

From by to bio: Bioenergy and the modern pulp and paper mill

Wilson Monteiro, Global Business Line Manager for Pulp, Paper and Fiber, ABB's Process Industries Division

INTRODUCTION:

The pulp and paper industry is an essential, if often understated, pillar of global industrial development. It is embedded in everyday life, supplying packaging, hygiene products, board and fiber-based materials that underpin modern economies. Yet the industry is also one of the most energy-intensive sectors, reliant on large and continuous flows of steam, electricity, and heat to sustain production.

This reality places the industry squarely at the intersection of three defining pressures: decarbonization, cost competitiveness, and energy security. Each of these pressures is intensifying, and together they are reshaping how mills are designed, operated, and evaluated. In this environment, bioenergy is moving from a peripheral sustainability topic and internal efficiency measure to a strategic asset that will increasingly influence resilience, long-term viability, and competitive positioning.

The most recent available data from the International Energy Agency¹ (IEA) underscores the scale and stakes. The IEA notes that paper production is highly heat-intensive, with drying accounting for around 70% of the sector's energy use. Bioenergy already supplies a substantial portion of that energy demand – around 40% of the sector's energy in 2022 – yet the IEA's Net Zero pathway implies the share must rise further through 2030. In parallel, global production remains enormous: Statista² reports that the quantity of paper and paperboard produced worldwide in 2024 exceeded 423 million metric tons.

The industry has long possessed many of the ingredients required for a low-carbon, circular energy model. What has changed is the urgency and the potential consequences of inaction.

Why bioenergy matters: Energy instability meets mill-level reality

The global energy system is experiencing a period of heightened instability. Price volatility, global tensions, constrained infrastructure, and accelerating policy intervention have combined to expose vulnerabilities across industrial supply chains. For many energy-intensive sectors, energy strategy has historically been treated as a procurement challenge: secure supply, negotiate contracts, hedge exposure. That model is being usurped by unexpected, often unprecedented events.

Recent grid stresses and fuel price shocks have demonstrated how quickly external dependencies can translate into operational risk. Mills that rely heavily on purchased energy have found themselves exposed not only to higher costs but also to uncertainty around availability and reliability. In extreme cases, energy constraints have directly limited production or accelerated asset rationalization decisions.

Image 1: Aerial view of pulp mill. Image ABB.



For pulp and paper, the implications are immediate because the industry's energy demand is both large and process critical. Drying cannot pause without consequences for quality and throughput, while recovery and steam networks are tightly bound to the mill's overall stability.

However, pulp and paper is better positioned than many industries to navigate this environment. Unlike sectors that must import nearly all of their energy, pulp and paper mills already sit on significant internal energy resources in the form of biomass residues and process by-products. Black liquor (the by-product from the kraft process when digesting pulpwood into pulp), bark and wood waste are streams already central to the process.

This advantage is only realized if bioenergy is actively optimized as part of an integrated operating strategy. Mills that treat bioenergy as a static background system are at risk of underutilizing a critical buffer against external volatility. Energy self-sufficiency is not a fixed attribute; it is a dynamic outcome shaped by process integration, control sophistication, and strategic intent.

This shift marks a deeper change in how energy is viewed within mill leadership teams.

Where once energy was considered simply as a cost to be minimized, it is now a core operational capability inseparable from production stability, emissions performance and long-term resilience. As a result, responsibility for energy decisions is moving closer to the heart of operations, engineering and executive leadership.

Bioenergy sits at the center of what is often described as the energy trilemma: balancing cost, security of supply and sustainability. In pulp and paper, that balance plays out daily in steam balances, load profiles, recovery boiler uptime and decisions about whether to export electricity or prioritize internal demand. The mills that succeed will be those that recognize there is no single optimization target, and that flexibility increasingly matters more than maximization.

In this context, a 'wait and see' approach to energy strategy is becoming increasingly risky as delaying decisions erodes optionality. The mills that treat energy as a strategic capability rather than an overhead will be better positioned to navigate volatility while meeting tightening emissions requirements.

Bioenergy's evolving role inside the modern mill

Bioenergy has long underpinned energy self-sufficiency in pulp and paper. What is changing is the scope of its role. Bioenergy is an energy-cost and resilience tool. Internal generation reduces exposure to volatile external markets and enhances security of supply. In some regions, mills have reached the point where they export surplus renewable electricity to the grid, effectively operating as local energy hubs. This creates new revenue opportunities, but also introduces complexity around grid interaction, market participation, and operational risk.

Furthermore, bioenergy is increasingly a circular economy platform. Side streams that were historically combusted by default are now being evaluated for alternative uses, including biofuels, renewable chemicals and heat supply to neighboring industries or communities. These options expand the value potential of biomass but also introduce strategic trade-offs that must be navigated carefully.

Across all its roles, the defining challenge is integration. Bioenergy does not exist alongside pulp production; it is embedded within it. Decisions about energy use reverberate across chemical recovery, water systems, process stability and product quality. Managing these interactions requires a level of operational visibility and control that goes beyond traditional siloed approaches.



Image 2: Paper dryer machine. Image ABB



Image 3: ABB Paper Machine. Image ABB

Trade-offs, not templates

One of the most persistent misconceptions about bioenergy is that its benefits are universal and straightforward. In reality, every bioenergy decision involves trade-offs, and those trade-offs vary significantly by region, asset profile and business strategy.

Consider the question of whether to burn biomass or repurpose it. Combusting residues for steam and power delivers immediate energy value and operational simplicity. Diverting those same streams into higher-value products may improve long-term economics or sustainability positioning, but it can also introduce supply chain complexity, regulatory exposure and process risk. The “right” choice depends on local markets, policy stability and the mill’s appetite for diversification.

Exporting electricity versus prioritizing internal resilience is rarely a simple either–or choice. Selling surplus power can strengthen the financial case for energy investments, especially in regions where grid incentives or favorable market conditions exist. However, relying too heavily on exports can leave a mill vulnerable during periods of high internal demand or unexpected equipment outages. As a result, many operators are moving toward more flexible operating models that maintain internal optionality – ensuring the mill can meet its own critical energy needs before maximizing short-term export revenue.

Capital allocation decisions add another layer of complexity. Investing in new bioenergy assets, such as upgraded recovery boilers, turbines or electrified solutions, can deliver step-change improvements, but often requires significant capital and long payback periods. In contrast, sweating existing assets through improved control, maintenance and optimization may offer faster returns with lower risk, even if the absolute gains are smaller.

Regulatory uncertainty looms over all these choices. Energy and carbon policies can change faster than industrial assets can be depreciated. As a result, many mill leaders prioritize flexibility: systems that can adapt to changing market signals, feedstocks and regulatory frameworks rather than locking into a single optimization pathway.

What emerges from these considerations is a clear pattern: there is no universal bioenergy blueprint. Successful strategies are context-specific, grounded in operational reality, and informed by a clear understanding of trade-offs. They rely less on maximizing any single metric and more on maintaining balance across production, energy, and sustainability objectives.

From concept to operation: integration in practice

Translating bioenergy strategy into operational performance remains a systems challenge. Recovery boilers, biomass furnaces, turbines, steam networks and electrification assets are deeply interwoven with pulping, drying and chemical recovery processes. A change in one area inevitably affects the others.

This is where advanced automation, electrification and digital tools become enablers rather than add-ons. Real-time monitoring of energy flows, predictive maintenance of critical assets and coordinated control across production and utility systems allow mills to operate closer to optimal conditions while preserving stability.

ABB’s longstanding experience in the pulp and paper industry reflects this integrated perspective. Over decades, the company has worked alongside mills as they modernize legacy assets, expand capacity and adapt to new energy realities.

The emphasis has consistently been on enabling visibility, control and flexibility rather than prescribing a single technological pathway.

A practical example of how operational leadership and cross-site collaboration can unlock circular energy value comes from ABB's account of Smurfit Westrock's Rethel mill in France. The mill operates entirely on recycled fiber and, like many recycled paper facilities, must remove plastics and other contaminants from incoming material streams. Historically, these plastic rejections went to landfill due to the absence of local recycling options. Over several years, the Rethel team worked with another mill in the group to redirect these rejects to a dedicated incinerator, where they are used to generate steam for paper production. According to the Rethel team, this collaboration has prevented around 90% of the mill's plastic rejects from being landfilled.

The Rethel mill example is important as it reframes what bioenergy in pulp and paper can mean. It is not always a story of installing a new boiler. It can be a story of operational ingenuity, cross-site collaboration, and working through regulatory hurdles to create a more circular outcome. It also reflects the broader reality of bioenergy adoption: meaningful progress often comes through a portfolio of practical, incremental improvements, heat integration initiatives, wastewater to biogas optimization, waste to energy partnerships, and steady reductions in fossil fuel dependence, rather than one transformative project.

A strategic reflection: bioenergy as a means, not an end

As the pulp and paper industry looks ahead, bioenergy will remain a central pillar of its transformation, but it should not be viewed as the destination. Instead, bioenergy is a strategic enabler of broader objectives: more resilient operations, stronger cost

competitiveness, credible decarbonization pathways, and long term relevance in an increasingly demanding market environment.

The mills that lead this transition will be those that treat energy as a core, integrated system rather than a support function. They will prioritize system-wide integration over isolated optimization, and flexibility over rigid maximization. Importantly, they will recognize that the value of bioenergy lies not only in the energy it produces, but in how it enhances decision making, stability, and adaptability across the entire operation.

ABB's role in this journey is that of an enabler and long-term partner – bringing together electrification, automation and digitalization to help mills navigate complexity rather than simplify it away. The company's perspective is shaped by decades of exposure to the industry's cycles, constraints and innovations, and by the recognition that transformation in pulp and paper is evolutionary, not episodic.

Ultimately, the strategic question facing mill leaders is no longer whether bioenergy has a role in the future that is already evident. The real challenge is how deliberately and intelligently it will be integrated into the mill's operating model. Will energy be treated as a passive input, or as a source of enduring competitive advantage? In a world where cost, security, and sustainability have merged into a single operational reality, the answer will increasingly determine which mills lead and which fall behind.

1 <https://www.iea.org/energy-system/industry/paper>

2 <https://www.statista.com/statistics/270314/global-paper-and-cardboard-production/>

Image 2: System 800xA visualization. Image ABB

