

WHY WIND BLADE RECYCLING SKIPPED THE EASY ROUTE

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A significant share of Europe's wind blade waste is built on chemistry the bottled-drinks industry has run at industrial scale for three decades. No equivalent infrastructure has been built for blades. The reasons are about engineering and capital flow, not science.

The blade-waste problem has acquired a reputation as one of the harder challenges in the energy transition. Composites are difficult to recycle. In the European countries with composite landfill bans the dominant disposal pathway has been shredding followed by co-processing in cement kilns, which destroys most of the value in the recovered material. The recycling start-ups that attract attention pursue supercritical solvents and high-temperature pyrolysis reactors that consume serious energy and produce mixed-quality outputs. Industry-wide pledges to eliminate blade landfill by 2030 have generated more press releases than tonnes processed.

Beneath the single label of "blade waste" lie two distinct polymer chemistries, and the harder of the two has received most of the attention.

The hard chemistry: epoxy

Most modern blades are bonded with epoxy resin. The crosslinks in cured epoxy are carbon-nitrogen bonds and aromatic ether linkages: strong, hydrolytically inert, indifferent to a hot oven. Breaking them requires temperatures hot enough to melt aluminium, or pressurised solvents at conditions that demand bespoke reactor steel. This is genuinely difficult chemistry, and it is the problem that wind industry research has spent the past decade addressing. Modern epoxy blades also contain

carbon fibre in their spar caps, which adds a recovery-economics dimension.

The easy chemistry: polyester

A significant portion of the operating European fleet — particularly older blades from independent suppliers — is bonded with unsaturated polyester or vinyl ester resin. These resins contain ester linkages in their molecular backbone: the same chemical groups that hold a PET drinks bottle together. Add water, a small quantity of caustic soda and modest heat — around 200°C, the temperature of a hot oven — and the bonds cleave. The polymer comes apart into recoverable monomer fragments. The glass fibres separate substantially intact. This is industrial PET recycling adapted to a larger object. The chemistry has been understood and run at scale for three decades. Resin chemistry sets the recycling pathway; fibre type sets the economics; everything else sets the engineering complexity.

Which raises the obvious question: if the chemistry is solved, why has no equivalent of the PET recycling industry emerged for wind blades?

So why isn't it being done?

The first answer is form factor. PET bottles arrive at recycling plants pre-sorted, washed and shredded into uniform flakes that move through continuous reactors at high throughput. A blade segment is a seven-to-thirty-metre object of irregular cross-section with embedded foam cores, lightning conductors, root inserts, gel coats and

adhesives. The upstream handling is a different industrial problem from bottle processing, even when the underlying chemistry is similar. Building a hydrolysis plant means building the cutting, sectioning, sorting and feeding infrastructure ahead of it.

The second answer is feedstock identification. Polyester hydrolysis works on a polyester-only feedstock; epoxy contamination disables the process. No standard exists for blade resin identification at the point of decommissioning, and no industry mechanism segregates blades by resin chemistry. Public fleet records do not capture which blade supplier built which blades for which turbines, even though that information would identify the polyester content: LM Wind Power, historically the largest independent blade manufacturer, built its market position on polyester through the 2000s, while other suppliers used epoxy from earlier dates. The information needed to feed a polyester-specific plant is not routinely collected at the asset level, and the demand for that information will not appear until a polyester-specific plant exists to consume the feedstock. The two pieces of infrastructure need to develop together.

The third answer is capital direction. Research and venture funding for blade recycling has overwhelmingly flowed through OEM-led consortia, which targets chemical disassembly of epoxy blades and represents a genuine technical advance on the harder material. Polyester hydrolysis is older, less novel and less patentable. It does not generate the venture-scale returns or the IP positions that justify innovation finance. The capital available for blade recycling has not been looking for solved chemistry; it has been looking for breakthroughs.

The fourth answer is the absence of an offtake market. PET recycling produces clean ethylene glycol and terephthalic acid that flow back into bottle production through established supply chains. Polyester blade hydrolysis produces propylene glycol, ethylene glycol, dicarboxylic acid fragments and styrene-maleic acid

residues — messier outputs whose buyers are smaller, more specialised, and not currently connected to wind operators. Building a recycling plant requires building or finding the buyers for what it produces. Nobody has done that connective work for the blade polyester stream.

The fifth answer is the default. Cement co-processing absorbs blade waste at gate fees of roughly €100–200 per tonne and is indifferent to resin chemistry: both polyester and epoxy combust adequately as auxiliary fuel and ash filler. From the perspective of an operator decommissioning a wind farm today, cement co-processing is the simplest, cheapest and operationally lowest-risk pathway. The polyester content of those blades, which could be feedstock for monomer recovery, is currently being burned as fuel. The opportunity cost is invisible because no alternative buyer is competing for the feedstock.

An infrastructure gap, not a chemistry gap

What these answers have in common is that none of them is about chemistry. The chemistry is solved. The barriers are engineering integration, feedstock identification, capital allocation, market formation, and the gravitational pull of the existing default. Each barrier is tractable. None has been addressed because the polyester stream has been treated as part of a broader composite recycling challenge rather than as a distinct problem with a different solution architecture.

The polyester fleet is decommissioning now. The window in which the polyester volume is large enough to justify dedicated infrastructure — roughly the late 2020s into the early 2030s — is the same window in which any plant would need to be built and financed against a feedstock stream that eventually declines as the modern epoxy fleet takes over. That is an unusual investment profile, but not an unworkable one. PET recycling itself was originally built against finite-window feedstock arguments and has compounded ever since.

The barrier to recycling Europe's polyester blade waste through PET-style chemistry is not in the chemistry. It is in the absence of the boring engineering and commercial

infrastructure that, in another industry, was built thirty years ago.

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