



# Circular cement solutions for wind energy waste

As the first generation of wind farms near retirement, turbine blade waste is one of renewable energy's toughest sustainability challenges. Early recycling failures left stockpiles, fines and reputational risks, but cement co-processing now offers a scalable path forward. By turning end-of-life blades into fuel and raw material for cement, operators cut emissions, save landfill space, and turn liabilities into assets. For OEMs, investors and regulators, the key question is whether operators have the expertise and stability to deliver at scale.



Only a decade ago, the waste challenge of the wind industry lay bare across the American landscape: massive turbine blades stretched across landfills in places like Wyoming and Iowa, stark monuments to the industry's struggle with the final leg of its sustainability story. The narrative of clean energy production falls flat when juxtaposed against decommissioned blades buried in landfills or piled up at failed recycling facilities.

Sustainability has always been at the forefront of the energy transition, and finding environmentally responsible solutions for decommissioned wind turbine blades has become increasingly important and highly visible. The initial solution of landfilling decommissioned blades created multiple challenges: these massive blades consumed valuable space, and landfilling as a disposal method ranks at the bottom of the EPA's waste hierarchy for sustainability. The original equipment manufacturers (OEMs) of the wind industry recognized that simply

burying blades was not a viable long-term solution, especially as the wind energy sector is projected to grow significantly over the next decade.

Industry analysts project that blade decommissioning volumes will triple in the next five years as wind turbines on first-generation wind farms reach the end of their natural lifespan. On average, turbine blades last 15 to 25 years; between now and 2040, more than 10,000 will need to be replaced.

Each onshore blade, weighing six to 22 tons, illustrates the scale of this challenge.

### Early failures and mounting regulatory pressure

#### Why early recycling attempts failed:

- Underestimated blade volumes
- Inadequate shredding equipment
- Financial instability
- Poor material handling that led to environmental hazards and fines

#### Consequences for the industry:

- Abandoned stockpiles in temporary yards and failed facilities
- Double costs for OEMs (paying failed vendors, then new vendors plus transport)
- Compliance and reputational risks from stranded materials

#### The regulatory shift:

- Growing investor scrutiny - funds require detailed end-of-life plans
- Some financiers won't commit capital without approved decommissioning strategies
- States mandating financial assurances and stricter decommissioning oversight

### From blade to resource

The wind industry was, and indeed, still is, very interested in more sophisticated recycling solutions. Almost all wind turbine blade material can be reused. Some reprocessing methods, such as incorporating shredded blade materials as direct additives to asphalt or concrete, present their own environmental risks.

In this case, when composite materials from the decommissioned wind blades break down, they can contaminate water systems through surface runoff and sewer networks. The industry needed an approach that reduced or eliminated these long-term concerns.

Several other approaches have emerged, including fiber recovery methods and pyrolysis processes. However, many face significant scalability challenges and remain in pilot phases, while newer market entrants often lack the financial stability and regulatory compliance infrastructure that manufacturers require.

Fortunately, in recent years, one such solution has emerged, a process that can transform decommissioned blades from waste into a fuel source, as well as provide a raw material replacement value. This process is known as cement co-processing.

Cement co-processing uses shredded wind turbine blades as fuel input in cement kilns, displacing coal and other fossil fuels as the energy source in the very heat-intensive cement manufacturing process.

### Manufacturing process

#### The overall process is straightforward in principle:

1. During repower projects, blades are lowered to the ground and cut into 40-foot sections for transport.
2. At the processing facility, shipments are inventoried to maintain traceability from wind farm to processing site.
3. Sections undergo specialized cutting and multi-phase shredding, creating confetti-like pieces.
4. The shredded material is blended with other scrap inputs to meet strict specifications for cement kilns.
5. Inside the kiln, the composite is transformed into both fuel and raw material for cement production.

### The results

The benefits are measurable. Independent third-party research has shown that cement co-processing of wind turbine blades:

- Reduces CO<sub>2</sub> emissions by 27 percent compared to using coal for cement production.
- Cuts net water consumption by 13 percent.
- Generates around 15,500 kWh of energy per blade, about 1.5 times the annual electricity usage of an average American household.
- Replaces 5 tons of coal, 2.7 tons of silica, 1.9 tons of limestone and 1 ton of other raw materials.
- Saves 30 to 45 cubic yards of landfill space per blade.



#### Simple process, difficult execution

Unfortunately, the cement co-processing method of wind blade decommissioning is more difficult than it sounds. While the process itself is easy to understand, it demands extensive operational infrastructure and substantial capital investment, creating a high barrier to entry that many underestimate.

First, there's the fundamental challenge of processing extraordinarily durable materials. Designed to withstand decades of punishing conditions, these structures resist standard recycling methods.

Their composition demands specialized, heavy-duty shredding equipment – sizeable investments that can quickly devour an underfunded CapEx budget. Facilities attempting to economize on equipment quickly discover the false economy of frequent breakdowns and excessively high maintenance cost.

Beyond the physical challenge of breaking down wind blades, success requires precise environmental controls and sophisticated monitoring systems throughout each processing stage. Due to the rigorous specifications required for acceptance at cement kilns, factors such as BTU, moisture, chlorine and particle size must all be carefully monitored during the process. One misstep in this delicate balance can render entire batches of blade waste unusable as an alternative fuel product.

This technical complexity explains why many early entrants failed; the knowledge of the equipment, expertise and capital required to execute this process successfully was gained through rigorous trial by error. Without

adequate resources, companies quickly find themselves overwhelmed by operational costs and quality control requirements, leading to stockpiled materials and unfulfilled commitments.

#### Choosing the right partner: a critical decision

##### Key factors to evaluate:

1. Financial stability to sustain long-term operations
2. Proven track record of processing at scale
3. Technical capabilities, advanced shredding, monitoring and quality control
4. Strong compliance history
5. Geographic reach and insurance coverage
6. Transparent reporting and documentation
7. Demonstrated scalability without bottlenecks or stockpiling

#### Forging a better process

Thanks to extensive research and development, today's leading operators have emerged with a blueprint for success. Having learned from early challenges, Veolia has invested in expanded processing areas, new equipment, upgraded shredding lines and improved separation technology, achieving approximately five times greater processing throughput.

#### Industry leaders' blueprint for success

##### Best practices adopted by successful operators:

- Careful material handling protocols
- Real-time monitoring to maintain kiln specifications
- Comprehensive reporting (shipping documents, sustainability certificates)
- On-site laboratories for immediate testing
- Dedicated technical teams for project support
- Zero-injury safety culture with inspections

#### Looking forward

As the industry continues to evolve, cement co-processing represents a significant step forward in transforming the wind energy industry into a truly circular economy. By turning end-of-life blades into valuable inputs, this industry has transformed one of its biggest challenges into an opportunity for innovation, unlocking another level of sustainability to the growing renewables market.

Perhaps the coming years will bring more and better solutions for recycling or repurposing retired turbine blades. In an industry built on harnessing natural forces, managing end-of-life assets has become as crucial as capturing the wind itself. Only those who master the full lifecycle of wind energy will lead the way toward a truly sustainable future.

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It offers a full spectrum of water, waste and energy management services, including water and wastewater treatment, commercial and hazardous waste collection and disposal, energy consulting and resource recovery.

Veolia helps commercial, industrial, healthcare, higher education and municipality customers throughout North America.

Headquartered in Boston, Veolia has more than 10,000 employees working at more than 350 locations across North America.