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How India’s Biscuit Plants Can Cut Energy Costs and Carbon Emissions

A tunnel oven can be burning fuel before the first biscuit reaches the belt. If orders change and the line waits, the factory can spend energy with almost nothing to show for it at dispatch. What would happen to margins if the plant tracked fuel per tonne of saleable biscuits as closely as it tracks flour usage?



Original illustrative rendering of a continuous biscuit-baking line.

The hidden energy story behind a packet of biscuits

Flour, sugar, fats and minor ingredients arrive in bulk or bags. The factory screens and weighs them, mixes them into dough and sends the dough to

a sheeter, rotary moulder, cutter or depositor. The choice depends on the recipe and product. A multi-zone tunnel oven then sets the shape, drives off moisture and develops colour and texture. The product cools before inspection, wrapping, case packing and dispatch. Sandwich varieties add a filling step. Bread, cakes and rusk share some equipment principles, but shorter or double-bake cycles, different moisture targets and shelf-life needs change the energy balance. Dairy and cold-chain loads need a separate assessment.

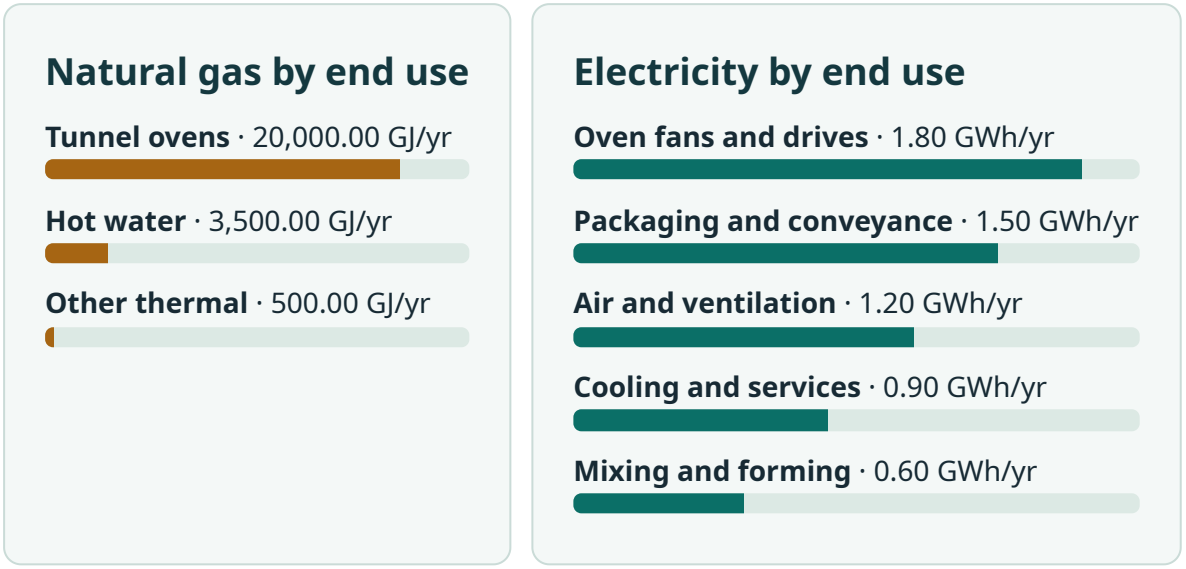


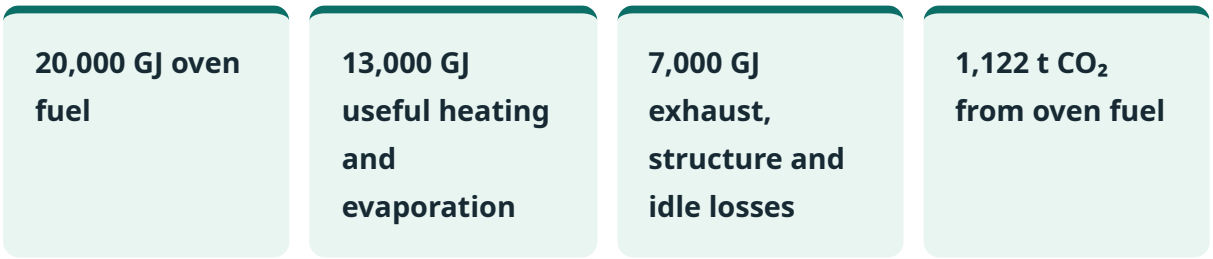
Mixers, drives and packaging lines use electricity. Burners deliver most of the baking heat in a gas-fired line. Air systems, ventilation, water services and sanitation support multiple stages.

Fuel enters the oven to heat product and evaporate water. Energy also leaves in the exhaust, goes into heating the conveyor and oven structure, or escapes from openings and surfaces. Some exhaust is essential for product quality and safe operation. The attainable savings depend on what remains after those requirements are met. A second balance runs alongside it. Electricity drives the belt, fans, mixers, wrappers and utility equipment. Product cooling may be ambient or conditioned according to the product and local climate.

Meter the line in four operating states: warm-up, good production, product changeover and idle. Tie readings to recipe, belt speed, throughput, moisture, scrap and sold tonnes. A monthly plant average can hide an efficient oven that spends too much time warm and empty. Comparing shifts on equivalent recipes can reveal whether apparent improvements come from a better oven setup or a change in the production mix. International studies identify baking as a major bakery end use, though

recipe, capacity utilisation and study boundaries make a single benchmark unreliable. [Food manufacturing energy review]





Hypothetical end-use and oven balances. CO_2 is calculated from all oven fuel and is not an energy output.

The hotspot allocations are assumptions for the hypothetical case. The oven split is a fuel-balance teaching model, with useful heating and evaporation of 13,000 GJ and exhaust, structure, idle and surface losses of 7,000 GJ. An audit must measure both the recoverable share and its temperature.

Where the carbon footprint comes from

Scope 1

Oven and boiler fuel, emergency diesel, leaks from site

Scope 2

Purchased electricity and any purchased steam, heating or

Scope 3

Flour, fats, sugar, packaging, freight, waste and the

refrigeration and other direct sources under the chosen boundary.	cooling. Report location-based results and market-based results where applicable.	remaining value chain, including relevant contract manufacturing.

Scope 1. Start with oven and boiler fuel invoices, meter reconciliation, diesel logs and a refrigerant register. Refrigerant leakage can matter even at plants where chillers account for modest electricity use. Use actual top-up and recovery data and the GWP applicable to the reporting framework. For wastewater, screen methane and nitrous oxide where the treatment process and loading justify it. A direct-fired oven can be a strong efficiency candidate, while a boiler serving sporadic sanitation loads may be better suited to hot-water storage or an appropriately sized heat pump.

Scope 2. The location-based method uses an appropriate grid-average factor for consumption. The market-based method uses eligible contractual instruments and the appropriate factors for unmatched consumption. Verify attributes, eligible geography and vintage, exclusivity and retirement or cancellation where applicable. If renewable attributes are sold away or claimed elsewhere, the buyer's inventory must reflect that. Purchased steam has its own supplier and generation boundary. The contract may change the reported market-based figure even where the factory remains on the same physical grid. GHG Protocol Scope 2 Guidance

Scope 3. Ingredients can dominate a product footprint. Wheat brings fertiliser, farm energy and milling. Fats introduce crop, processing and potentially land-use exposure. Sugar, dairy and cocoa matter where recipes use them. Film and cartons add material conversion and end-of-life emissions. A published biscuit lifecycle study confirms the importance of raw materials while showing variation by product and impact category. Use purchased tonnes and defensible secondary factors to screen suppliers, then seek product-level primary data from high-impact suppliers. Biscuits lifecycle study



Generic illustrative rendering of biscuit flow-wrapping.

Procurement can specify supplier data, traceability and lower-carbon materials. Product and quality teams can reduce broken biscuits, improve yield and test lighter packaging with barrier and shelf-life checks. Suppliers control farming practices, mill electricity and packaging-conversion energy. Hauliers control vehicle choices and driving practices. Buyers can influence both through measurable contract terms. Track packaging grams per kilogram sold alongside breakage and expired returns. A lighter wrapper saves little if it raises product waste.

▼ Screen all 15 Scope 3 categories

Category	Applicability and ownership
1. Purchased goods and services	Likely material. Ingredients, packaging and contract manufacturing as appropriate. Procurement and suppliers.
2. Capital goods	Ovens, buildings and generation assets in acquisition year. Engineering and finance.
3. Fuel and energy-related activities	Upstream fuel and electricity and applicable grid losses outside Scopes 1 and 2. Utilities and suppliers.
4. Upstream transport and distribution	Inbound and company-purchased outbound logistics. Logistics team and carriers.
5. Waste generated in operations	Third-party treatment of food scrap, packaging rejects and waste streams. Operations and contractors.
6. Business travel	Screen travel volumes. Finance and travel providers.
7. Employee commuting	Screen shift travel and staff buses against control boundary. HR and employees.
8. Upstream leased assets	Leased plants and warehouses where outside Scopes 1 and 2. Finance and landlords.
9. Downstream transport and distribution	Distribution and retail activities outside buyer-paid transport, where relevant. Sales and distributors.
10. Processing of sold products	Screen bulk crumbs or intermediate ingredients. Typically limited for finished biscuits. Commercial team.
11. Use of sold products	Ready-to-eat ambient products generally have little direct use energy. Assess relevant chilled or heated lines separately.
12. End-of-life of sold products	Consumer packaging and food waste. Packaging and sustainability teams with waste-system data.

Category	Applicability and ownership
13. Downstream leased assets	Screen owned assets leased to others outside Scopes 1 and 2. Finance.
14. Franchises	Assess franchises where present and outside Scopes 1 and 2. Commercial and finance.
15. Investments	Screen equity interests outside Scopes 1 and 2, including relevant project interests. Finance.

GHG Protocol category guidance

Three operating models and the cost of waiting

Illustrative profile	Cost and carbon exposure	Operating practice and risk
Conventional	Fuel and grid purchases dominate exposure. High energy intensity if idle losses or scrap are recurring.	Monthly utility readings and basic procurement. Changes in volume can hide declining efficiency.
Transitioning	Lower fuel intensity and some renewable coverage. Residual exposure to time-of-day charges and unused renewable generation.	Line meters, heat-recovery projects and initial supplier data. Savings depend on sustained operating discipline.
Advanced	Lower exposure where hourly procurement, efficient line operation and targeted electrification work together.	Verified supplier data, quality-controlled pilots and interval energy monitoring. PPA, technology and execution risks still require ownership.

A manufacturer using 24,000 GJ per year spends ₹24 lakh more annually for every ₹100/GJ rise in delivered fuel price, before changing production. A ₹1/kWh increase on six million units adds ₹60 lakh if every unit is affected. Actual cash exposure depends on tariff components, negotiated terms and the ability to pass cost increases through without losing volume. There is also a bid risk. Customers can ask suppliers for product footprints and supplier data before government reporting applies to those suppliers. Building a defensible baseline after a tender arrives leaves little time to validate ingredient factors or reconcile contract manufacturing.

Which technology changes earn their place?

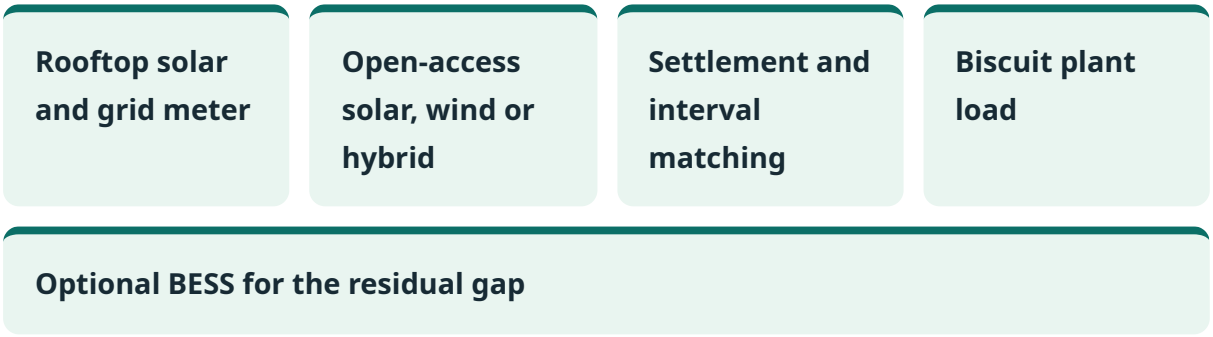
Start with burner tuning, insulation inspection, line scheduling and utility controls. The ovens must keep delivering the intended colour, moisture, texture and microbiological outcome. Revalidate the affected recipes and process controls after any change to zone setpoints, airflow, belt speed or heat recovery. Check breakage and quality rejects as well as the fuel meter. The product specification defines the operating envelope for the energy project.

Conventional equipment	Practical alternative	Engineering and commercial test
Gas tunnel oven with uncontrolled idle time	Metered zones, sequencing, tuned excess air and insulation repairs	Site study and burner specialist. Confirm combustion and product results across recipes.
Hot oven exhaust discharged outdoors	Indirect heat recovery for air or hot water	Match heat source and off-taker hours. Address condensate, fouling, pressure drop and hygiene. Include fan energy and cleaning.
Boiler or gas heater supplying low-temperature water	Heat pump with buffer storage	Validate heat source, temperature lift, seasonal COP, cleaning-water schedule and backup. Include electrical capacity.
High-temperature fossil heating	Electric oven zone or replacement line, subject to a pilot	Assess heating profile, product quality, network capacity and delivered electricity. A resistance boiler may cost more to operate.
Fixed-speed fans, pumps and oversized compressors	Speed control where duty varies, leak repair and compressor sequencing	Use measured pressure, air flow and loading. Protect cooling duty and food-grade air requirements.
Fossil boiler at site with viable local feedstock	Biogas or qualified biomass system	Assess year-round fuel, storage, local air permits, particulate controls and ash. Report biogenic CO_2 separately where required and account for other GHGs.

Low-temperature heat is the clearest opening for a heat pump. A tunnel oven's high-temperature, multi-zone recipe is a different problem. Thermal storage may help shift hot-water production or improve heat recovery

utilisation. Green hydrogen would require an economic supply case, safe plant integration and a suitably validated burner and process. That makes it a low priority for the representative plant while efficiency and lower-temperature alternatives remain available.

Build the renewable power portfolio around the load curve



Pull twelve months of interval data at the utility settlement interval and reconcile totals to bills. Overlay planned production, weekly shutdowns, cooling demand and expansion. Model rooftop solar against daytime on-site load and roof constraints. Add open-access solar and wind profiles from actual candidate sites, then compare contracted solar, wind and hybrid portfolios. Wind can add generation when solar is low, depending on site and season. An evening production shift needs evidence from historical wind traces and developer guarantees.

Convert each offer into rupees per unit actually utilised. Include wheeling and transmission charges and losses, banking and lapse, scheduling and deviation costs, applicable surcharges, fixed charges, standby, PPA take-or-pay and any annual escalation. Compare with the marginal bill cost avoided in each time-of-day block. Demand charges may persist even when grid energy declines. For Maharashtra, begin with the applicable MSEDCL HT industrial category and the operative MERC tariff schedule for the billing period, then reconcile the time-of-day meter registers, power purchase

adjustment and demand terms to a real bill. The ₹8.50/kWh used below is a scenario assumption. MSEDCL tariff orders and schedules

Third-party open access and captive models allocate risk differently. In a group captive structure, model ownership, capital tied up, credit risk, drawal, compliance and liability across users. The central green open-access framework uses a 100 kW threshold for eligible non-captive consumers, subject to the amended aggregation provisions and applicable implementation. Captive consumers have no central minimum load threshold under those rules. The 2026 captive amendment retains minimum 26% captive ownership and 51% annual captive consumption, with specific rules for associations of persons and identified generating units. Test user allocations and applicable verification before committing to a PPA. Green open-access rules · 2026 captive amendment

Battery value comes from the gap that remains after a sensible generation mix. If a battery delivers 1 MWh at 85% AC round-trip efficiency, it needs about 1.18 MWh of charging. Charging at ₹5/kWh costs about ₹5,880 per MWh delivered. Displacing power at ₹9/kWh leaves about ₹3,120/MWh before degradation, maintenance, financing and demand effects. Model avoided production losses separately if a suitable battery can support critical processes during an outage. Confirm islanding design, power rating, duration, reserve state of charge, usable end-of-life capacity and permissions. A battery that trims peaks may need a different dispatch plan from one that backs up the line.

A hypothetical plant and three investment choices

Consider an Indian biscuit plant producing 20,000 tonnes of saleable product a year. It uses 24,000 GJ of natural gas and 6 GWh of electricity, equivalent to 2.28 MJ/kg of combined purchased final energy. Peak demand is assumed at 1.25 MW and annual load factor is about 55%. Over 330 operating days, a stylised daily profile of sixteen hours at 0.9 MW and eight

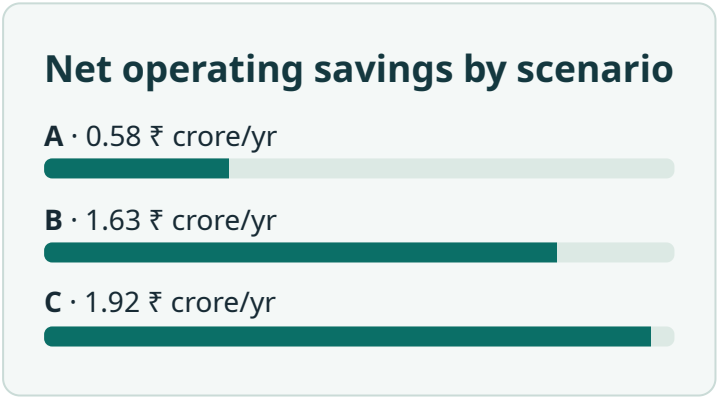
at 0.47 MW approximates the annual power total. Shutdown load and short peaks are netted in this rounded illustration. Actual renewable utilisation requires a block-by-block simulation.

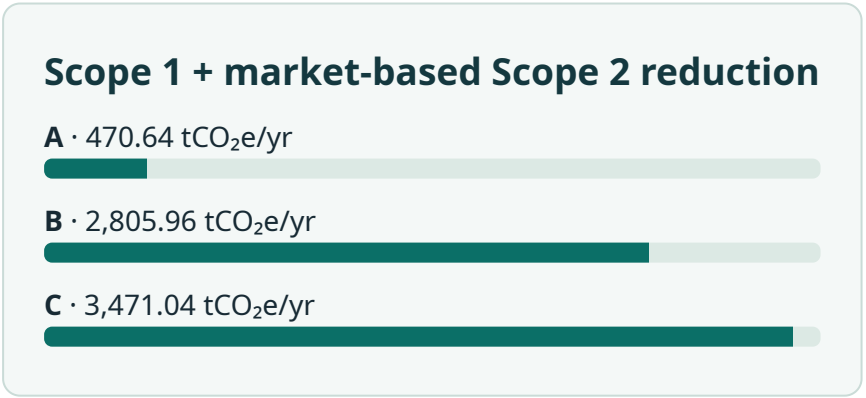
The plant pays ₹900/GJ of gas and avoids ₹8.50/kWh of variable grid purchases. The hybrid PPA costs an assumed ₹5.80 per utilised kWh, inclusive of delivery and settlement allowances under the scenario. Grid demand and other fixed charges are held constant. Natural gas uses the IPCC default 56.1 kg CO_2/GJ on a net calorific basis. Electricity uses a rounded illustrative 0.70 kg CO_2e/kWh for grid purchases and unmatched market-based power. Replace these with relevant inventory factors and accounting rules. The model uses zero for eligible renewable generation at point of generation and excludes lifecycle emissions, refrigerants and minor combustion gases. IPCC stationary combustion · CEA electricity factor database

Scenario A reduces idle fuel use and improves compressor and fan controls. Scenario B adds heat recovery and a hybrid PPA. Scenario C includes deeper efficiency, a heat pump for low-temperature service and higher use of contracted renewable power. In C, 3,000 GJ of the 6,000 GJ gas reduction comes from replacing low-temperature gas heating. At 80% reference heater efficiency it delivers 2,400 GJ of useful heat. A heat pump at COP 3 uses approximately 222 MWh per year to deliver that heat. The remaining 3,000 GJ is fuel efficiency. All cases are standalone comparisons with the same baseline.

Metric	Baseline	A · Efficiency	B · Heat recovery + hybrid	C · Deeper efficiency + heat pump
Gas, GJ/yr	24,000	21,600	20,400	18,000
Total plant electricity, GWh/yr	6.00	5.52	5.28	5.32
Utilised hybrid power, GWh/yr	0.00	0.00	3.00	3.80
Residual grid purchases, GWh/yr	6.00	5.52	2.28	1.52
Gross annual energy-cost savings, ₹ crore	0.00	0.62	1.75	2.14
Added annual O&M, ₹ crore	0.00	0.04	0.12	0.22
Net annual savings, ₹ crore	0.00	0.58	1.63	1.92
Plant CAPEX, ₹ crore	0.00	0.85	3.20	7.50
Simple payback, years	—	1.46	1.97	3.90
Ten-year NPV, ₹ crore	—	2.74	6.79	4.31
Ten-year IRR	—	68%	50%	22%
Scope 1 reduction, t CO_2/yr	—	135	202	337
Scope 2 reduction, location-based,	—	336	504	474

Metric	Baseline	A · Efficiency	B · Heat recovery + hybrid	C · Deeper efficiency + heat pump
tCO_2e/yr				
Scope 2 reduction, market-based, tCO_2e/yr	—	336	2,604	3,134
Scope 1 and market-based Scope 2 reduction, tCO_2e/yr	—	471	2,806	3,471
Abatement cost, ₹/tCO_2e	—	-9,469	-3,939	-2,021





Both charts use the hypothetical plant model. CAPEX, payback and the location-based comparison appear in the table.

The grid electricity line in the bill falls from 6 GWh to about 2.28 GWh in B and 1.52 GWh in C. Total electricity use in C is about 5.32 GWh after adding heat-pump consumption. The interval pilot should confirm the assumed extra renewable utilisation against the revised load shape and hours available for heat-pump operation. The model treats the open-access electricity as using the same grid region for location-based purposes. Moving to the PPA therefore delivers no separate location-based reduction in this example. Carbon reductions for Scope 1 plus location-based Scope 2 are about 471, 706 and 811 tCO_2e in A, B and C respectively. The table separately shows market-based reductions under the stated attribute assumptions.

Simple payback uses upfront plant CAPEX divided by annual net operating savings. NPV uses ten years of constant net savings and a 10% discount rate. IRR uses the same cash flows. Levelised abatement cost uses annualised CAPEX at 10% over ten years, less net annual savings, divided by annual Scope 1 plus market-based Scope 2 abatement. Negative values indicate cost savings in the model. Project lives vary by equipment. Assumptions exclude taxes, escalation, financing payments, depreciation, subsidies, captive equity and residual value. Scenario B and C assume a third-party PPA. Budget separately for captive investment if that model is selected.

For a manufacturer with assumed annual revenue of ₹100 crore, net savings would add approximately 0.58, 1.63 or 1.92 percentage points to EBITDA margin at fixed volume and price. If B’s renewable landed cost rises by ₹1/kWh, its annual net savings fall by ₹30 lakh and simple payback rises from about 2.0 to 2.4 years. If a C supplier promises a COP of 3 but the system delivers 2.3, annual heat-pump use rises by about 68 MWh. At ₹8.50/kWh, that costs about ₹5.7 lakh a year, before changes in demand or renewable allocation. A short monitored trial is worth more than a brochure efficiency number.

At the same discount rate, C's extra plant CAPEX over B is ₹4.3 crore and its annual incremental net savings are about ₹29 lakh. That increment has a negative ten-year NPV of about ₹2.54 crore. A plant might still pilot the heat pump if it needs to replace ageing equipment, can access cheaper electricity, or places a measurable value on fuel resilience. B is the strongest NPV option under the stated assumptions. A requires the smallest cheque and gives the fastest payback.

Five years of decisions and who owns them

Timing	Priority action and owner	KPI and gate
0–6 months	High priority · Utilities and operations meter ovens and compressed air, tune controls and track idle loads.	GJ and kWh per saleable tonne by recipe. Gate on baseline quality and food-safety sign-off.
6–18 months	High priority · Procurement and finance run a profile-based power tender. Engineering tests heat recovery and efficiency.	₹ per utilised kWh, lapse, load coverage and recovered GJ. Gate on verified settlement and approved heat sink.
18–36 months	Medium priority · Engineering and quality pilot hot-water electrification. Procurement obtains ingredient and packaging footprints.	Seasonal COP, useful heat and verified supplier coverage. Gate on connection capacity, hygiene and procurement evidence.
36–60 months	Conditional priority · Leadership scales proven projects and evaluates storage and oven replacements.	Measured savings, hours of peak draw reduction, quality yield and emissions by scope. Gate on an incremental investment case.

What will change the investment case?

Electricity procurement is increasingly a time-of-use decision. A low daytime rate can reward a hot-water buffer that shifts heating into solar hours. Rising evening import costs can raise the value of reliable wind generation or targeted storage. The state and the billed category matter. Before approval, confirm how interval scheduling, banking and captive verification treat the project, and whether the factory's current tariff and practices match the model.

India's Carbon Credit Trading Scheme compliance mechanism applies through notified obligated entities and targets. A biscuit plant should verify coverage by entity and notification before budgeting any compliance cost or credit revenue. Also check whether it is a designated consumer under applicable energy-conservation requirements and whether renewable consumption obligations apply. BRSR and BRSR Core are listed-entity frameworks with phased applicability. SEBI's 2025 circular allows assessment or assurance and makes the specified value-chain disclosures voluntary from FY 2025–26. Customer questionnaires can still be mandatory under commercial contracts. The EU definitive CBAM currently covers selected goods in specified sectors. Finished biscuits fall outside those sectors, while packaging inputs and customer reporting should be reviewed on their own facts. State pollution-control consent, fuel or stack approvals, water permissions and effluent discharge requirements depend on site and activity. BEE carbon market · Renewable consumption obligation · SEBI circular · EU CBAM sectors

TOPTIER's Perspective

Decarbonization should improve business performance and stand up to verification.

Require three pieces of evidence before approving the next energy investment. Ask production for measured fuel and electricity per accepted tonne. Ask procurement for the delivered renewable cost and utilisation by

settlement block. Ask engineering for a quality-controlled trial and a savings verification plan. Include supplier data for the ingredients and packaging that dominate the product footprint. Leadership can then see which actions lower recurring costs, which improve resilience and which depend on future power prices or technology performance.

Begin with a representative month of line and bill data, then build a full-year load and generation model before signing a PPA. Give the savings a named owner and report them against a production-adjusted baseline. The most persuasive result is a factory that can show what it changed, how much it saved and how reliably it continues to produce.

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

“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.”