How India’s Flexible Packaging Film Plants Can Cut Energy Costs and Carbon Emissions

TOPTIER Industry Decarbonization Special Edition · BOPP, BOPET and CPP films



Original generated illustration of a flexible film line.

A film plant can make a thinner roll and still spend more energy per saleable tonne. That can happen when an extrusion line runs below its efficient throughput, a stretching oven stays hot through interruptions, or extra web breaks send more material back through the extruder. The film gets thinner. The utility bill stays stubbornly full-size.

For a CFO, the question is how much electricity, heat and resin the plant buys for each tonne it can actually invoice. For a plant head, it is how to lower that cost while protecting seal strength, film gauge, clarity, barrier performance and customer approvals. Both

questions start with the same operating data. The answer may be a better production campaign, more useful heat recovery or a better-matched electricity contract. Each solves a different part of the cost problem.

Where the energy goes between pellet and roll

BOPP is biaxially oriented polypropylene. BOPET is biaxially oriented polyester. A typical sequential line melts and filters resin, casts it onto a chill roll, stretches the web lengthwise over heated rolls, then stretches it across its width in a tenter oven. Temperature and tension are controlled through orientation and subsequent stabilization. The line then cools, treats and winds the film. Slitters convert mother rolls into widths specified by customers. In a CPP line, the web is cast and cooled without the biaxial stretching stages. A plant making both products needs separate intensity baselines.

From resin to finished film

01 · Prepare
PP or PET resin, masterbatch and permitted regrind → dose and dry PET where required.

02 · Extrude and cast
Extruder and melt filter → flat die and chill roll. Inputs include power, heat and cooling.

03 · Orient or bypass
BOPP/BOPET → lengthwise rollers → tenter oven →

04 · Finish and dispatch
Cool, treat and wind → slit. Optional metallization or

thermal stabilization. CPP → skip orientation.	coating → inspect, pack and dispatch.

Generic process sequence. Coating and metallization may also operate as separate finishing lines.

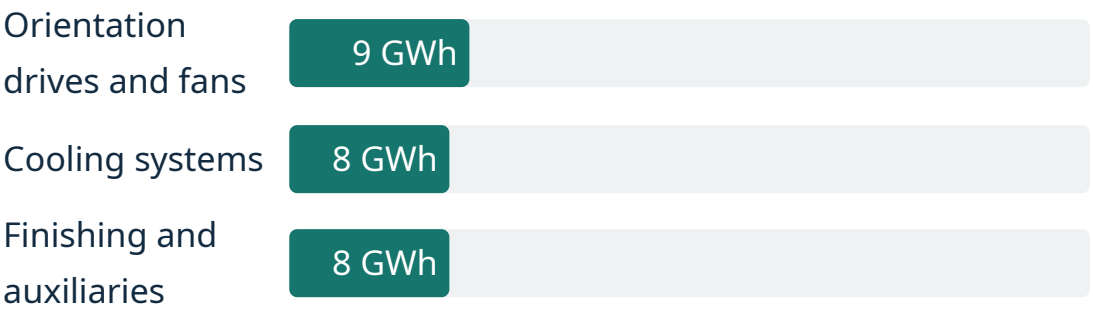
Polypropylene and polyester grades consume utilities differently. PET commonly requires controlled drying before extrusion because moisture can degrade the polymer during processing. Extrusion needs shaft power and controlled heat. A tenter oven needs both thermal input and fan power, and a high recirculation rate carries its own electrical cost. Cooling-water pumps and chillers serve the casting and other cooling circuits. Depending on the finishing route, treatment stations, vacuum metallizers or coating dryers add separate loads. Some sites also run air washers, compressors and effluent treatment. Verify the equipment boundary before combining data.

Measure kWh and fuel GJ per saleable tonne by line and grade family. Record tonnes per hour, scrap, startup duration and uptime alongside energy. Standardize how internal regrind is counted. When a film break reduces accepted output, the site may use less energy in total while its unit cost rises. A rolling daily dashboard should reconcile good tonnes, resin feed, trim returned, reject tonnes and electrical and thermal readings. Line speed alone cannot tell the full story.

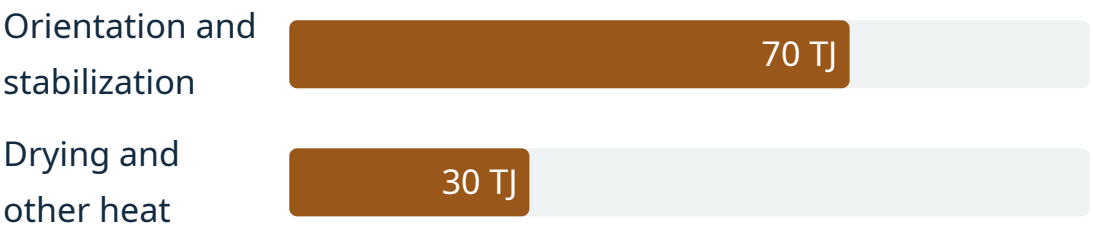
Illustrative energy hotspots

Electricity allocated by equipment group





Natural gas input allocated by duty



Inputs
40 GWh purchased power and 100 TJ gas.

Useful duties
Melting, orientation, drying, cooling and finishing.

Loss paths
Exhaust, shell losses, rejection heat, standby and reprocessing. Meter before allocating losses.

Baseline CO_2
Purchased grid power 28,400 t and gas combustion 5,610 t.

Hypothetical engineering allocation, not measured line data. Bar lengths show each share of the respective energy carrier. Useful heat and losses require field measurements.

Separate energy used under normal production from standby and startup. Meter the extrusion drive and auxiliaries, the oven heater and fan bank, and the chill-water plant. Check compressed air and finishing as second-tier loads. Use temperature, airflow and production data to distinguish real oven loss from required exhaust,

drying or process control. Cooling heat rejected to air or water may be recoverable only if a nearby process needs it at the right temperature and time. The hotspot chart is a hypothetical metering example. Film stretching equipment and engineering examples

Who controls the carbon footprint?

Emissions across the film value chain

Scope 3 · Upstream
Resin and additives, capital goods, upstream energy, inbound transport.

Scope 1 · At the factory
Fuel burn, backup diesel and refrigerant leaks, where present.

Scope 2 · Energy purchased
Electricity, steam, heat and cooling purchased from others.

Scope 3 · Downstream
Customer conversion, outbound logistics as applicable, and disposal or recycling.

Ownership or control and purchasing arrangements determine the inventory boundary. Source basis is GHG Protocol.

Scope 1 covers direct emissions. On-site gas combustion for process heat and diesel for backup contribute where these fuels are used. Screen refrigerant leakage from controlled chillers, owned vehicles, captive fossil generation and wastewater emissions where the treatment process can generate methane or nitrous oxide. Converting bought polymer into film by melting and stretching provides no basis to assume a large intrinsic chemical greenhouse-gas source. Coating VOCs may be material for local air compliance,

and any oxidizer fuel or relevant oxidation emissions should be assessed on their own evidence. Audit fuel meters, refrigerant charge and top-up logs, and actual wastewater treatment routes.

Scope 2 covers purchased energy. Purchased electricity typically serves drives, coolers and auxiliary systems. Purchased steam, heat or cooling also belongs in Scope 2 where applicable. Location-based reporting reflects the average emissions of the grid serving purchased electricity. Market-based reporting reflects qualifying contracts and their energy attributes where the guidance calls for dual reporting. Verify ownership, exclusivity, vintage and market boundaries, retire certificates where required, and retain meter and settlement evidence. Use the applicable factor hierarchy for uncovered purchases. The same renewable attribute can support only one claim. GHG Protocol standards and guidance

Scope 3 follows the material. Upstream polymer production, masterbatch and other purchased goods are likely priorities. Downstream converting and disposal can also matter. Procurement teams can improve purchasing specifications, resin yield and supplier data. Converters, brand owners and waste operators must collaborate on package design, performance and end-of-life outcomes. Screen every category before declaring a hotspot or setting targets. Scope 3 category methods

#	GHG Protocol category	Film plant screening and owner
1	Purchased goods and services	Likely material. Procurement controls resin, additives, consumables and packaging specifications; suppliers provide grade-level data.

2	Capital goods	Check line build and replacement years. Engineering requests equipment and construction inventories.
3	Fuel- and energy-related activities	Check upstream fuel and purchased electricity emissions and grid losses outside Scopes 1 and 2. Energy team reconciles purchased quantities.
4	Upstream transport and distribution	Likely relevant. Include inbound and purchased outbound freight as applicable. Logistics seeks load and route records.
5	Waste generated in operations	Likely relevant. Reconcile discarded trim, sludge and outsourced treatment. EHS validates manifests.
6	Business travel	Screen site and customer travel through expense records.
7	Employee commuting	Screen commuting, company shuttles and contractor boundaries as applicable.
8	Upstream leased assets	Check rented warehouses or utilities outside Scopes 1 and 2.
9	Downstream transport and distribution	Assess customer-paid transport as applicable; avoid duplication with category 4.
10	Processing of sold products	Likely relevant for intermediate film converted into packaging. Engage converters for printing, lamination and sealing data.
11	Use of sold products	Screen direct use-phase emissions. Passive film typically has limited direct energy use. Justify boundary and treatment of any indirect use.

12	End-of-life treatment of sold products	Likely relevant. Brand owners and recyclers help determine disposal pathways; scenario-test geographic variation.
13	Downstream leased assets	Conditional on owned assets leased to others outside Scopes 1 and 2.
14	Franchises	Conditional on operating a franchise model.
15	Investments	Check ownership structures and investments outside the organizational boundary.

Begin with supplier-specific cradle-to-gate resin data that uses comparable geography, technology, recycling allocation and system boundaries. Keep emission factors attached to individual grades. Ask for underlying evidence and identify when data describe production at another site or region. For portfolio decisions, compare a functionally equivalent package, such as the film needed to protect a specified quantity of product for a given shelf life. Downgauging that increases seals failing or food being discarded can undermine the intended benefit. Recycled content trials require grade, migration and food-contact checks as applicable, plus quality and customer sign-off. Polymer life-cycle inventory reference

Three ways film plants manage the same exposure

Illustrative profile	Energy and carbon maturity	Commercial exposure
Conventional	Mostly grid power and fossil heat, site-level	Greater exposure to tariff and fuel movements. Difficult to isolate yield losses or

	meters, limited supplier data.	substantiate grade-level carbon claims.
Transitioning	Partial renewable procurement, line metering, targeted oven recovery and early supplier engagement.	Lower avoidable energy costs with contract, balancing and retrofit performance risks to manage.
Advanced	Meter-verified controls, matched clean power, qualified heat electrification and resin inventory by supplier and grade.	More stable exposure where contracts perform. Greater execution and data governance demands. Better evidence for customer tenders.

The difference shows up when a large customer asks for a product carbon figure or when the utility changes the cost of an evening unit. The conventional site may have a site electricity total and little else. A transitioning site can separate grade mix and operating hours from an equipment saving. An advanced site can explain which plant and resin supplier produced a specific grade, what attributes it owns and how it verified the outcome. These are maturity profiles. A company disclosure with limited detail cannot establish how its plant performs.

Improve the line before committing to new supply

Start with losses the operations team can repeat and verify. Check chill-water setpoints against actual quality limits. Sequence pumps or chillers against useful load. Look for compressed-air leaks or inappropriate use of compressed air for duties that a blower can handle. Verify drive speed control on variable-load equipment. For

heat, check oven seals and insulation, and examine standby setpoints and ventilation schedules. Adjust oven flow or exhaust only within process and safety limits, especially where solvent is present. Confirm results against matched operating conditions.

Conventional equipment and practical upgrades

Existing system	Alternative	Indicative impact	Maturity, CAPEX class and gate
Chillers, pumps, blowers, drives	Setpoint tuning, sequencing, variable-speed drives and efficient motors	2 GWh alongside line controls in low case	Commercial · low to moderate · audit duty and maintain quality
Tenter standby and exhaust	Controls, insulation and exhaust-to-makeup-air recovery	5 TJ low case; 20 TJ combined moderate case	Commercial · moderate · measure fouling, pressure drop and safety limits
Grid-only power	Meter-matched hybrid procurement	16 GWh useful in moderate case	Commercial · low plant CAPEX under PPA · test settlement and charges
Fossil heat on compatible duty	Industrial heat pump with backup	35 TJ fuel displaced and 3.11 GWh added in strategic case	Commercial on suitable sinks · high · confirm COP at required lift

Separate trim pelletizing or disposal	Qualified direct flake dosing or regranulation	Yield and Scope 3 impact unquantified	Commercial · moderate · test gels, traceability and customer requirements
Diesel standby where installed	Critical-load storage or hybrid backup	Site-specific; zero in model	Commercial · high · confirm transfer time, duration and avoided downtime
Purchased diesel freight	Route consolidation and mode or fleet trials	Site-specific; zero in model	Commercial · low to moderate · coordinate suppliers and service levels

Savings are hypothetical where quantified. Standalone equipment quotes are needed to separate cost and performance.

A heat exchanger on a suitable oven exhaust stream can preheat clean makeup air or feed another compatible sink. Assess contamination, dewpoint, fouling, fan power, bypass controls, maintenance access and minimum run hours. A vendor case describes roughly 1.6 GWh/year of savings from one stretching oven air and heat-recovery example. It is evidence of an engineering pathway. Its savings depend on the starting installation and alternative heat uses. For clean trim, direct flake dosing or controlled regranulation can reduce material loss or avoid a processing pass if optical properties, gels, contamination and traceability remain within specification. OEM oven case · Material recirculation case

Map heat by temperature before choosing the replacement. A heat pump can serve a compatible low-temperature sink if waste heat is

stable and useful output temperature is achievable at a defensible coefficient of performance. It may preheat a stream ahead of a higher-temperature stage. Run electric resistance or electric boiler numbers separately. With gas at ₹900/GJ input and 80% conversion, useful heat costs about ₹4.05/kWh thermal before auxiliary costs. Electricity at ₹8.50/kWh needs a heat-pump COP above about 2.10 for energy-cost parity at those prices. On grid electricity at 0.710 tCO_2/MWh, matching the gas combustion intensity would require roughly COP 2.81 for location-based electricity CO_2 parity. Both screens change with actual marginal prices, factors and equipment performance.

Keep backup heat for critical zones until a pilot demonstrates reliability through product changes and seasonal conditions. Test thermal storage where heat can be shifted, and verify utility transformer and feeder headroom before installing large electric systems. Screen biomass or biogas against fuel logistics, air permits, sustainable supply and lifecycle accounting. Leave hydrogen for a clearly defined heat duty with a credible fuel contract, safety case and comparative economics.

Buy renewable power that the plant can use

Electricity delivery and settlement

Behind the meter
Rooftop solar → film plant; self-consumption follows operating load.

Across the grid
Open-access solar, wind or hybrid → losses, schedule and settlement → film plant.

Residual supply
Distribution grid → unmatched and contracted standby demand.

Optional storage
Charge from eligible supply → discharge into viable residual peaks or backup duty.

Schematic commercial and electrical flows. Wind and solar matching depends on interval generation and state settlement rules.

Start with at least 12 months of interval data and separate current operation from planned production growth. Model site load after confirmed efficiency upgrades, with shutdowns, grade changes and on-site generation. Rooftop solar offsets daytime purchases where roof, dispatch and interconnection allow. Remote solar can scale daytime supply. Wind may improve evening or seasonal coverage, depending on the actual location and generation series. A hybrid contract earns its place when it yields more useful settled units or better risk-adjusted economics than either stand-alone option.

Compare offers at the meter. For each billing interval, reconcile load, losses, eligible generation, banking withdrawals, surplus and grid imports. Check banking credit and expiry, curtailment, scheduling and deviation exposure. Compare charges, losses, take-or-pay, minimum draws, balancing costs and billing demand. Price risk transfers explicitly in the PPA. An attractive headline tariff can still leave substantial evening exposure, and a high annual supply percentage can hide surplus that never offsets a bill.

Green open access may be structured with third-party procurement, captive ownership or group captive participation. Central rules provide a 100 kW eligibility route for qualifying sanctioned load or contract demand and allow aggregation within the same electricity division under the amended framework.

Captive consumers have no such minimum under the central provision. Rule 3, amended in March 2026, retains plant-level tests of at least 26% ownership and 51% annual captive consumption and changes verification and treatment of certain group arrangements. Project structure, ownership evidence, consumption allocation and the verification agency matter. Test each project against applicable state orders, utility procedures, charges and customer-specific terms. In Maharashtra, use the effective tariff order for the actual connection and voltage, then apply the relevant ToD windows and open-access settlement provisions. Central green open-access framework · Captive rule amendment · MSEDCL tariff orders · Distribution open access

Size BESS against the residual gap after optimizing procurement. Calculate avoided charges from the actual billed peak and demand ratchet, then model tariff spreads net of round-trip losses, usable capacity and degradation. Value backup from avoided production losses for specific critical loads. Verify that the power conversion system and operating scheme can support islanding or ride-through if those services drive the investment. Include augmentation, fire protection and any applicable storage conditions in the project economics. The example below carries zero battery value until the interval analysis establishes a use case.

What could the numbers look like?

Consider a hypothetical Indian film plant making 50,000 saleable tonnes a year. It uses 40 GWh of purchased electricity and 100,000 GJ of natural gas input. An 8 MW maximum demand implies a 57% annual load factor at that consumption. For screening, assume 5.5 MW average weekday daytime demand and 4 MW outside that window as indicative levels with outages and weekends shaping the

annual total. These snapshots cannot validate matched renewable delivery. The example assumes ₹8.50/kWh avoidable grid energy, ₹5.50/kWh per useful qualifying renewable unit and ₹900/GJ for gas. Model electricity and fuel spend is ₹43 crore before fixed and demand charges.

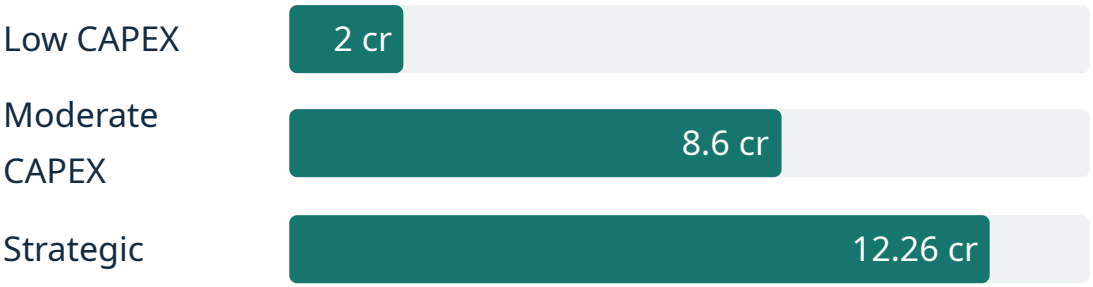
The low-capex case cuts auxiliary and line electricity by 2 GWh and eases heat loss by 5,000 GJ. The moderate case combines 3 GWh of efficiency, 20,000 GJ of gas savings and 16 GWh of useful qualifying off-site renewable supply. In the strategic case, electricity efficiency reaches 4 GWh and gas efficiency reaches 25,000 GJ. A heat pump displaces a further 35,000 GJ of gas input at 80% incumbent conversion and COP 2.5, adding 3.11 GWh of electricity. Of 24 GWh of useful renewable electricity, 4 GWh is assumed self-consumed behind the meter with attributes retained and 20 GWh is qualifying off-site supply. The ₹5.50 blended cost includes the assumed cost of that renewable service, with related asset investment excluded from plant CAPEX. The cases are alternatives against the same baseline. The ₹4 crore, ₹18 crore and ₹44 crore budget allowances are hypothetical bundles of progressively larger works. Bidder scope, shutdown costs and utility upgrades can move those allowances materially.

Three investment paths against one conventional baseline

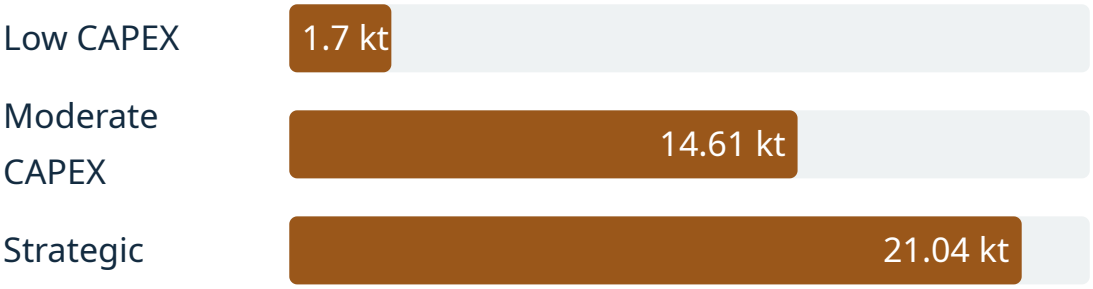
Metric	Conventional	Low CAPEX	Moderate CAPEX	Strategic
Electricity end use · GWh	40.00	38.00	37.00	39.11
Gas input · GJ	100,000	95,000	80,000	40,000

Useful renewable supply · GWh	0	0	16	24
Residual conventional purchases · GWh	40.00	38.00	21.00	15.11
Plant CAPEX · ₹ crore	—	4	18	44
Incremental annual O&M · ₹ crore	—	0.15	0.55	1.10
Net annual operating savings · ₹ crore	—	2.00	8.60	12.26
Simple payback · years	—	2.00	2.09	3.59
10-year NPV at 10% · ₹ crore	—	8.29	34.84	31.31
10-year project IRR	—	49.1%	46.7%	24.8%
Scope 1 reduction · tCO_2/year	—	280	1,122	3,366
Scope 2 location-based reduction · tCO_2/year	—	1,420	2,130	3,471
Scope 2 market-based reduction · tCO_2/year	—	1,420	13,490	17,671
Annualized cost · ₹/t market-based CO_2 reduction	—	-7,933	-3,881	-2,422

Net operating savings · ₹ crore/year



Modeled Scope 1 + market-based Scope 2 reductions · $ktCO_2$/year



Illustrative, rounded. Ten flat year-end cash flows, year-zero CAPEX, no tax, escalation, financing, salvage or working capital. Abatement cost uses annualized CAPEX less net operating savings; negative values indicate modeled net savings. Inventory decreases are not estimates of physical grid emissions avoided.

For the example reporting year FY 2024–25, the screening grid factor is 0.710 tCO_2/MWh and direct gas combustion uses 0.0561 tCO_2/GJ on a net calorific basis. Baseline modeled energy CO_2 is 5,610 t Scope 1 plus 28,400 t Scope 2. Off-site supply affects market-based results subject to contractual quality and residual factor rules. This example assumes zero generation CO_2 for qualifying renewables and uses the grid average as a proxy for uncovered market-based electricity. Location-based figures apply to purchased electricity and reflect the 4 GWh of on-site self-consumption in the strategic case. Scope 3 changes are unquantified and outside the modeled totals. Diesel, refrigerants and non-CO_2 combustion gases are outside this screening calculation. The CEA also reports 0.675

tCO_2/MWh for FY 2025–26. Use the applicable vintage in a real inventory. CEA reported annual factors CEA Indian power sector database · IPCC stationary combustion factors

For every case, multiply the avoided conventional grid purchases by ₹8.50/kWh, subtract the cost of useful renewables at ₹5.50/kWh, add avoided gas cost and deduct incremental O&M. For the moderate case, the three gross savings are ₹2.55 crore from electricity efficiency, ₹1.80 crore from gas savings and ₹4.80 crore from renewable procurement. Subtract ₹0.55 crore in annual incremental O&M to reach ₹8.60 crore per year. A ₹1/kWh change in realized renewable spread changes annual savings by ₹1.60 crore. At half the assumed usable renewable delivery and the same paid-per-use spread and costs, annual savings fall to ₹6.20 crore and simple payback moves from 2.1 to 2.9 years. Take-or-pay would warrant a separate downside case. The net annual savings improve operating cash margin before finance, tax and depreciation by about ₹1.72/kg of product at unchanged sales and output. As a share of revenue, divide by the facility's actual sales.

Low capex is typically the first commitment when engineering data are weak or production is changing. The moderate case in this example delivers the highest modeled NPV; its commercial strength depends on matching and settlement. The strategic case delivers the largest modeled market-based reduction and has the tightest dependence on heat-pump duty, load and contract quality. A plant should compare these paths against its own hurdle rate and reliability requirements, with outage and quality costs included in the approval model.

Five years from metering to verified performance

Five-year implementation roadmap

Window	Accountable functions	Work	KPI	Priority and dependency
0–6 months	Operations + energy	Meter extrusion, oven and utilities; optimize controls and establish resin yield.	kWh and GJ/saleable tonne, trim %	High · historian tags, scale and meter calibration
6–18 months	Procurement + finance	Tender matched renewables, implement chill-water and drive upgrades, request resin data.	Settled GWh, landed ₹/kWh, supplier data coverage	High · load baseline, permissions, PPA and attribute checks
18–36 months	Engineering + quality + EHS	Recover exhaust heat, test low-temperature electrification and approved regrind.	Recovered GJ, verified COP, defect rate	Medium · heat balance, outage plan, equipment and grade qualification
36–60 months	COO + CFO + sustainability	Scale verified projects and supplier program; assess storage on measured gaps.	Realized payback, audited inventory, grid and gas intensity	Conditional · measured pilots, supplier data and grid capacity

Milestones reflect a typical sequencing decision; permitting and shutdown windows may change delivery.

Make the first budget gate an evidence review. Ask operations to reproduce the baseline for a stable grade campaign, then verify whether savings survive shift changes, warmer cooling water and another product mix. Procurement can run competitive bids against measured demand while engineering prepares a heat balance. Keep legal and finance in the bid review so tariff protection, equity terms and captive qualification have named owners. Each later capital release should follow a performance trial or a contractual guarantee that represents site operating conditions.

Where the market is moving

Resin and electricity price movements can squeeze margins even when order volume holds. Customer procurement teams increasingly need evidence on material origin, recycled content and product emissions, especially when they aggregate supplier data. An effective response starts with an auditable mass balance and a consistent approach to product carbon footprints. Record who supplies the resin, what boundary their data cover, how the film is converted and how claims are supported. Circular design and recycling claims should reflect the actual collection and processing market served by the package.

India’s Carbon Credit Trading Scheme has a compliance mechanism for notified obligated entities with specific greenhouse-gas intensity targets. Verify the legal entity, installation and applicable schedule before assigning a compliance cost or credit. EU CBAM currently covers specified codes in cement, iron and steel, aluminium, fertilisers, electricity and hydrogen. Ordinary plastic packaging film is outside those listed sectors. Confirm actual tariff classification for

exported goods. Treat customer disclosure and product requirements as separate commercial workstreams. BEE's Perform, Achieve and Trade scheme applies to designated consumers under notified conditions. Check the installation and relevant cycle before assuming a film-conversion line has PAT obligations. BEE designated consumer framework BEE compliance mechanism · Notified intensity targets · European Commission CBAM scope

BRSR applicability follows SEBI's listed-entity framework. Its March 2025 circular provides voluntary value-chain ESG disclosure for the top 250 listed entities from FY 2025–26 and voluntary assessment or assurance from FY 2026–27. Suppliers can still receive data requests through customer contracts. In India's packaging EPR regime, check the legal role of the entity, the packaging category and applicable plastic waste rules and portal obligations. All-plastic flexible packaging and multilayer structures with nonplastic layers require different classification checks. For equipment retrofits, check state board consent conditions for stack, effluent, waste and any change in capacity, fuel or coating chemistry. SEBI circular · CPCB packaging EPR portal

TOPTIER's Perspective: Decarbonization Should Improve Business Performance, Not Just Sustainability Reports.

Run three tests before approving capital. First, can the plant reduce kWh, fuel GJ or virgin resin per accepted tonne without compromising the specification? Second, can a solar, wind or hybrid offer save money on the units the site can settle, with a credible plan for captive verification and renewable attributes? Third, can a thermal or storage investment outperform the next best use of

capital across actual production, tariff and outage conditions? Publish savings against a documented baseline and tie them to financial and operating records.

Bring twelve months of electricity bills and interval demand, fuel purchases and grade-level production history to the first discussion. Those inputs can reveal whether the next rupee belongs in the oven, the power contract or the resin specification.

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> 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.

Sources checked 19 November 2026. Business case baseline factor vintage FY 2024–25.