Energy Efficiency in the Dryer Section

Fabric Optimization Strategies for Steam Consumption Reduction

Technical analysis with production-machine case studies demonstrating 8–15% energy savings
through systematic dryer fabric permeability optimization and tension management

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Executive Summary

The dryer section accounts for approximately 65–75% of a paper machine's total thermal energy consumption, representing the single largest energy cost center in paper manufacturing. For a typical fine paper machine producing 200,000 tonnes per year, dryer steam consumption of 1.6–1.8 tonnes of steam per tonne of paper translates to an annual energy cost of €2.5–4.0 million at current European industrial natural gas prices. For mills in regions without access to low-cost biomass or recovered heat, dryer energy is the difference between profitability and loss.

This white paper demonstrates that systematic dryer fabric optimization — specifically, matching fabric air permeability to each dryer group's operating conditions and maintaining optimal fabric tension — can reduce dryer steam consumption by 8–15%. These savings are achieved without any capital expenditure: the optimization is implemented purely through fabric specification changes at the next scheduled replacement. For the example machine above, this represents €200,000–600,000 in annual savings with zero investment payback period.

1. Introduction — The Dryer Section Energy Challenge

Paper industry energy costs have risen substantially over the past decade, driven by higher global fuel prices, expanding carbon pricing mechanisms (EU Emissions Trading System, emerging schemes in Asia and the Americas), and increasingly stringent corporate net-zero commitments. Simultaneously, competitive pressure in global paper markets makes it extremely difficult to pass energy cost increases through to product pricing. Mill energy managers are therefore intensively focused on energy efficiency improvement projects — particularly those with rapid or immediate financial payback.

Dryer fabric optimization stands out as one of the most capital-efficient energy levers available to mill operators. Unlike heat recovery systems, high-efficiency dryer hoods, or press section rebuilds — all of which require significant capital investment with multi-year payback periods — fabric optimization is implemented through specification changes at normal fabric replacement intervals. There is zero additional capital expenditure. The energy savings begin from the day the first optimized fabric is installed. This paper provides the technical basis, the practical methodology, and the production-machine evidence to support immediate implementation.

2. Dryer Section Energy Balance Analysis

The dryer section removes the remaining water from the paper sheet after mechanical dewatering in the press section, typically taking the sheet from 38–48% dryness (post-press) to 92–95% dryness (pre-size press or at the reel). The energy required for this drying process is dominated by four components:

Energy Component	Share of Total	Physical Description

Energy Component	Share of Total	Physical Description
Latent heat of evaporation	70–75%	Energy required to convert liquid water to vapor (~2,260 kJ/kg at atmospheric pressure)
Hood exhaust air losses	15–20%	Warm, humid air exhausted from the dryer hood to maintain dew point
Cylinder shell & condensate losses	8–10%	Heat lost through cylinder ends, bearings, and condensate removal system
Fabric & sheet sensible heating	3–5%	Energy to raise the temperature of fabric and sheet to drying temperature

The dryer fabric directly or indirectly influences three of these four components. Improved sheet-to-cylinder contact increases conductive heat transfer (reducing the steam required per unit of water evaporated and thus reducing the latent heat component). Optimized permeability enhances water vapor removal from the pocket between the fabric and the sheet (reducing the exhaust air volume required to maintain the pocket dew point). And lower fabric mass reduces the sensible heat demand of repeatedly heating and cooling the fabric as it cycles through the dryer section. These effects are compounding — a 5% improvement in each area can yield a 10–15% total reduction in specific steam consumption.

3. Fabric Permeability & Heat Transfer Fundamentals

The relationship between dryer fabric air permeability and heat transfer is fundamentally non-linear and strongly position-dependent. High-permeability fabrics allow better water vapor evacuation from the sheet-fabric-cylinder interface but reduce the contact pressure between the sheet and the cylinder surface — which is the primary mechanism for conductive heat transfer. Low-permeability fabrics maximize contact pressure and thus conductive heat transfer, but can trap a stagnant vapor boundary layer between the sheet and the fabric, which acts as an insulating barrier.

PAPTEX recommends a permeability grading strategy: higher permeability in the early dryer groups (where the evaporation rate is highest and vapor evacuation through the fabric is the rate-limiting step), transitioning progressively to lower permeability in the later dryer groups (where the drying rate is limited by the sheet's internal thermal conductivity and maximum contact pressure is beneficial for driving heat into the increasingly dry sheet).

Dryer Group	Sheet Dryness	Drying Regime	Recommended CFM	PAPTEX Fabric
Group 1 (post-press)	38–55%	Constant rate — free water removal	350–500	FY-2800 / RY-3000
Groups 2–3	55–75%	Falling rate — transition zone	250–350	FY-2500 / FY-2200
Groups 4–5 (pre-size	75–92%	Falling rate — bound	150–250	FY-2200 / FY-2000

Dryer Group	Sheet Dryness	Drying Regime	Recommended CFM	PAPTEX Fabric
press)		water removal		
After size press	55–75%	Constant rate (re-wetted sheet)	300–450	FY-2500 / FY-2200
Final dryer groups	75–93%	Falling rate — bound water, shrinkage control	100–200	FY-2000 / FY-1800

4. Optimizing Fabric Tension for Energy Efficiency

Fabric tension directly determines the contact pressure between the sheet and the dryer cylinder surface. Higher tension increases contact pressure, which improves conductive heat transfer by reducing the thermal resistance of the sheet-cylinder interface. However, higher tension also increases the fabric wear rate, roll bearing loads, and the drive energy required to overcome the increased friction. The optimal tension balances the heat transfer benefit against these mechanical costs — and PAPTEX research shows that for most machines, the balance strongly favors increased tension.

Production machine measurements by PAPTEX show that setting fabric tension at the upper end of the recommended range (3.5–4.0 kN/m for flat yarn fabrics) yields 3–7% better heat transfer compared to tension at the lower end of the range (2.0–2.5 kN/m), while increasing fabric wear rate by only an estimated 5–10%. The net economic outcome is strongly positive — the value of the steam savings far exceeds the modestly shortened fabric life (typically 5–15 days shorter on a 180-day base life). The economic crossover point, where the incremental wear cost equals the steam saving value, occurs at tensions well above the recommended operating maximum for all fabric types.

5. Case Studies from Production Machines

Case Study 1 — Newsprint Machine, Finland: An 8.6 m newsprint machine producing standard 45 gsm newsprint at 1,450 mpm was consuming 1.72 tonnes of steam per tonne of paper. The machine was running uniform-permeability (350 CFM) flat yarn dryer fabrics in all positions. PAPTEX implemented a permeability grading program: replacing the uniform fabrics with 450 CFM in Group 1, 300 CFM in Groups 2–3, and 200 CFM in Groups 4–5. The fabrics were changed at their normal replacement intervals over a 4-month period — no special downtime, no capex. Post-optimization steam consumption stabilized at 1.51 t steam/t paper, a reduction of 12.2%. Annual savings: approximately €340,000 at Nordic industrial energy prices.

Case Study 2 — Double-Coated Woodfree, Germany: A 4.2 m machine producing double-coated woodfree paper at 1,050 mpm achieved an 8.6% steam reduction after implementing PAPTEX's tension optimization protocol (increasing post-size-press dryer group tension from 2.2 to 3.5 kN/m) combined with a permeability-grade fabric set. Annual savings of approximately €215,000 were achieved. Additionally, the cross-direction moisture profile improved by 0.4 percentage points (standard deviation), attributed to more uniform contact pressure across the sheet width from the optimized tension. This quality improvement was an unexpected bonus that reduced the mill's moisture-related customer claims.

Case Study 3 — Recycled Board, Italy: A 5.2 m machine producing testliner and corrugating medium at 680 mpm achieved the highest savings in PAPTEX's study database: 15.2% steam reduction. Savings were realized by combining permeability grading, tension optimization, and implementation of a structured dryer fabric cleaning program (weekly alkaline batch cleaning of the Group 1 fabric, which had been operating with heavy starch contamination). The exceptionally high savings percentage was partly attributable to the poor baseline condition — the machine had been running uniform low-permeability fabrics with no systematic cleaning for over 3 years. This case demonstrates that the worse the current practice, the larger the improvement opportunity.

6. Implementation Roadmap

Phase 1 (0–3 months): Conduct a comprehensive dryer section energy audit. Measure current fabric permeabilities, tensions, and steam consumption by dryer group. Document the baseline performance with a minimum of 4 weeks of steady-state production data at normal operating rates. The quality of the baseline data determines the credibility of the savings calculation.

Phase 2 (3–6 months): Implement permeability grading at the next scheduled fabric changes, starting with the dryer group that shows the largest gap between the actual and recommended permeability. Install tension measurement equipment if not already present — you cannot optimize what you do not measure.

Phase 3 (6–12 months): Complete the transition to a fully graded permeability set across all dryer groups. Optimize tensions group by group, documenting the steam consumption impact at each adjustment. Implement weekly steam-consumption-by-group monitoring as a standard operating procedure.

Phase 4 (12+ months): Sustain and continuously refine. Trend the steam consumption data over multiple fabric lives. Adjust fabric specifications based on accumulated performance data. Consider next-level optimization opportunities: anti-static fabrics for coated grades prone to static-induced sheet flutter, or spiral fabrics for positions with exceptionally high contamination rates.

7. Conclusions & Next Steps

Dryer fabric optimization is one of the most capital-efficient, lowest-risk energy savings opportunities available to paper mills today. The three primary levers — permeability grading, tension optimization, and systematic fabric cleaning — are all implementable through specification changes at normal fabric replacement intervals. There is no capital expenditure requirement, no production downtime beyond normal scheduled changes, and no operational risk beyond normal fabric change risk.

PAPTEX application engineers are available to conduct on-site dryer section energy audits and develop a mill-specific optimization plan. The audit is provided at no charge and typically requires 2–3 days of on-site access. Contact tech@paptex.com or your regional PAPTEX sales representative to schedule.

8. References

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