monitor the final standard and customer reporting rules when designing future evidence requirements. GHG Protocol Scope 2 Guidance [2].

Scope 3. Start with the bill of materials and purchasing records. Screen components, bare boards, copper, plastics, solder, packaging and electronics purchased for resale or incorporation. Semiconductor manufacturing and board fabrication can carry significant embedded emissions, though the ranking depends on product mix. For customer-owned components, document ownership, supply arrangements and reporting boundaries with the OEM and avoid omissions or double counting within the inventory. Ask high-impact suppliers for product data that state the boundary, reporting year, production geography, allocation method and energy-attribute treatment. Spend-based factors help prioritise initial outreach. Move priority parts to mass- or unit-based estimates and then verified supplier-specific data where feasible. GHG Protocol calculation guidance [3].

Yield and freight offer two ways to act before the supplier survey is complete. A failed test may waste a valuable board and trigger retesting, replacement purchases or expedited freight. Review defects by product family and fix the recurring causes through stencil, placement, thermal profiling and test process controls. Use purchasing and logistics data to verify whether better yield has reduced replacement demand or airfreight. For parts whose specifications belong to customers, involve the OEM before substituting materials, redesigning packaging or changing suppliers.

Why a conventional operating model gets expensive

A grid-dependent plant with coarse metering can see the total bill while missing the cost of idle heating, excessive air pressure and competing cooling and reheating loads. Buying against the average bill rate also overstates recoverable savings when fixed demand charges survive a renewable contract. Long-tenor procurement can add exposure to volume commitments as shifts or production mix change. A monthly PPA settlement can look attractive just as a weekend surplus, schedule deviation or unclaimed banked volume cuts realised savings.

A transitioning plant can meter its major loads, qualify oven standby, start supplier data collection and source renewable electricity against a measured demand curve. An advanced plant can extend controls to individual lines, contract for electricity that matches its load, electrify selected heat, and improve component data and yield. The advanced plant may have lower energy and emissions intensity, but it also manages more interfaces between Quality, utilities, power settlement and suppliers. These are illustrative operating profiles. For global practice, Jabil's FY25 report discloses both Scope 2 methods and describes the move towards finer-grained monitoring. Its enterprise metrics reflect a different operating footprint and serve as examples of reporting practice. Jabil FY25 reporting [4].

What to upgrade first

Reflow and curing. Test product-family batching and approved automatic standby. The test should capture reheating time, the first acceptable board after restart and energy over a full operating cycle. Keep traceable records of time above liquidus and other

customer-approved profile parameters. Validate loaded and lightly loaded conditions before adopting a new oven setpoint or conveyor speed. An oven that restarts twice as often can erase much of the saving from deeper standby.

Cooling and ventilation. Trend temperature, relative humidity and chiller kW per unit of cooling alongside line occupancy. Establish acceptable limits for product, ESD controls and staff comfort. Try unoccupied setbacks by zone, verify the required capture at extraction points, and test variable-speed control only where airflow and process constraints permit. Larger sites should examine chiller sequencing and condenser performance. Lower cooling demand can also improve the business case for a smaller renewable power contract.

Compressed air and test. Survey leaks during low activity, measure header pressure and point-of-use pressure, and review compressor sequencing. The US Department of Energy reports that leaks can waste 20–30% of compressor output in some systems. Actual electricity savings depend on the plant's measured leakage and how the compressors respond. On test stations, use fixture sleep between jobs and limit burn-in changes to validated product specifications. Meter test energy by product family to find out whether the opportunity lies in idle stations or test schedules. US DOE compressed-air sourcebook [5].

Technology choices for an electronics assembly site

Reflow ovens	Fixed standby settings	Qualified recipe-based standby and batching
Compressed air	Single pressure with persistent leaks	Leak repair, pressure zoning and sequencing
Cooling and exhaust	Fixed-speed and uniform schedules	Validated zoning, resets and variable speed
Hot water	Gas heat wherever installed	Recover heat first; pilot heat pump where viable

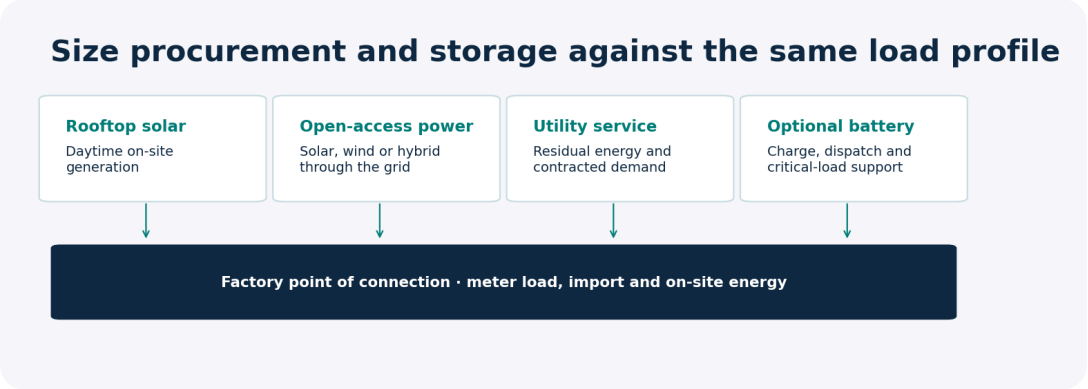
Technology choices depend on manufacturing qualification and measured duty.

Where there is a steady hot-water demand, investigate compressor heat recovery before buying new heat plant. Compare recovered heat availability with the sink’s temperature and operating schedule, including weekends. A heat pump can serve part of the remaining demand when the temperature lift is reasonable. Biomass or biogas may merit screening for substantial sustained thermal loads with secure supply and appropriate controls. The model below assumes a small hot-water load and prioritises recovered heat and a heat pump. Hydrogen adds fuel supply, infrastructure and operating complexity for limited benefit in this particular case.

Buy renewable power against the hours you use it

Collect 12 months of electricity bills and interval data. Start with the consumption after planned efficiency projects and model rooftop generation against that profile. Rooftop solar can be a good fit for daytime assembly if the roof, electrical connection and weekend load support on-site use. Open-access solar can increase daytime

supply where roof area is constrained. Use wind data to test whether a prospective site actually produces during the factory's evening, night or monsoon deficits. Hybrid procurement can reduce residual grid purchases when the two profiles complement each other. Compare eligible, consumed units after losses, surplus settlement and banking limits.



Conceptual integration. Open access uses the grid; battery dispatch and metering depend on site design.

In India, the central Green Energy Open Access framework provides for a 100 kW eligibility threshold through one connection or qualifying aggregation within the same electricity division of a distribution licensee, with a captive exception. Confirm applicable rules, orders and approvals for the consumer and project locations. For example, a Maharashtra buyer on MSEDCL supply should start with the applicable MYT order and subsequent directions, identify its voltage and consumer category, and model its actual billed time-of-day blocks, including any seasonal treatment. Build landed cost from the developer tariff, transmission and wheeling charges and losses, scheduling and deviation exposure, banking, applicable surcharges and duties, and residual utility demand charges. The example below uses hypothetical tariffs for a screening calculation. Central open-access framework [6] · MSEDCL tariff orders [7].

Compare a third-party PPA, own captive generation and group captive procurement on the same interval model. Group captive adds equity, governance and annual compliance. The notified March 2026 amendment to Rule 3 requires at least 26% captive ownership and 51% captive consumption at the applicable collective or identified-unit level, subject to the rule's structure. For an association of persons, track each user's admissible proportionate consumption and the exception for a user holding at least 26% ownership. Follow the applicable verification and declaration procedures. Failure can trigger surcharge liabilities and carrying costs under the rule. Write responsibilities for monthly tracking, outages, volume adjustments, exit and attribute allocation into the contracts. Gazette, G.S.R. 186(E) [8].

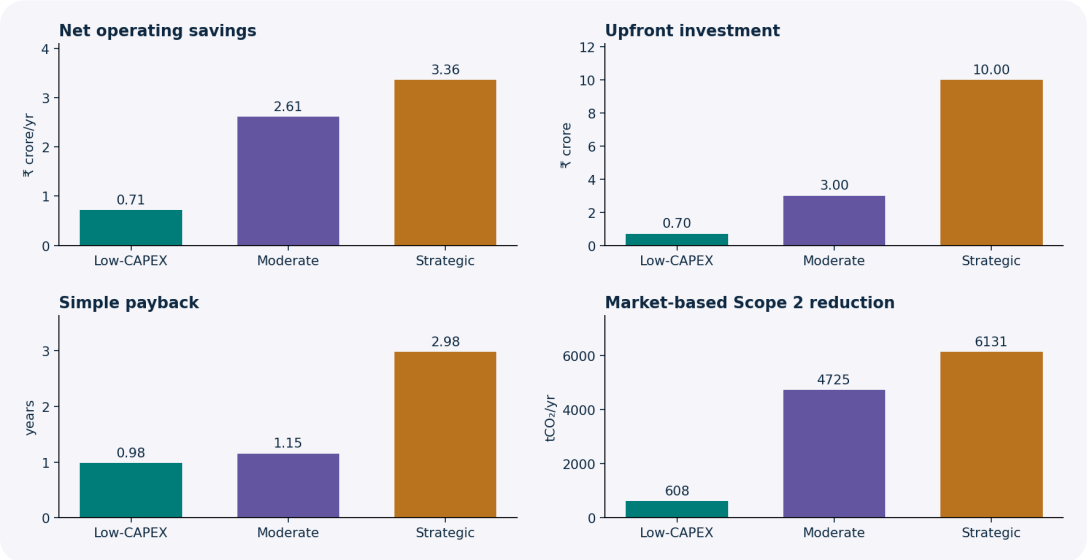
A battery earns its place when the remaining mismatch has a predictable value, such as repeated demand peaks, usable renewable surplus, a tariff spread after round-trip losses, or outage risk on a defined critical load. Test power in MW and energy in MWh separately. A 1 MW/2 MWh system has a nominal two-hour duration at rated output. Actual duty depends on usable capacity, state of charge, degradation and reserve requirements. Verify whether the system can island, which loads can restart, and whether a brief UPS transfer requirement calls for a different solution. For commercial approval, assess degradation, replacement or augmentation, site protections, insurance, and the value of flexibility under the applicable tariff and PPA. Size storage against the residual load after evaluating the best solar-wind mix.

A hypothetical Indian assembly plant with a 12 GWh annual load

The example plant has 2 MW maximum demand, a 68.5% annual load factor, and 3,000 GJ of annual natural gas use for hot water.

Average load is 1.37 MW. Assume production-led daytime demand, a smaller second-shift demand, and overnight utilities and testing. The model uses ₹8.50/kWh avoidable grid energy, ₹5.80/kWh for usable landed renewable energy, and ₹900/GJ for gas. The baseline variable energy cost is ₹10.47 crore a year, before fixed demand charges. The assumptions and detailed calculation method accompany the article.

Start with three cumulative packages. The low-CAPEX package cuts 0.9 GWh from oven standby, air leaks and utility controls. The moderate case cuts 1.5 GWh, recovers heat equivalent to 300 GJ of gas input and adds 5.5 GWh of usable renewable supply. In the strategic case, gross efficiency rises to 1.8 GWh, and a heat pump adds about 142 MWh to displace another 1,800 GJ of gas input. A battery charges with 500 MWh of renewable electricity and delivers 425 MWh. Its 75 MWh losses are included in purchased electricity. The 7.5 GWh of delivered renewable energy includes the battery charging energy once. Demand savings of ₹30 lakh a year are assumed separately and should be validated against billable kVA.



Source: hypothetical 12 GWh model. Market-based figures assume qualifying renewable attributes.

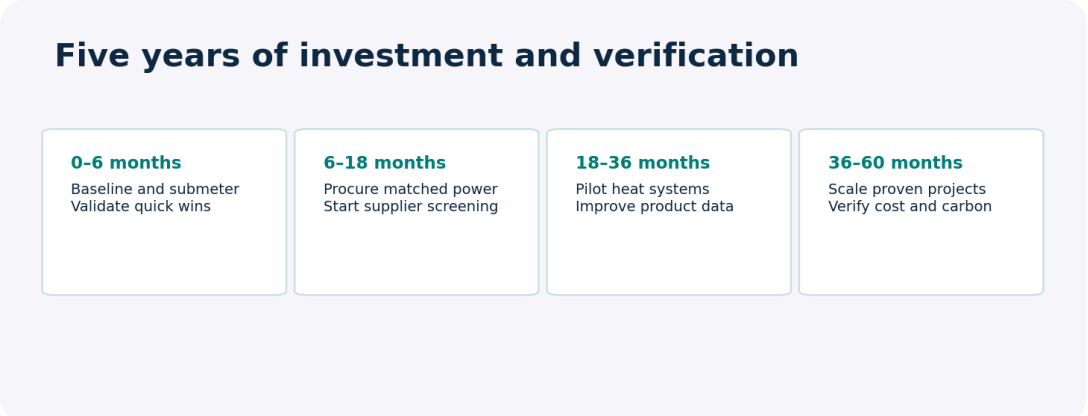
Metric	Baseline	Low-CAPEX	Moderate	Strategic
Purchased electricity (MWh/yr)	12,000	11,100	10,500	10,417
Usable renewable electricity (MWh/yr)	0	0	5,500	7,500
Residual ordinary grid purchase (MWh/yr)	12,000	11,100	5,000	2,917
Natural gas input (GJ/yr)	3,000	3,000	2,700	900
Net annual operating savings (₹ cr)	-0.000	0.715	2.607	3.360
Upfront investment (₹ cr)	0.00	0.70	3.00	10.00
Simple payback (years)	—	0.98	1.15	2.98
10-year NPV (₹ cr)	0.00	3.69	13.02	10.64
IRR (%)	—	102.1	86.7	31.4
Scope 1 reduction (tCO_2/yr)	0	0	17	118
Scope 2 location-based reduction (tCO_2/yr)	0	608	1,013	1,069
Scope 2 market-based reduction (tCO_2/yr)	0	608	4,725	6,131
Levelised market-based abatement cost (₹/tCO_2)	—	-9,894	-4,468	-2,772

In this example, the moderate package has the highest 10-year net present value, while the low-CAPEX package returns its capital

fastest. The strategic package delivers greater modeled reductions in market-based Scope 2 and direct combustion emissions. Its incremental financial return depends on securing more usable renewable electricity, sustaining heat-pump performance and capturing demand savings. One useful next comparison is the strategic package with and without the battery, using the same interval data. If peak savings vanish, the strategic package's annual benefit falls by ₹30 lakh. If renewable landed cost increases by ₹1/kWh, the moderate and strategic cases lose ₹55 lakh and ₹75 lakh a year, respectively.

The location-based calculation applies the grid factor to all grid-delivered electricity including contracted open access. The market-based case assumes qualifying attributes for the renewable volume and uses the grid factor as a screening proxy for unmatched supply. In a formal inventory, follow the factor hierarchy and disclose the use of any proxy. Scope 1 here covers gas combustion. Refrigerants, diesel and other sources need separate activity records before those reductions can be claimed. Scope 3 savings require actual changes in purchasing, freight or waste and remain outside the quantified case. CEA grid factors [9] · GHG Protocol [2].

Five years of implementation



Stages are indicative and depend on engineering and investment approval.

In the first six months, appoint an owner for the electricity and carbon baselines and review them with production every month. Start with idle-load audits, validated standby and air leakage. Between months six and eighteen, procure electricity against the residual load, introduce automated energy monitoring and shortlist suppliers for primary data. In months eighteen to thirty-six, pilot heat recovery and electrification on a stable heat duty and expand supplier and freight work. In months thirty-six to sixty, scale the measures that meet production, finance and carbon requirements. Verify changes using meter data, bills, approved process records and renewable attribute documentation.

Customer requirements and India’s regulatory context

EMS suppliers increasingly need to explain how the carbon footprint of a board or product was calculated. Be ready to show where the power and materials data came from, how emissions were allocated across production, and which attributions were backed by contracts. Check SEBI BRSR and BRSR Core obligations against the company’s listing status, ranking and fiscal year. Listed-company disclosures can also translate into data requests to privately held suppliers. India’s Carbon Credit Trading Scheme compliance mechanism applies through designated obligated entities and notified targets. Confirm coverage for the legal entity and facility before modelling a compliance liability or offset revenue. The EU’s definitive CBAM covers selected goods in specified sectors. Check the product’s Annex I customs code and current rules before assuming that an export is subject to it.

Customer disclosure requirements can apply independently. SEBI [10] · BEE [11] · European Commission [12].

At site level, verify pollution-control consents, waste classification and handling arrangements for solder dross, spent chemicals, scrap boards and electronic rejects. Where the E-Waste (Management) Rules apply, identify each actor's role and obligations, including any producer registration and extended producer responsibility. Keep waste records and recycler documentation. Do not infer electronics assembly consent requirements from semiconductor fabrication or bare-board plating. CPCB e-waste guidance [13].

TOPTIER's perspective on decarbonization and business performance

Use the factory's actual process, production schedule and metered energy footprint as the starting point. Qualify savings with engineers and Quality. Compare renewable portfolios on delivered, usable units and contract downside. Electrify process heat where sufficient operating hours, electricity economics and technical conditions justify it. Screen storage against outstanding peaks and resilience requirements. Pair the purchasing team with the product engineers to improve data and yield for high-impact components. Review performance against signed baselines and track energy cost per good unit alongside carbon.

Three inputs can start that review: twelve months of electricity bills, interval load data, and a list of the lines and utilities that remain on between shifts. Add the product mix and major component purchases when building the carbon baseline. Each dataset answers a different investment question. Together they show where the factory can cut costs now and where it needs a pilot or better evidence.

> The most effective decarbonization strategy is not necessarily the one with the most advanced technology. It is the one that delivers the right combination of energy efficiency, commercial savings, operational reliability, and measurable carbon reduction.

TOPTIER ENERGY SERVICES PVT LTD
Strategic Renewable Energy Procurement | Industrial Energy Optimization | Decarbonization Advisory
www.t-esco.in · +91 9156337278