

Future vertical

Appliance Filtration

Enzymatic degradation of captured PET microfibres in laundry filtration systems.

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SECTION 5 · VERTICALS

1. Customer Description

1.1 Vertical Overview

The customer segment targeted within this vertical is the laundry microplastic filtration industry, particularly companies developing washing-machine filters, cartridges, and integrated filtration systems designed to capture synthetic microfibres before they enter wastewater. Synthetic textiles, particularly polyester, release microscopic fibres during washing, creating a persistent source of microplastic pollution. Washing-machine filtration has already demonstrated effectiveness as a mitigation strategy; a community-scale study involving 97 households found that installing washing-machine filters significantly reduced microfiber emissions reaching municipal wastewater treatment (Erdle et al. 2021). Companies such as Xeros, CLEANR, PlanetCare, Matter, and Filtrol have built commercial filtration technologies around this problem, demonstrating that laundry microplastic capture is already a technically viable and established product category (PlanetCare 2026; Xeros Technology Group n.d.; Matter n.d.; CLEANR n.d.; Filtrol n.d.-a).

Existing filtration systems, however, primarily concentrate rather than eliminate the captured plastic. Once retained, polyester microfibres must still be removed from cartridges, filter bags, collection chambers, or other filtration media and subsequently stored, returned, recycled, or disposed of. This creates a clear downstream opportunity for PetaScale. Rather than competing with established manufacturers solely on filtration efficiency, PetaScale can address the persistent polyester remaining after the filtration step through controlled enzymatic degradation.

1.2 PetaScale Product Fit

PetaScale is positioned to complement existing laundry microplastic filtration technologies by adding an enzymatic degradation step after polyester microfibres have been captured and concentrated. The proposed workflow is therefore capture, concentration, and controlled degradation of retained polyester. This allows PetaScale to build on existing filtration infrastructure rather than developing an entirely new washing-machine filter.

Post-capture treatment also provides a more practical environment for PET-degrading enzymes than direct addition to a normal wash cycle. Laundry conditions involve short cycle times, changing temperatures, detergent exposure, variable pH, and continuous water movement, all of

which can limit enzyme stability and enzyme-substrate contact. In contrast, a cartridge, retained-filter medium, secondary treatment chamber, or off-cycle regeneration system can provide greater control over temperature, pH, residence time, and contact between the enzyme and captured PET. PetaScale can therefore focus on integrating its technology through an immobilized-enzyme cartridge, enzyme-functionalized filtration medium, or downstream treatment module.

1.3 Technical Feasibility

The scientific basis for this strategy is supported by two complementary areas of research: laundry microplastic filtration and enzymatic PET degradation. Washing-machine filters have demonstrated the ability to capture and concentrate synthetic microfibres before their release into wastewater (Erdle et al. 2021), while engineered PET-degrading enzymes have demonstrated the ability to hydrolyze PET under controlled conditions. Importantly, immobilized enzymes have previously been incorporated into cartridge-filter systems while retaining catalytic function over repeated reaction cycles, providing precedent for integrating reusable biocatalysts within filtration architectures (Heilmann et al. 2007).

More directly, immobilized PET-degrading enzymes have demonstrated activity against textile-derived PET fibres. Fritzsche et al. immobilized a PET-degrading cutinase onto solid carriers and successfully hydrolyzed post-industrial PET fibres while reusing the enzyme over multiple treatment cycles. In a 1 L-scale configuration, terephthalic acid yields exceeded 97% within 14 hours across the first three consecutive cycles (Fritzsche et al. 2025). This provides direct technical support for investigating an immobilized-enzyme system capable of acting on polyester microfibres collected through laundry filtration.

Commercial deployment will nevertheless require validation under realistic laundry conditions. Textile-derived PET differs from standardized laboratory PET and may contain dyes, coatings, additives, finishing agents, and varying levels of crystallinity that affect enzyme accessibility and hydrolysis. Captured material may also contain detergent residues, natural fibres, lint, other polymer microplastics, and additional contaminants. PetaScale will therefore need to evaluate degradation rate, enzyme loading, temperature and pH tolerance, detergent compatibility, residence time, enzyme retention, reusability, and treatment cost using realistic laundry-derived material rather than relying exclusively on model PET substrates.

1.4 Customer Segment and Commercial Integration

The most relevant early customers and integration partners are companies that have already commercialized laundry microplastic filtration technologies and therefore possess the filtration hardware, manufacturing capabilities, distribution channels, and customer relationships required for deployment. PlanetCare uses replaceable cartridges that capture up to 98% of microfibres and last for up to approximately 30 wash cycles before replacement (PlanetCare 2026). Xeros develops the XF1 and XF3 integrated and external washing-machine filtration systems and advertises capture of up to 98% of microplastics (Xeros Technology Group n.d.). Matter develops Regen technology for integrated and external laundry filtration, including self-cleaning systems designed to reduce maintenance requirements (Matter n.d.). CLEANR uses its VORTX technology to concentrate captured microplastics into removable CLEANR Pods and reports capture of at least 90% of microplastics down to 50 µm (CLEANR n.d.). Filtrol provides an external washing-machine filtration system using reusable filter bags and advertises an 89% catch rate (Filtrol n.d.-a).

These companies are therefore positioned as potential customers or integration partners rather than exclusively as competitors. Their existing products already perform the capture and concentration stages required for PetaScale's proposed system. PetaScale can consequently focus its development efforts on its core enzymatic technology and determine how PET-degrading enzymes can be incorporated into existing cartridges, filtration media, or downstream treatment chambers without requiring replacement of the manufacturer's entire filtration platform.

The commercial value of this integration will depend on demonstrating a measurable improvement over physical capture alone. Depending on the filtration architecture, enzymatic degradation could reduce accumulated polyester microfibre mass, decrease the amount of retained material requiring disposal or centralized processing, extend cartridge or filter-media capacity, support regeneration, or simplify downstream microplastic management. These outcomes will need to be quantified during pilot testing and compared directly with the cost, maintenance requirements, and performance of the manufacturer's existing system.

1.5 Overall Fit

Following PetaScale's initial WWTP focus, the company is positioned to scale into the laundry microplastic filtration market by targeting the post-capture treatment of polyester microfibres. Established filtration manufacturers have already demonstrated effective microplastic capture, meaning PetaScale does not need to compete primarily by building another filter. Its stronger commercial position is to provide the enzymatic degradation technology that acts on the concentrated polyester retained by existing systems.

This strategy allows PetaScale to enter the market through partnerships with established filtration manufacturers while maintaining a focused technical advantage in enzyme optimization, immobilization, stability, reuse, and PET degradation. Commercial success will depend on demonstrating that enzymatic treatment provides measurable operational or environmental value without compromising normal filtration performance. By extending existing systems from capture and downstream disposal toward capture and degradation, PetaScale can address the persistent polyester microplastics that remain after conventional filtration and provide a differentiated solution within an already established microplastic-control market.

1.6 Filtration Product Landscape

The global water filtration and purification market is split into two primary physical product lines. Rather than a uniform industry, the modern water filtration landscape is an interconnected ecosystem spanning appliance-level and point-source filtration to large-scale industrial and municipal treatment systems. Deploying our enzymatic technology requires direct compatibility with these current mechanical and structural filter designs.

1.6.1 Conventional and Mechanical Separation Product Lines

These traditional, highly robust systems focus on physical particle trapping using mesh, depth, or granular layers. They handle high-volume streams and heavy dirt loads.

- **Screens and Mesh Filters.** Surface filtration units that physically capture particles and fibres based on size. They are used across household and commercial laundry, textile processing, and industrial water systems for suspended solids and fibre removal.
- **Bag Filters.** Replaceable bags that retain particles internally. They are heavily utilized in the textile industry and industrial effluent lines for affordable, high-capacity lint and sediment collection.

- **Cartridge Filters.** Modular, replaceable filtration elements available in pleated, depth, wound, and media-filled configurations. Widely used across household, commercial, and industrial liquid filtration for suspended-solids and contaminant removal, the category is also evolving toward specialized cartridges designed to capture synthetic microfibres and microplastics.
- **Disc Filters.** Stacked, grooved plastic rings compressed tightly to catch particulates. Commonly deployed in municipal wastewater treatment plants (WWTP) for their high backwash efficiency, though high fluid shearing stress limits their compatibility with biological agents.
- **Sand and Granular-Media Filters.** Deep beds of natural silica or multi-layered media. They provide tortuous depth filtration in municipal WWTP and large textile plants, offering excellent, stable surfaces for enzyme deployment.
- **Microfibre Filters.** Fine specialized meshes designed specifically to target microscopic synthetic textile. These are increasingly integrated directly into consumer washing machine appliances and premium industrial effluent loops.

Cartridge filter systems may provide a suitable configuration for PETase deployment due to their ability to retain captured particles within a confined filtration medium, potentially increasing enzyme-PET contact time. Importantly, previous research has demonstrated cartridge filter systems containing immobilized enzymes, with immobilized biocatalysts positioned on the upstream surface of a cartridge operating at low pressure drop and retaining catalytic function over repeated reaction cycles (Heilmann et al. 2007). Combined with evidence that immobilized PET-degrading enzymes can hydrolyze textile PET fibres (Fritzsche et al. 2025), this provides precedent for investigating PETase-functionalized cartridges for simultaneous microfiber capture and degradation. PETase-specific integration into commercial microfiber cartridges will therefore be evaluated through a closed pilot, assessing enzyme immobilization, PET degradation performance, enzyme retention, and cartridge reusability before potential commercial deployment.

Potential customers include PlanetCare, Pentair, and Parker Hannifin, which offer cartridge or cartridge-based filtration technologies relevant to microplastic capture. PlanetCare's washing-machine microfiber filter uses replaceable cartridges to capture up to 98% of microfibres released in laundry wastewater, with cartridges retained for up to approximately 30 wash cycles before replacement (PlanetCare 2026). Pentair's Everpure H-Series, including the H-300 cartridge, is specifically certified under NSF/ANSI Standard 401 for microplastic reduction and removes

particles down to 0.5 μm (Pentair 2026). Parker Hannifin also provides cartridge-based microfiltration solutions for bottled-water production, with the company specifically identifying its microfiltration systems as capable of reducing suspended microplastics from drinking water (Parker Hannifin n.d.).

Disc filtration systems are commonly used for high-throughput tertiary filtration in municipal and industrial wastewater. Unlike many conventional disc-filter designs where rotating media and intensive backwashing can create mechanical shear that may challenge enzyme retention and stability, Alfa Laval's AS-H Iso-Disc uses stationary pile-cloth filter plates with a moving linear backwash manifold. Its low-head, outside-in depth filtration captures solids down to <10 μm, while the stationary media provides a potentially more stable surface for PETase immobilization. Individual removable filter plates could also facilitate enzyme-functionalized media replacement or regeneration (Alfa Laval 2024). Pilot validation would assess PETase stability, activity, and retention on the cloth media under continuous filtration and backwashing conditions.

Sand and granular-media filtration act as a particularly promising pathway for PETase integration. An academic research project at Cornell University poses direct proof-of-concept exists for silica immobilized PETase with potential deployment in sand filtration systems but pilot-scale application is still unvalidated (Su, Pagar, and Goddard 2026). Another ongoing USDA/NIFA-funded Cornell project is investigating PETase immobilization onto activated charcoal for municipal water treatment, including enzyme binding, recovery and reusability, followed by testing within a simulated filtration system against polyester-based plastics. This provides direct research precedent for activated-carbon-based PETase filtration, although full experimental results are still underway (Su 2024). Together, these provide a strong technical basis for integrating PETase into established granular filtration media, with pilot-scale validation as the next step toward potential commercial deployment.

Potential customers include HUBER Technology, Veolia Water Technologies, Paques, and AWI, which manufacture commercial sand and granular-media filtration systems for municipal and industrial water treatment. HUBER's CONTIFLOW Sandfilter is particularly relevant, as the company explicitly identifies microplastic removal as an application and reports >99.9% microplastic removal for tertiary treatment (HUBER SE 2025). Veolia's FILTRAFLO range includes commercial granular-media pressure and multimedia filters for water-treatment applications (Veolia Water Technologies n.d.). Paques' ASTRASAND is a continuous sand-filtration system deployed across more than 500 municipal and industrial wastewater facilities, while AWI supplies

packaged granular-media filtration systems and filter media including sand and granular activated carbon (Paques Biotechnology n.d.; Anthratech Western n.d.).

Immobilized PET-degrading enzymes have demonstrated activity against textile-derived PET fibres, supporting the potential for enzymatic treatment of microfibres retained by filtration systems. A 2025 study immobilized a PET-degrading cutinase onto solid carriers and successfully hydrolyzed post-industrial PET fibres, demonstrating repeated enzyme reuse. In a 1 L-scale configuration, terephthalic acid yields exceeded 97% within 14 hours across three consecutive cycles, showing that immobilized enzymes can remain active against textile PET substrates over repeated treatment cycles (Fritzsche et al. 2025). Further studies demonstrate the potential to translate immobilized PET-degrading enzymes toward continuous-flow and water-treatment applications. A 2026 continuous-flow system immobilized HotPETase-LCI onto Janus particles packed within a stainless-steel column, enabling simultaneous capture and degradation of PET nanoparticles; however, degradation decreased at higher flow rates, highlighting residence time as an important consideration for filtration applications (Wei et al. 2026). Collectively, these studies support investigating enzyme-functionalized or post-capture degradation modules alongside existing microfiber filtration systems, with direct PETase integration into commercial washing-machine filters to be explored through pilot validation.

1.6.2 Membrane Filtration Product Lines

These high-precision, engineered barriers separate contaminants based on molecular size and weight. They are organized from largest pore size to non-porous barriers:

- **Microfiltration (MF).** Pore size 0.1 to 10 μm. Captures suspended solids, large bacteria, and heavy microplastic particles. It is widely used as a pre-treatment stage in municipal and industrial facilities.
- **Ultrafiltration (UF).** Pore size 0.01 to 0.1 μm. Successfully strips out viruses, proteins, and macro-molecules. It is a critical component in WWTP membrane bioreactors (MBR) and commercial laundry water recycling skids.
- **Nanofiltration (NF).** Pore size 0.001 μm. Removes divalent ions, hardness, organic molecules, and fine chemical residues. It is commonly used in industrial wastewater reuse systems.
- **Reverse Osmosis (RO).** Non-porous membrane. Uses high pressure to force water through a semi-permeable boundary, rejecting dissolved salts, heavy metals, and “forever

chemicals" (PFAS). It is the premier standard for premium household and commercial drinking water systems.

MF is attractive because it is fundamentally a particle-removal membrane. PET microplastics retained by the membrane can accumulate at the membrane surface, giving an immobilized enzyme access to its insoluble substrate. More importantly, there is already strong precedent for putting enzymes directly onto MF membranes. A 2024 study immobilized protease, lipase and amylase directly onto PVDF (polyvinylidene fluoride) microfiltration membranes. The resulting membrane remained enzymatically active during filtration and hydrolyzed foulants accumulating on its surface (Mulinari et al. 2024). An earlier study used a commercially available 0.45 μm PVDF MF membrane and immobilized industrial lipases onto it. The enzyme-loaded membrane remained catalytically active and reusable over filtration cycles (Schmidt et al. 2022).

UF has a similarly good argument. Researchers have actually fabricated enzyme-functionalized PVDF-based UF membranes. For example, one system used a PVDF/nylon composite UF membrane with covalently immobilized trypsin. During filtration, the enzyme digested proteins accumulating on the membrane surface, producing a biocatalytic/self-cleaning membrane (Vanangamudi et al. 2018a). Another UF study developed a PVDF/nylon/chitosan membrane with immobilized trypsin and α-chymotrypsin; the high-surface-area functional layer enabled stable enzyme attachment (Vanangamudi et al. 2018b).

So, the architecture already exists with other enzyme/substrate systems for both MF and UF, providing a credible basis for PetaScale to advance PETase-functionalized MF and UF toward pilot validation.

Commercial MF and UF membranes from Koch Membrane Systems, Cembrane, Meidensha, and Millipore have been experimentally evaluated for PET-containing microplastic streams. Koch's KMS PURON PVDF hollow-fibre UF membrane (0.03 μm) achieved 100% microplastic removal from PET-recycling wastewater containing approximately 12.3 ± 1.8 mg/L PET. Cembrane SiC and Meidensha Al_2O_3 MF membranes (0.1 μm) achieved 87.7 to 98.9% and 90.3 to 97.7% removal, respectively, from PET-fibre-containing laundry wastewater, while a Millipore polycarbonate membrane achieved >90% microplastic removal from drinking water containing PET alongside other polymers. These demonstrated capture efficiencies make these manufacturers relevant potential customers for PETase-integrated membrane filtration (Pinto et al. 2025).

2. Market Size and Opportunity

2.1 Total Addressable Market (TAM): 450 Million CAD

As this vertical remains largely experimental, the TAM build rests on layered assumptions and should be interpreted as a ballpark ceiling rather than a definitive figure. Globally, an estimated 500,000 tonnes of synthetic microfibres enter the ocean annually from textile washing (Ellen MacArthur Foundation 2017), a conservative floor, as additional fibre is shed but captured in wastewater treatment before reaching marine environments. Of this, we assume 15% (≈75,000 tonnes) is addressable, not because industrial laundry generates that share, but because B2C filter deployment is initially uneconomical, making centralized industrial facilities the practical entry point. Within that addressable volume, 60% (≈45,000 tonnes) is estimated to be degradable PET/polyester fibre.

For modeling cost, a broad proxy of ~10,000 CAD per tonne is applied to represent the combined compliance, handling, and degradation value per unit of fibre managed, not a per-weight price, but an estimate of the economic value captured through treatment. Multiplying these assumptions yields a global TAM of ≈450 million CAD.

2.2 Serviceable Addressable Market (SAM): 23 Million CAD

The SAM is derived through a bottom-up build using the Canadian industrial laundry landscape. Under NAICS 81233CA, Canada hosts 306 listed establishments (IBISWorld 2025). With an assumed average contract value (ACV) of 75,000 CAD per facility, the SAM totals ≈23 million CAD.

A per-facility rate is used because, even at a national scale, PET microfibre volumes amount to only tens of tonnes per year, making weight-based pricing impractical. The unit of measure therefore reflects facilities serviced, not fibre mass.

Within the broader industry, valued at ~1.87 billion CAD in annual revenue (IBISWorld 2025), PetaScale's SAM represents roughly 1.2% of market value, a proportion that sits well within the realm of reason for a compliance driven service.

2.3 Serviceable Obtainable Market (SOM): ~150,000 CAD

Based on three pilots with two conversions and an average contract value (ACV) of 75,000 CAD per facility, the SOM places PetaScale's projected annual revenue from this vertical at ≈150,000 CAD within three years. Although modest in absolute terms, the strategic value lies in the regulatory tailwinds and the foothold captured within the broader textile filtration opportunity, positioning PetaScale for long-term expansion as mandates evolve.

This vertical's trajectory is fundamentally tied to the spread of filtration requirements and compliance mandates, making it best viewed as a long-position in the industry.

Table 2.1. Pilot-to-contract pipeline, Years 1 to 3

Year	Pilots	New conversions	Contracts	Revenue (CAD)
1	2	0	0	0
2	1	1	1	75,000
3	0	1	2	150,000
Total	**3**	**2**	**2**	**150,000**

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3. Barriers to Entry

3.1 Procurement Cycles

Commercializing PETase-integrated filtration would require PetaScale to establish a procurement pathway that evolves from laboratory validation to scalable enzyme manufacturing and, ultimately, integration into filtration manufacturers' existing supply chains.

3.1.1 Phase 1: Pilot and Laboratory Procurement

Early procurement would focus on research-scale enzyme production, immobilization materials, filtration prototypes, and access to analytical testing services. Enzyme specifications would establish measurable performance criteria including catalytic activity, PET degradation rate, operating temperature and pH range, stability, and reusability under representative filtration

conditions. During prototype validation, HPLC and mass spectrometry could be used externally to analyze influent and effluent samples and quantify PET hydrolysis products, verifying enzymatic degradation rather than physical capture alone. Where enzymes, immobilization technologies, or filtration platforms involve external collaborators, agreements should clearly establish ownership and permitted use of existing background IP and newly generated foreground IP.

3.1.2 Phase 2: Scale-Up and Regulatory Procurement

Following technical validation, procurement would shift toward scalable enzyme manufacturing through fermentation partners or CDMOs. Technology transfer from laboratory-scale production to larger fermentation systems would require process optimization, pilot batches, analytical validation, quality controls, and manufacturing specifications before consistent commercial production could be established. Supply agreements would also need to secure critical fermentation inputs and reduce dependence on single-source raw materials. Regulatory requirements would depend on the final product architecture and intended market. For drinking-water applications, materials, treatment chemicals, and components may require evaluation under standards such as NSF/ANSI/CAN 60 and 61, which assess health effects associated with drinking-water treatment chemicals and system components (NSF n.d.-a, n.d.-b). If commercial manufacturing or environmental testing involves qualifying engineered microorganisms, additional biotechnology requirements may apply. In the United States, EPA regulates certain intergeneric microorganisms under TSCA Section 5, including notification requirements for commercialization or environmental R&D release (U.S. Environmental Protection Agency 2025, 2026).

3.1.3 Phase 3: Commercial Manufacturing and Supply Chain Integration

At commercialization, procurement would expand from production capability to supply resilience. Reliance on a single enzyme manufacturer could create production and delivery risk, supporting qualification of secondary manufacturing capacity and long-term supply agreements where economically feasible. Product formulation would also influence logistics: if enzyme activity requires refrigerated transport, cold-chain requirements would increase distribution complexity, creating an incentive to investigate stabilization approaches such as lyophilization or immobilization that could support ambient storage. Finally, filter-specific end-of-life requirements would need to be developed with OEM partners. For replaceable cartridge systems, this could include take-back, regeneration, recycling, or controlled disposal pathways for spent media containing captured microplastics and immobilized enzymes.

Overall, the procurement barrier is therefore not limited to purchasing PETase at sufficient volume. Commercial entry requires a coordinated transition from research-grade enzyme and analytical procurement, to validated manufacturing and regulatory qualification, and finally to resilient commercial supply and OEM integration.

3.2 Technical Validation Requirements

The central technical barrier for PetaScale is whether PETase can be integrated into an existing filtration product without compromising either PET degradation or the filter's normal performance. Answering this requires validation across six interconnected areas, from demonstrating effective PET degradation and enzyme-substrate contact to ensuring compatibility with real filtration operations and eventual scale-up.

- **PET degradation performance.** Demonstrate actual PET depolymerization rather than physical capture alone by measuring PET conversion, degradation rate, TPA/MHET production, enzyme loading requirements, and performance across relevant particle and fibre sizes. Validation must also establish sufficient enzyme-substrate contact and residence time, ensuring immobilized PETase remains accessible to captured PET within the filtration matrix under realistic flow conditions.
- **Hydraulic and filtration compatibility.** PETase integration cannot make an otherwise good filter perform poorly. Compare the functionalized versus unmodified filter for flow rate, flux, pressure drop, PET retention, fouling and throughput. This is especially important for MF/UF and cartridges, where coatings or immobilization layers could alter permeability.
- **Enzyme stability under operating conditions.** Test retained activity across realistic temperature, pH, flow rate, shear and water chemistry. This is particularly important because PETase needs enough residence and contact time with captured PET for degradation. Continuous-flow PET degradation studies already indicate that degradation performance can decline as flow rate increases, making residence time an important design variable (Wei et al. 2026).
- **Operational and cleaning compatibility.** PETase must remain active during the routine cleaning and maintenance procedures used by existing filtration systems. Validation should test whether repeated backwashing, cleaning solutions, detergents, disinfectants, and filter regeneration reduce enzyme activity or cause the enzyme to detach from the filter material.
- **Immobilization, leaching and reusability.** Determine whether PETase remains attached to the matrix, how much activity is retained after repeated cycles, whether enzyme leaches

into the treated water, and when the enzyme or media requires replacement or regeneration. This is both a technical and economic requirement, because poor reusability directly increases enzyme consumption and operating cost.

- **Real-world and scale-up validation.** Progress from controlled PET solutions to representative water matrices, then from bench-scale media coupons to complete filter prototypes and eventually OEM/pilot systems. Real wastewater, laundry effluent, or industrial streams contain salts, organic matter, other polymers, and suspended solids that can change fouling, PET accessibility, and enzyme activity.

3.3 From Barriers to Commercial Value

Existing filtration technologies can already achieve high levels of microplastic capture, meaning PetaScale must demonstrate not only that PETase can be integrated successfully, but that enzymatic degradation provides meaningful value beyond physical removal. Conventional filters ultimately concentrate captured microplastics into spent cartridges, backwash streams, or other waste that still requires downstream management. PetaScale aims to shift this model from capture and disposal toward capture and degradation, integrating immobilized PETase into existing filtration platforms to break down retained PET while maintaining normal filter performance. By optimizing enzyme stability, enzyme-substrate contact, reusability, and loading, PetaScale can work toward reducing the cost of enzymatic treatment while minimizing the accumulation of captured PET waste. Rather than developing entirely new filtration systems, PetaScale can partner with established manufacturers and integrate its technology into existing products, reducing infrastructure and manufacturing requirements. A staged development pathway from laboratory validation to OEM pilots and outsourced commercial enzyme production would further limit upfront costs and regulatory risk, allowing manufacturing investment to scale alongside demonstrated technical performance and customer demand.

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4. Competitor Matrix

Commercial laundry-microfiber mitigation products currently rely primarily on physical capture or shedding prevention. PetaScale's proposed differentiation is therefore not higher filtration efficiency alone, but the addition of post-capture enzymatic degradation or filter regeneration. This positioning is consistent with the vertical's proposed workflow of capturing and

concentrating polyester microfibres before exposing them to PET-degrading enzymes under more controlled conditions.

Importantly, enzymatic capture-and-degradation is not entirely novel as a concept. In 2019, the University of Exeter iGEM team PETexe developed a prototype washing-machine filter intended to capture microfibres and degrade PET using PETase. However, no currently marketed commercial washing-machine product combining microfiber capture with PETase/MHETase depolymerization was identified in the sources reviewed for this analysis. The latter should be presented as a review-limited finding rather than a claim of global absence.

4.1 Company Summary

Table 4.1. Competitive landscape in laundry microfiber mitigation

Company / Product	Competitive Relationship	What They Are Doing	Current Performance / Product Model	What They Are Lacking Relative to PetaScale
Matter / BSH Bosch Microplastic Filter using Matter Regen technology	Major filtration benchmark; potential OEM/integration partner	Matter develops both integrated and external domestic-laundry microfiber filtration systems. Matter's Regen technology is used in the Bosch Microplastic Filter and incorporates active self-cleaning rather than disposable	Bosch and Matter report filtration of up to 97% of microplastics, operation for up to six weeks or approximately 20 wash cycles before emptying, and no replacement filter cartridges or bags. Matter states that the product is intended to last for the life of the	The system captures and concentrates microplastics but does not provide an identified PETase- or MHETase-based depolymerization step. Because its existing maintenance burden and consumables use are already low, PetaScale would need to

		filtration cartridges.	washing machine (Matter n.d.; BSH Hausgeräte n.d.).	demonstrate additional value through reduced retained-plastic waste, longer emptying intervals, catalytic regeneration, reduced filter volume, or improved lifecycle performance rather than simply reducing cartridge consumption.
Samsung Less Microfiber Filter	Major filtration benchmark; appliance-OEM substitute	Samsung offers an external washing-machine filter using a 65 to 70 µm mesh that captures, redirects, and compresses microfibres. SmartThings connectivity monitors filter status and alerts users when maintenance is required.	Samsung reports capture of up to 98% of microfibres/micro plastics under its specified testing conditions. Samsung states that the system was independently evaluated by Ocean Wise. The filter requires cleaning approximately every 30 uses,	The technology stops microfibres from entering wastewater but transfers the captured material to the solid-waste stream rather than depolymerizing it. PetaScale could potentially address this disposal endpoint, although any enzymatic module would need to justify its additional

			after which captured material is removed and disposed of as general waste (Samsung Electronics 2023, 2024).	hardware, enzyme, validation, and operating costs relative to Samsung's comparatively infrequent maintenance requirement.
Xeros XFilter XF1 / XF3	Major filtration benchmark; strong potential OEM/licensing partner	Xeros develops both integrated (XF1) and external (XF3) microfiber-filtration systems for domestic washing machines and licenses its technology for appliance integration.	Xeros currently advertises capture of up to 98% of microplastics, capture of 80%+ of natural fibres, compatibility with all wash cycles and detergent types, minimal energy consumption, and a filter designed to last the lifetime of the machine (Xeros Technology Group n.d.).	No enzymatic degradation of retained polyester is identified in the current XFilter product description. Because XFilter does not depend on frequent cartridge replacement, PetaScale would need to demonstrate benefits such as lower retained-solid volume, reduced emptying requirements, improved

				regeneration, smaller filter architecture, or improved downstream environmental outcomes.
PlanetCare PlanetCare 2.0 Microfiber Filter	Filtration competitor and potential integration partner	PlanetCare uses an external washing-machine filter with replaceable cartridges and a closed-loop cartridge-return system. Used cartridges are returned to PlanetCare, disassembled, refurbished, and fitted with new filtering media.	PlanetCare reports 98% filtration efficiency, independently tested, with cartridges lasting up to 30 washes. PlanetCare states that returned cartridges are refurbished and reused (PlanetCare n.d.-a, n.d.-b).	PlanetCare already addresses post-capture handling more comprehensively than conventional disposal-only systems, but its detailed support materials state that the used filtering media and captured fibres are currently being collected and stored until sufficient quantities are available for reuse or recycling. Proposed or pilot pathways include insulation, concrete reinforcement,

				chemical recycling, and furniture. The captured PET is therefore not currently degraded within the washing-machine filter itself. PetaScale could potentially reduce reverse logistics, captured-fibre accumulation, or cartridge-processing requirements if enzymatic degradation proves technically and economically superior.

CLEANR CLEANR Washing Machine Filter / VORTX	Strong potential early integration partner and filtration competitor	CLEANR uses biomimetic VORTX separation technology to concentrate microplastics into a disposable, non-woven CLEANR Pod. The system connects externally to a washing machine and incorporates app-based maintenance monitoring.	CLEANR reports ≥90% capture of microplastics down to 50 µm. Pods are changed approximately every five loads. The current US package is advertised at US$229 and includes 50 pods for 250 washes. Full pods may be placed in managed waste or returned through CLEANR's Pod Collection Program (CLEANR n.d.).	Captured microplastics remain physically contained rather than depolymerized. The comparatively frequent pod-replacement interval creates a clear consumables and maintenance burden. Consequently, CLEANR represents one of the strongest potential test cases for PetaScale's regeneration hypothesis: enzymatic reduction of retained polyester could potentially extend pod capacity or reduce disposal frequency, provided it can do so without increasing

				downstream particle release.
Filtrol Filtrol	Lower-complexity filtration competitor; potential retrofit test platform	Filtrol is a reusable external inline washing-machine filter connected directly to the drain hose. Wastewater passes through a replaceable/cleanable filter bag that captures synthetic fibres, lint, and other debris.	Filtrol advertises an 89% catch rate. Its filter bags are reusable and can be hand-washed; replacement bags are also commercially available (Filtrol n.d.-a, n.d.-b).	Captured fibres still require manual removal and appropriate disposal. No enzymatic PET-degradation step is identified. The accessible inline architecture could make systems of this type suitable for testing an immobilized enzyme layer or secondary post-filtration degradation chamber.

Environmental Enhancements MicroPlastics LUV-R / Lint LUV-R	Mechanical-filtration competitor; useful low-complexity benchmark	Environmental Enhancements sells reusable external stainless-steel mesh filters attached to washing-machine discharge lines. The company offers both a finer MicroPlastics LUV-R and the coarser Lint LUV-R.	The MicroPlastics LUV-R is advertised at 87% initial capture efficiency using a 150 µm screen and requires cleaning approximately every 2 to 3 loads. The coarser Lint LUV-R is advertised at 65% initial efficiency and requires cleaning approximately every 10 to 15 loads. Both become more efficient as captured material forms a filter cake, according to the manufacturer, and both use reusable screens rather than disposable cartridges (Environmental Enhancements n.d.-a, n.d.-b).	Frequent manual cleaning, particularly for the finer MicroPlastics LUV-R, remains a major maintenance requirement, and retained material must be removed rather than degraded. A successful PetaScale regeneration module could theoretically reduce retained polyester and cleaning frequency, although this would require experimental validation.

Cora Ball	Indirect substitute / shedding-prevention technology	Cora Ball is an in-drum device that both entangles released fibres and reduces fibre shedding from clothing. It requires no plumbing or external filter installation.	Two independent university studies cited by Cora Ball reported reductions in microfiber pollution of approximately 26% and 31%, depending on study conditions. Removed fibre tangles are currently disposed of in household trash (Cora Ball n.d.).	Its microfiber reduction is substantially lower than the capture efficiencies advertised by dedicated external filters. It also does not degrade the fibres it catches. Its primary competitive advantage is simplicity, low infrastructure requirements, and long product life rather than maximum capture. PetaScale would therefore need to justify its greater system complexity through a stronger measurable reduction in persistent PET waste.

PETexe University of Exeter iGEM / startup concept (2019–2020)	Historical direct technological precedent	PETexe designed and tested a prototype water filter capable of capturing laundry microfibres and incorporating PET-degrading enzymes so that fibres could be degraded within the filter. The project specifically used PETase and investigated washing-machine applications.	The University of Exeter reported in 2019 that the prototype caught approximately 75% of fibres and that the team was experimenting with enzyme concentrations with the objective of degrading captured PET between washes. Current commercial deployment or continued operation of PETexe could not be verified from the sources reviewed (University of Exeter 2019).	PETexe establishes prior conceptual and prototype precedent for the core capture and enzymatic degradation architecture. PetaScale therefore cannot position this general concept itself as unprecedented. PetaScale's defensible differentiation would instead need to arise from its enzyme discovery/optimization platform, enzyme performance, immobilization architecture, real-world operating conditions, economics, scalability, intellectual

				property, or commercial integration strategy.
PetaScale Proposed filter-integrated enzymatic treatment	Proposed differentiated solution	PetaScale would integrate PET-degrading enzymes with an existing microfiber-capture architecture, most plausibly through a retained-enzyme cartridge, downstream treatment chamber, or off-cycle regeneration system. The objective is to act on captured polyester after filtration rather than relying on PETase activity during a short wash cycle.	Not yet commercially validated. Existing literature supports PET hydrolysis, polyester-fibre hydrolysis, PETase immobilization, and PETase/MHETase systems, but the team's reviewed evidence does not establish commercially meaningful degradation of realistic mixed laundry lint within consumer operating conditions.	PetaScale must still demonstrate activity against realistic textile PET, including higher-crystallinity fibres; enzyme stability and reuse; compatibility with detergent-containing effluent; acceptable reaction time; enzyme retention; acceptable pressure drop; absence of increased downstream micro- and nanoplastic fragmentation; and a favourable total-cost and lifecycle comparison with mechanical filtration alone.

4.2 Competitive Positioning

The competitive landscape indicates that filtration efficiency itself is unlikely to constitute PetaScale's primary competitive advantage. Current commercial products reviewed for this analysis already advertise microfiber or microplastic capture efficiencies ranging from approximately 87% to 98% for dedicated fine-filtration systems, with leading products also offering self-cleaning mechanisms, reusable filters, lifetime filter designs, cartridge-return programs, or smart maintenance monitoring.

The more defensible opportunity is therefore the post-capture stage. Existing commercial systems primarily concentrate fibres for subsequent household disposal, managed-waste disposal, centralized handling, storage, reuse, or recycling. PetaScale could potentially add value by reducing the amount of persistent polyester that remains after filtration through controlled enzymatic depolymerization. This is consistent with the vertical's existing conclusion that filter companies may function as potential customers or partners rather than exclusively as direct competitors.

Among the currently marketed commercial washing-machine filtration products reviewed, PetaScale did not identify a product that combines microfiber capture with in-filter PETase/MHETase depolymerization. Historical research and prototype precedent for this architecture exists, most notably PETexe.

Accordingly, PetaScale's differentiation must ultimately be established through measurable performance rather than conceptual novelty. Relevant metrics include longer cleaning intervals, lower cartridge consumption, lower reverse-logistics or disposal requirements, lower clogging and backpressure, reduced retained-plastic mass, enzyme reuse, lower lifecycle impact, and competitive total cost of ownership. If PetaScale were to fulfill these metrics, then filtration is a viable vertical to scale into or pursue post-WWTP vertical commercialization.

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