Closing the Loop in the Textile Industry: Value Creation in the State of Brandenburg

Policy Paper for Stakeholders committed to a Circular Bioeconomy in Brandenburg

Fraunhofer IAP

BENEFICIAL DESIGN INSTITUTE

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In 2020, approximately 6.95 million tonnes of textile waste were generated in the EU (EEA, 2024). Worldwide, 92 million tons of textile waste end up in landfills or incineration each year, releasing greenhouse gases. The EU Circular Economy Action Plan strongly promotes circular processes in the textile sector (BMUV, 2024). Focusing on increasing resource efficiency, the recommendations of the National Circular Economy Strategy (NKWS) emphasize sector dialogues on circular business models, improved collection of textile waste, promotion of high-quality recycling, and support for research (BMUV, 2024).

Rethinking Textile Recycling

How can polyester-containing textile waste from fast fashion, workwear and industrial cleaning be utilized as an efficient, innovative resource? To address this, the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam, in cooperation with the consortium partners Beneficial Design Institute and RITTEC 8.0 Umwelttechnik GmbH (to be renamed Matterr in 2025), developed a biologically integrating recycling system. At the end of 2024, the State of Brandenburg funded the pioneering feasibility and potential study "Applications for the Biopolymer Polyhydroxybutyrate (PHB) from Textile Waste" (short: TexPHB). Among other achievements, this study found that bacterial fermentation was successfully used to convert the lowest category of textile waste – previously considered worthless – into PHB, a thermoplastically processable and biodegradable bioplastic. The study also demonstrated how this category of waste can be used as a resource and raw material for a broad range of applications with a market-ready product portfolio.

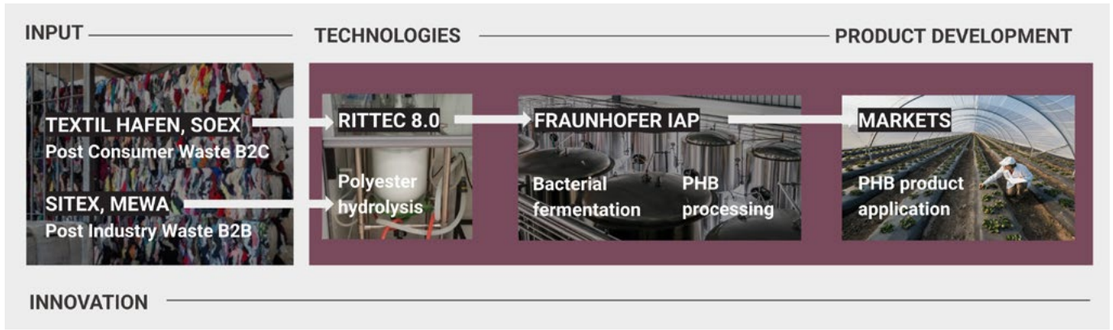

Figure 1 *Transformation process of textile waste fractions – used textiles in the lowest waste category – into polyhydroxybutyrate (PHB) through polyester hydrolysis and bacterial fermentation.*

The process begins (1) with the collection, selection, and preparation of textiles from the lowest waste category, namely fast fashion from households and workwear and industrial cleaning cloths from textile services. This step is followed by (2) the selective recovery of valuable, PET-forming monomers monoethylene glycol (MEG) and terephthalic acid (TA). Subsequently, (3) MEG is converted into high-quality, biodegradable PHB using fermenting bacteria.

The feasibility study shows that PHB is one of the bioplastics that are completely biodegradable, compostable, bio and compatible. Due to its high tensile strength, PHB is particularly suitable for processing techniques such as injection molding and 3D printing. The feasibility of the process has been successfully demonstrated – all 18 types of textile waste tested could be polymerised, and the conversion of MEG to PHB is achievable.

Circular Textile Cycle as a Key to a resource-efficient economic Model in Brandenburg

The innovative use of textile waste offers opportunities for the state of Brandenburg.

1. New Market Potentials: The use of PHB from textile waste replaces petroleum-based plastics and opens new market opportunities in geotextiles, medical products, water protection, agriculture, coatings, geotextiles, and funeral services.

2. Innovation Leadership: Brandenburg can position itself as a pioneer in the development and application of recycling and transformation technologies for critical textile waste streams and textiles that were previously considered worthless.

3. Jobs and Regional Value Creation: The conversion of textile waste on-site into biocompatible (biodegradable) PHB creates qualified jobs in research, recycling, and production, establishes regional economic cycles, and generates value creation within the region.

4. Promotion of European Cooperation: The state of Brandenburg, Poland, and the Netherlands are model regions within the framework of the EU initiative *„Regional Innovation Valleys for Circular Economy"* (RIV-Circular). Through close cooperation, these countries can contribute to strengthening a Europe-wide network, as well as global value chains in the circular textile economy.

5. Environmental and Climate Protection: The transformation of textile waste into biodegradable materials significantly reduces the amount of microplastics that enter into the environment. Closing the textile waste loop directly and indirectly contributes to climate and disaster protection.

Relevant legal framework for regulating textile and waste management

Closed Substance Cycle Waste Management Act; Sec-tion 20 KrWG: Mandatory separate collection of textile waste and textiles for reuse.

EU-Directive 2008/98/EC: obliges EU member states to prevent waste.

EU Ecodesign Regulation (EU) 2024/1781: Specification of requirements for the environmentally friendly design of products.

Regulation on shipments of waste 2024/1157/EU: from May 2027 Ban on the disposal and export of non-hazardous waste to non-OECD countries.

Market potential and Value Creation through PHB Application in the State of Brandenburg

PHB from textile waste has significant potential to substitute conventional plastics based on fossile-based resources due to its material properties, opening up novel and diverse market potentials in various industries. The following overview shows the central application areas of PHB, as well as other biodegradable bioplastics such as polybutylene succinate (PBS) and polyactide (PLA).

Figure 2 *Market potential for PHB from textile waste in Brandenburg - fields of application and value creation effects*

Medical Products

PRIVATE HOUSEHOLDS | HEALTH & WELLBEING

CORE CHARACTERISTICS

- Medical PHBs for orthopedic screws, pill capsules, and wound closures.[1]
- Adjustable degradation rates enable products with specific durability: minimizing infection risks and follow-up procedures.
- Sustainable alternative to polypropylene (PP) for surgical instruments, housings, and sterilizable devices.
- Recyclable PHB devices for closed-loop recycling models in hospitals.

Relevance

In 2022, the medical plastics market in Germany had a volume of USD 1.32 billion, with 37.7% (USD 498 million) attributed to polypropylene (PP).[2] This segment is growing at a CAGR of 5.72%, with a projected market volume of USD 868.1 million by 2032. German hospitals generate 4.8 million tonnes of waste annually, placing them among the five largest waste producers in the country — around 90% of this waste is classified as non-hazardous. At the same time, the healthcare sector accounts for 4.4% of global CO_2 emissions, and 5% of Germany's total emissions (57.5 Mt CO_2 per year).[2] The use of PHB can help reduce CO_2 emissions through biodegradability and targeted recycling. Furthermore, stricter EU regulations present a strategic opportunity for early PHB integration in Brandenburg's medical sector.

Challenges

- The market is dominated by single-use plastics due to strict hygiene standards.
- Regulatory approval processes for PHB-based medical products need to be clarified.
- The structural integrity of PHB for surgical applications must be ensured.

MARKET POTENTIAL

Target Market

Medical implants, devices, and equipment

Geographic Focus

Primarily Brandenburg, with potential for scaling to other regions with medical technology manufacturers in Germany and the EU

Potential Customers

Pharmaceutical companies, medical device manufacturers, hospitals

Important Market Facts

- First-mover advantage: 15% growth in the EU market for medical bioplastics.[3]
- Germany has the third-largest medical technology market worldwide (€43 billion annual revenue).[4]
- Germany's plastic imports totaled USD 49.8 billion in 2023, highlighting supply chain dependency – regional PHB production helps counteract this.[5]
- 766,200 tonnes of German plastic waste exports in 2021: A 25.2% decrease compared to the previous year, indicating a shift toward national recycling.[6]

Facilitating Legal Frameworks

- EU MDR (Medical Device Regulation) requires
- safe, sustainable materials and opens up new PHB certification opportunities.[7]
- Integration of biopolymers into regulated industries is prioritized by the European Green Deal and Plastics Strategy.[8]
- Germany's Circular Economy Act (KrWG) targets plastic waste reduction and promotes PHB-based solutions.[9]

OPPORTUNITIES FOR BRANDENBURG

- High-performance material for medical use: PHB is biocompatible, biodegradable, non-toxic, and bioresorbable – ideal for implants and recyclable medical devices.[10]
- Complies with EU sustainability directives and reduces reliance on petroleum-based polymers.
- Reduces hospital waste, especially in high-waste facilities.
- Economically attractive: the medical sector offers optimal conditions for PHB integration.
- Strengthens supply chain sovereignty by reducing dependence on imported medical plastics (nearshoring).
- Supports Brandenburg's biotech and medtech sectors, drives innovation, and creates jobs.

Local Advantages for PHB in Medicine

Brandenburg is developing into a significant hub for medical biotechnology, with 614 companies in the life sciences sector, including 250 biotech firms, 330 medical technology companies, and 34 pharmaceutical companies.[11] In particular, the Berlin-Brandenburg metropolitan region — with institutions such as Charité and leading hospitals — could serve as early adopters. Through targeted funding programs for biotechnology and medical technology, the state supports early market adoption of innovative materials like PHB. In addition, existing medical device manufacturers can integrate PHB into their supply chains, thereby strengthening local production and increasing regional value creation.

Starting Points for implementation in Brandenburg

- Establish Brandenburg as a center for medical PHB and expand the production of biopolymer-based raw materials.
- Promote collaborations with hospitals, suppliers and research institutions for pilot projects involving PHB-based implants and instruments.

PRODUCT PROFILE

PHB is an ideal alternative to conventional resorbable materials such as polylactic acid (PLA). PHB-based medical products fall into three main categories:

I. Resorbable surgical sutures

PHB-based sutures fully dissolve in the body, eliminating the need for later removal and reducing the risk of infection.

II. Implantable & resorbable medical devices

PHB implants such as bone screws or pill capsules biodegrade naturally, avoiding follow-up procedures and shortening healing times.

Figure 3 *Resorbable Pill Capsules*

Figure 4 *Resorbable Bone Screws*

III. Recyclable high-performance medical products

PHB blends for surgical instruments and disposable products are sterilizable, reusable, and recyclable. Hospitals in Brandenburg could pilot closed-loop recycling systems using PHB collection schemes.

Production Method

Injection molding, 3D printing, and possibly fiber spinning

Material Composition

PHB monomaterial (medical quality)

Similar Products

Biodegradable capsules, resorbable screws, surgical sutures & wound closures, sterilizable medical housings and trays

Tree Protection and Branch Clamps

REGIONAL INDUSTRY | STRENGTHENING OF THE ECOSYSTEM | PROMOTION OF BIODIVERSITY

CORE CHARACTERISTICS

- Grazing, fraying, and gnawing protection: Shields young tree trunks from physical damage, pests, and environmental stress.
- Branch clips and cable ties: Fastening devices for young plants to ensure stability and upright growth.
- Used for 2-3 seasons, then decompose into non-toxic by-products. No labor-intensive cleanup required, and soil health is not affected.

Relevance

Significant amounts of plastic waste are generated in agricultural sectors, with materials such as polypropylene (PP) accounting for a major share. In 2019, an estimated 12.5 million tonnes of plastic were used globally in plant and animal production. In Germany, plastic emissions in agriculture and horticulture exceeded 13,000 tonnes. Of this, 556 tonnes were from films, nets, and coatings, while 273 tonnes came from operational materials such as plant pots or supports. These plastics often remain in the environment for decades and pose serious risks, including damage to ecosystems, water pollution, and reduced soil fertility due to microplastics.

Challenges

- PHB production costs are currently higher than those of conventional plastics like PP.
- Ensuring the structural integrity of PHB products throughout their entire lifecycle.
- Need to adapt the biodegradation timeline to suit different agricultural requirements.

MARKET POTENTIAL

Target Market

Agriculture & Forestry

Geographic Focus

Primarily Brandenburg, with potential scalability to other regions in Germany and the EU

Potential Customers

Fruit growers, forest management, forestry, landscaping and horticulture, livestock farming

Important Market Facts

- 31,800 people employed in animal and plant production in Brandenburg, with one in five agricultural jobs in horticulture
- 300 horticultural businesses in the Berlin-Brandenburg region[14]
- 37 tree nurseries in 2021[15]

Facilitating Legal Frameworks

With the tightening of EU regulations on single-use plastics and the increase in subsidies for green innovations, Brandenburg stands to benefit significantly from the introduction of PHB.

Critical Factors

Healthy food production and the protection of natural ecosystems suffer when farmers do not implement strategies for disposing of agricultural plastics.[16] Governments, NGOs, and citizens bear annual cleanup costs of up to USD 15 billion for plastic waste removal.[17] Brandenburg could benefit significantly from the introduction of PHB. By producing and exporting PHB-based agricultural products, the region could attract investment, strengthen the local economy, and take a leading role in sustainable horticulture, agriculture, and forestry.

OPPORTUNITIES FOR BRANDENBURG

- Adaptation of agriculture to EU sustainability goals and circular economy principles
- Use and degradation do not affect soil fertility or water quality
- Compliance with regulatory requirements and supports economic viability through subsidies and savings on cleanup efforts
- Reduces on-site labor of material removal due to its biodegradability

The Potential of a Circular Bioeconomy

Brandenburg's agricultural sector spans more than 1.3 million hectares of arable land and forms the foundation of a thriving agroeconomy.[18] In 2016, approximately 45% of the state's land area was used for agriculture. Around 5,300 farms make the region a hub for forestry and crop production.[19] The sector relies heavily on agricultural plastics such as plant containers and mulch films. Transitioning these products — typically made from petroleum-based PP (polypropylene) and PE (polyethylene) — to PHB could significantly reduce the carbon footprint, lower dependence on fossil resources, and position Brandenburg as a leader in sustainable agriculture and forestry.

Starting Points for implementation in Brandenburg

- Establish Brandenburg as a production hub for PHB (intermediate) products to secure regional supply chains and create jobs
- Collaborate with agricultural and horticultural businesses to field-test PHB products and demonstrate their benefits at scale
- Cooperation with governmental and supranational bodies to secure subsidies for the production and adoption of PHB

PRODUCT PROFILE

This product is being developed to protect young trees from grazing damage, environmental stress, and accidental harm. It offers a sustainable alternative to petroleum-based polypropylene (PP) plastics, which have been the predominant material used in this sector to date. A concrete application example is the state government's "Avenue Tree Concept 2030," which aims to plant 20,000 trees.[20]

Figure 5 *Tree protection, reusable and biodegradable*

Figure 6 *Tree base cover, reusable and biodegradable*

Production Method

Injection molding, 3D printing

Material composition

PHB monomaterial

Comparable Products

Cable ties, animal troughs, crates, pallets, bulk containers, fastening pins

Geotextiles

PUBLIC PROCUREMENT | ESTABLISHMENT OF NEW INDUSTRIES | CLIMATE PROTECTION | DISASTER CONTROL

CORE CHARACTERISTICS

- Biodegradable geotextile fleeces made from PHB, with design variations for different requirements
- No microplastic release into soil or water
- Protects biodiversity and prevents pollution
- Areas of application: erosion control as well as separation layers, filters, drainage systems, and soil reinforcement
- Ecological restoration

Relevance

While synthetic geotextiles are suitable for durable and resilient applications, they often pose an environmental problem in projects with temporary or semi-permanent requirements. A sustainable alternative for such specific restoration applications is biodegradable geotextiles made from PHB. These support both infrastructure and environmental goals. Naturally degradable materials such as jute or coconut are already available.[21] [22] In addition, initial developments of blended fabrics made from natural fibers and biopolymers offer increased durability.[23] [24] The residue-free biodegradability of PHB greatly benefits this approach.

Challenges

- Spinning PHB into filaments still requires further development, as adhesion and sticking remain a challenge. Nonwoven extrusion offers a practical solution in this context.
- PHB geotextiles must meet construction industry requirements, particularly regarding tensile strength, UV stability, and permeability.
- Synthetic geotextile manufacturers benefit from low-cost production methods and established supply chains.
- Synthetic geotextiles offer greater UV resistance and chemical durability.

MARKET POTENTIAL

Target Market

Public water management, civil and structural engineering, construction industry

Geographic Focus

Primarily Brandenburg, with potential scalability to other regions in Germany and the EU

Potential Customers

Construction and building technology, infrastructure and civil engineering, agriculture and horticulture, environmental remediation, water management, and urban greening

Wichtige Marktfakten

- Growing public demand for sustainable infrastructure solutions
- EU regulations promoting the use of biodegradable construction materials
- PHB geotextiles offer significant growth and expansion potential: the global geotextile market was valued at USD 7.10 billion in 2022 and is expected to grow at an annual rate of 6.6% from 2023 to 2030[25]
- In 2022, nonwoven geotextiles accounted for approximately 65.5% of market revenue[25]

Facilitating Legal Frameworks

EU directives such as the Construction Products Regulation (2024) and the Microplastics Regulation (2023) require the reduction of synthetic polymers.

Similar Products

Erosion control, flood barriers, wave protection, artificial shoreline reinforcements, rockfall nets, catch nets, temporary surface stabilization, geotextile filters

CHANCES FOR BRANDENBURG

- Establishing Brandenburg as a production center for PHB (intermediate) products secures regional supply chains and creates jobs in the region
- Biodegradable geotextiles support Brandenburg's sustainable procurement strategy and offer environmentally friendly solutions for construction projects

The Potential of a Circular Bioeconomy

- PHB geotextiles enhance material circularity and rely on biocompatibility.
- Around 95% of geotextiles currently are made from polypropylene nonwovens (PP). PHB is an ideal substitute, offering the same functionality with the added benefit of being fully biodegradable.[26] Cost savings can be achieved by eliminating waste disposal costs, as PHB materials fully decompose after use.
- Unlike synthetic products, PHB does not cause long-term waste accumulation, nor does it require the removal of synthetic microplastics from soils.
- Up to 50% lower CO_2 emissions during production compared to petroleum-based products.

Starting Points for implementation in Brandenburg

- Collaboration with agricultural and horticultural companies to field-test PHB products and demonstrate their advantages on a larger scale
- Cooperation with national and supranational authorities to implement these solutions along rivers such as the Oder (including cross-border collaboration with Poland and the EU)
- Securing additional research funding and potential subsidies for PHB production

PRODUCT PROFILE

Geosynthetic materials can be classified into four categories: geotextiles, geogrids, geomembranes, and geocomposites.[27]

Geotextiles — the most commonly used — are divided into woven and nonwoven (fleece) types. Woven geotextiles offer high tensile strength, while nonwoven geotextiles have the advantage of higher flow rates and permeability.[28] Fleeces made from yarn filaments or short staple fibers are bonded using thermal, chemical, or mechanical methods and are ideally suited for semi-permanent applications.[28] Nonwoven fabrics are increasingly used in erosion control, drainage, and filtration projects. The use of biodegradable PHB for geotextile fleeces offers a sustainable alternative to petroleum-based products.

Figure 7 *Geotextile, Bioshoreline, Waterbodies*

Production Method

Extrusion for geotextile fleeces, tailored for specific areas of application.

Material Composition

100% PHB or PHB blends with other biodegradable polymers for enhanced durability.

Similar Products

Optional blends with PLA for improved UV resistance, though at the expense of faster biodegradability.

Policy Levers for Closing the Loop in the Textile Sector

Based on this study's findings, it is recommended that the state government implement a multi-stage package of measures. This would establish the necessary framework to develop a textile circular economy , as well as resource-efficient business models in Brandenburg. The state government should:

1. **Promote the establishment of companies that drive forward the regional production of bio-based raw materials from textile waste, as well as regional textile biorefineries by linking hydrolysis and fermentation plants at strategic locations and integrating them into local value chains.** Objectives: Efficient use of resources, reduction of transport routes and creation of regional added value, strengthening of import independence, security of supply and competitiveness in Brandenburg.

2. **Design targeted support programmes for research and, above all, the development of new recycling technologies and biopolymers from textile waste.** The aim is to create new added value by developing and optimising innovative materials and processes for the sustainable use of textile waste, accelerating technology transfer and innovation processes.

3. **Initiate the establishment of a competence cluster for data-driven textile recycling and bioeconomic value creation in Brandenburg.** Objective: to strengthen competitiveness by building up expertise and pooling research, development and industrial utilisation of textile waste into marketable (pre-)products.

4. **Support companies in digital data collection along the entire textile value chain in order to establish a comprehensive, overarching system** that includes data collection, e.g. automated fibre analysis, take-back systems for B2B textile waste and public procurement. Objective: To increase the effectiveness of public procurement, provide reliable, standardised data on the composition, quantities and contamination levels of textile waste in the B2B and B2C sectors, and increase data-based value creation and circular economy business models.

5. **Prepare companies for ecodesign and the Ecodesign Directive, including funding through Fit for 55:** This also includes gathering baseline data. The aim is to increase competitiveness through ecological product design and digital product passports, as well as product-oriented life cycle analyses.

6. **Promote the integration of local companies into supraregional and global value chains in the circular textile and fashion industry** as part of the EU initiative Regional Innovation Valleys for Circular Economy (RIVCircular). Objective: To strengthen the competitiveness of small, medium-sized and larger companies within the framework of Europe-wide networks.

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Project Partners

The Fraunhofer Institute for Applied Polymer Research (IAP) is the applicant for project funding from the MLUK in 2024 and, within this project, is developing a novel approach for the bacterial fermentation of MEG with patent potential. Fraunhofer IAP has had the topic of biopolymers from textile waste on its agenda for a year and is aiming to form a consortium for the valorization of cellulose from polycotton.

The Beneficial Design Institute (BD-I) is the local driving force behind the project, managing the project and investigating both the input streams from the three textile waste sources and the markets and potentials for the use of PHB in the state of Brandenburg. As a design research and development company, it specialises in holistic innovation concepts, sustainable fashion and textile design, and advising organisations on recyclable materials and closed loop cycles based on the cradle-to-cradle philosophy.

The Matterr GmbH (until 2024 RITTEC) is a project partner responsible for processing the textiles into MEG via alkaline hydrolysis. The Matterr pilot plant currently operates at TRL 7 for the recycling of PET packaging and polyester-containing textiles, and is expected to reach TRL 9 by the end of 2026 according to current plans.

Industrial partners from various textile waste sources also provided significant support for the feasibility and potential analysis with their expertise and the necessary used and sorted test materials:

MEWA Textil-Service SE & Co. Management OHG is a textile service company offering a full service for workwear and cleaning cloths on the European market and provided cleaning cloths for workshops and printing companies.
Sitex - Textile Dienstleistungen Simeonsbetriebe GmbH is a textile service company specialising in workwear and service textiles for use in medical facilities and provided medical workwear.
IZ Circular Textiles GmbH / SOEX is focused on the Europe-wide collection and sorting of used textiles and the worldwide marketing of second-hand goods and secondary raw materials. In 2025, it was taken over in parts by Interzero Holding GmbH & Co. KG. Textile waste random samples from the lowest category were examined quantitatively.
Textilhafen is part of **Komm & Sieh gGmbH**, a non-profit inclusion company run by the Berliner Stadtmission with a focus on clothing banks for homeless people and regional textile cycles in neighbourhood shops and the Textilhafen and has provided post-consumer fast fashion products.

Impressum

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The Fraunhofer Institute for Applied Polymer Research (IAP) specializes in researching and developing polymer applications and supports companies and partners in developing and optimizing innovative and sustainable materials and processes. The focus is on producing and processing environmentally friendly, economical polymers on a laboratory and pilot plant scale and converting them into marketable and new bio-based plastics. The Fraunhofer IAP has had biopolymers from textile waste on its agenda for a year and is seeking to establish a joint consortium for the recycling of cellulose and polyester from polycotton.

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The Beneficial Design Institute GmbH (BD-I) is a design research institute specialising in eco-design and sustainability, based in the Berlin-Brandenburg metropolitan region. It develops holistic innovation concepts and cicular product solutions for the textile and fashion industry. As the driving force behind the „TexPHB“ feasibility study and project developer of the regional initiative „Nature of Fashion_Design for Transformation“, BD-I combines design, material and circular economy expertise with practical implementation – from research to market readiness. The aim is to transform the industry in a regenerative way through biocompatible materials, new value creation paths and consistently nature-inspired design.

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