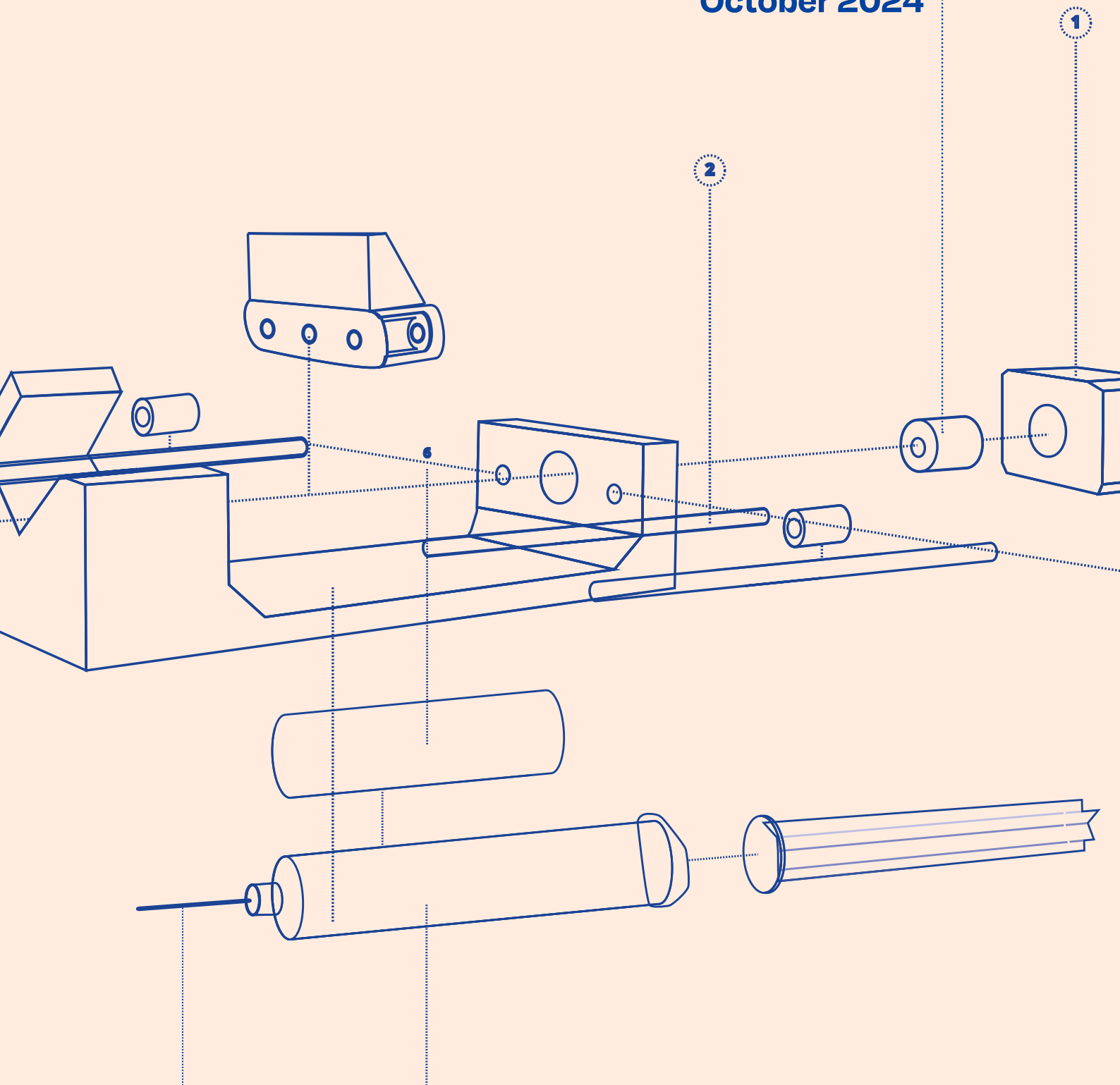
HOW OPEN SOURCE HARDWARE CAN DESIGN OUR WAY OUT OF THIS

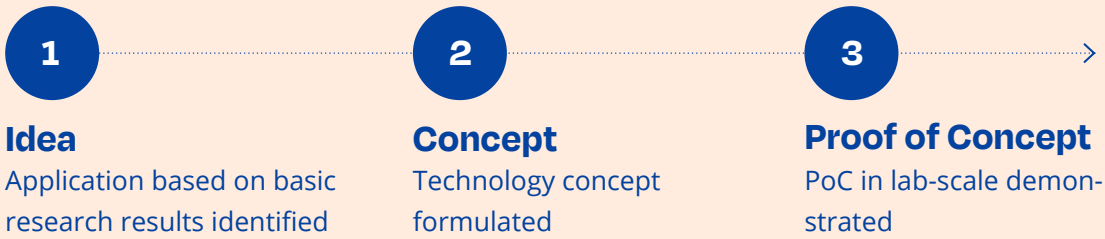
Juni Sun Neyenhuys
Design Culture Now
October 2024



1_INTRODUCTION

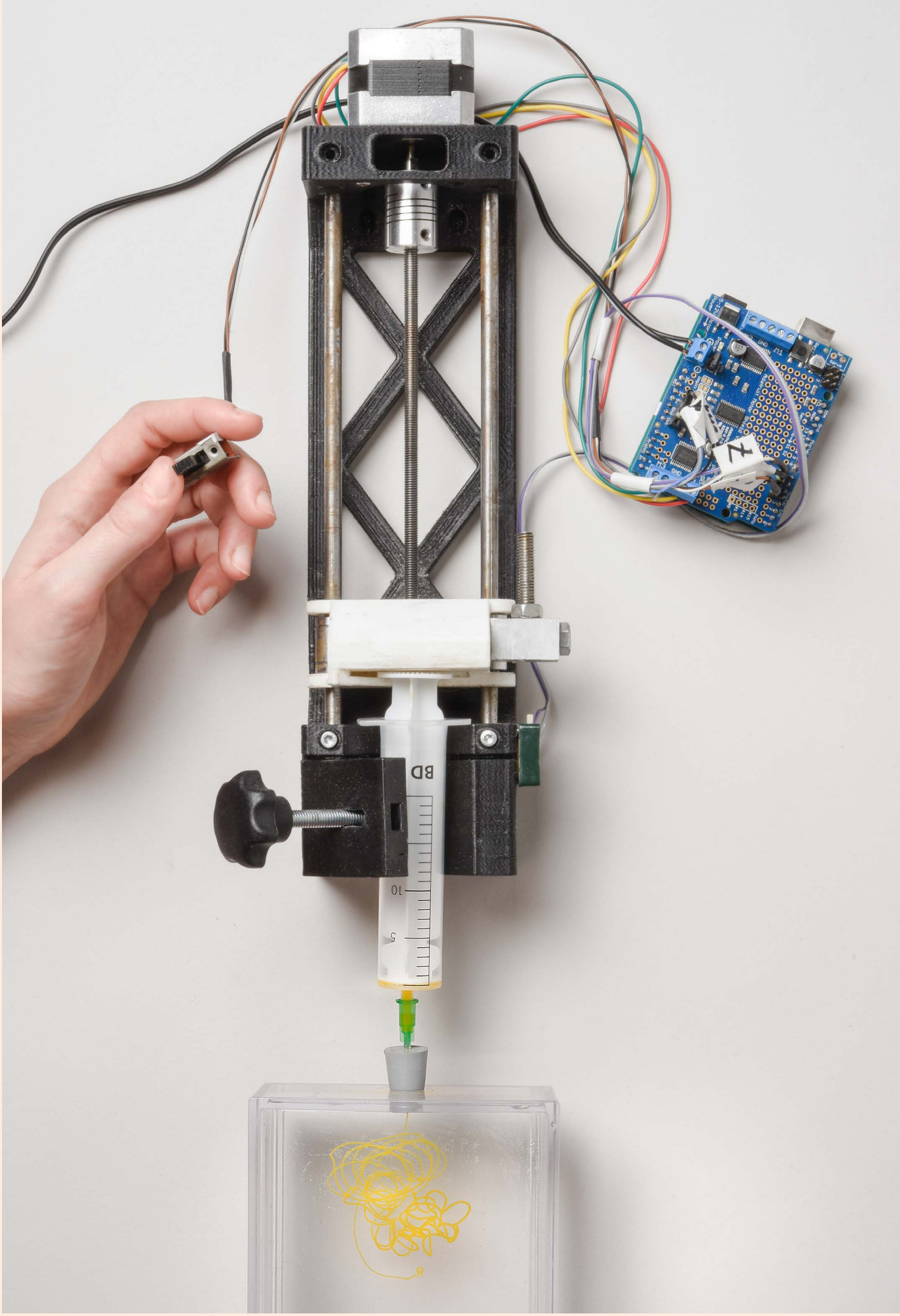
In the third lecture by Guy, the focus was on design and neoliberalism, specifically why the capitalist, globalized system and design are mutually beneficial. However, it is evident that we must design our way out of the current destructive and extractive system if we want to survive as humanity: „The dependency on unending growth cannot be decoupled from resources (...) within planetary boundaries“ (Kate Raworth, TED 2018). A promising alternative to the linear take-make-use-waste economy of consumerism is the circular economy.

According to the European Union, 80% of a product's environmental impact is influenced by decisions made at the design stage (Ellen Macarthur Foundation, 2021). As a textile and material designer, I am motivated to contribute to this shift towards a circular economy. Key aspects of this transition include a material revolution, where we move away from fossil-fuel-based and plastic materials to those that can be reintegrated into natural biological cycles—materials that nourish rather than harm the environment. Another essential pillar of the circular economy is decentralized production, with the use of local raw materials and reduced reliance on long transport routes. The rapid development of sustainable materials and local production both require accessible technology. The current industry operates in a centralized system dominated by large players, and laboratory-scale machinery is prohibitively expensive, limiting innovation potential. For example, a wet-spinning machine for bio-based fibers costs half a million euros. Moving from idea to proof of concept (Technology Readiness Level 1– 3, see graphic below) requires significant investment, meaning valuable innovations often stall due to resource limitations. One promising solution to democratize innovation lies in open-source hardware, as it opens access to affordable, customizable technology.



This is why I am currently developing with my team an open-source wet-spinning machine, designed to democratize bio-based fiber development. The machine processes water-based biopolymer solutions into fibers through environmentally friendly wet spinning, aligning with green chemistry principles (Biomimikry Life's Principles). This technology empowers innovators worldwide to develop bio-based, biodegradable fibers on a small scale (see picture 1). My hope is that this will accelerate eco-friendly fiber innovation, as today, up to 60% of all fibers are polyester-based, contributing to 35% of microplastics in our oceans (Preferred Fibres & Materials Market Report, p. 72).

In this essay, I will examine how open-source hardware tools can accelerate material innovations and facilitate the industry's transformation towards circularity and regeneration, focusing specifically on the designer's role in driving this change. My writing style aims to be informative yet engaging, reflecting the collaborative spirit of open-source principles while encouraging readers to envision a future where design can foster positive change.



First prototype of the open source wet-spinning machine

What is Open-Source Hardware?

Open-source software is widely adopted by companies of all sizes; for example, all supercomputers run on Linux, as does NASA's operating system (The Circular Economy and Open Source, Ep. 102). While open-source software has already changed the world, open-source hardware remains an emerging field. However, the principles are the same: OSH is „hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design" (OSHWA, 2020). This openness gives people freedom to control technology while sharing knowledge and supporting commerce through open exchange. Ideally, OSH uses readily available components, open design tools, and unrestricted content, maximizing accessibility and fostering innovation (OSHWA, 2020).

What is the Circular Economy?

The circular economy is a system that eliminates waste by keeping products and materials in circulation through maintenance, reuse, refurbishment, remanufacturing, recycling, and composting (Ellen MacArthur Foundation). Products cycle through either a technical cycle, where they are reused, repaired, remanufactured, or recycled, or a biological cycle, where biodegradable materials return to Earth as nutrients.

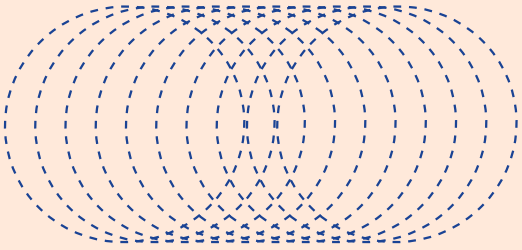
To understand how open-source hardware enables the transition to a circular economy, I will compare open-source principles with the fundamental processes of nature, supporting these ideas with case studies of successful open-source initiatives.

2_WHY THE CIRCULAR ECONOMY NEEDS OPEN-SOURCE HARDWARE

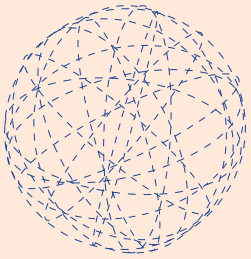
1_Universal Building Blocks – Nature's Open Code

In a circular economy, products must be kept in circulation. In the current structure, this would mean that each product would need to be returned to the original manufacturer for disassembly, repair, or recycling—a process that would be resource-intensive and impractical on a large scale. Nature, however, operates differently; it functions in networks where basic building blocks—fats, proteins, polysaccharides, and minerals—serve as universal resources that any organism can use to build and rebuild complex structures (The Nature of Fashion p. 5).

For a truly circular economy, open-source design is essential. With open-source design, the composition of a product can be „decoded" anywhere, enabling the product to be disassembled and its materials reused locally as new raw materials (see graphic page 4). The Open Funk Mixer, an open-source smoothie mixer, embodies these principles: its blueprints are freely available, allowing anyone to repair, modify, or recycle the materials when needed. The mixer's modular design also enables easy replacement of components, ensuring long-term use.



Circular Economy without Open Source



Circular Economy with Open Source

2_Think Global, Act Local: Local Micro-Productions

Although globally connected, nature operates in a highly decentralized and locally adapted manner. Each organism occupies a unique ecological niche, optimized for its surroundings. Economist John Maynard Keynes observed that „It is easier to ship recipes than cakes and biscuits." Similarly, open-source hardware enables the creation of local microfactories, which, like organisms in their ecological niches, use local raw materials and benefit from short supply chains. WikiHouse, a UK-based initiative providing open-source blueprints for houses, exemplifies this approach. Users can download designs that can be fabricated using standard CNC machines and assembled on-site. This model not only encourages local, decentralized production but also promotes global collaboration, as users share design modifications with the wider community.

3_Wisdom of the Crowd

In nature, 99% of interactions are collaborative, with only 1% based on competition. Species exchange resources and adapt together, leading to system-wide innovations that enhance resilience. In contrast, proprietary systems slow innovation, as companies restrict access to technology through patents, stalling collaboration. Open-source hardware allows anyone to contribute to existing solutions, accelerating innovation and scaling through collective knowledge.

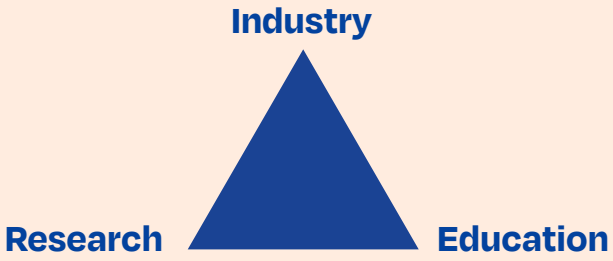
A notable example is 3D printing. Developed in the 1980s, 3D printing remained limited until patents expired, after which the technology flourished, democratizing digital fabrication and rapid prototyping. The RepRap project, an open-source, self-replicating 3D printer, spurred significant advancements within the maker community and catalyzed industrial development in 3D printing (Interview with Tom Dietel).

Studio Hilo's open-source spinning machine also illustrates the power of community-driven innovation. This low-tech machine enables rapid prototyping for local yarn production. Farmers, for example, use it to spin wool from their sheep, while makerspaces and educational institutions explore new possibilities in yarn production. Recently, Studio Hilo and collaborators developed „Elastic Wool," an innovative yarn with natural elasticity achieved without synthetic fibers.

These examples highlight how open-source hardware is essential for the transition to a circular economy. By democratizing innovation and enabling resource-efficient, local production, OSH accelerates sustainable material development. Open-source hardware solutions, such as the wet-spinning machine, empower innovators to progress from concept to prototype without requiring extensive investment, fundamentally changing the landscape for material innovation.

3_THE DESIGNER'S ROLE

For open-source hardware to establish itself sustainably and succeed in the market, designers have two key responsibilities. First, fostering collaboration between research, education, and industry is essential (see graphic below). Universities and research institutions may develop ideas on a laboratory or pilot scale, but industry brings these concepts to market. Designers are trained to quickly adapt to diverse perspectives and facilitate interdisciplinary collaboration throughout innovation processes (Interview Tom Dietel).



Second, open-source technologies must be user-friendly and accessible, as they rely on community engagement. This involves designing modular frameworks that enable expansion and creating clear, visual documentation to reduce entry barriers. Effective community platforms and event formats are also essential for user engagement, while strong branding can foster a sense of belonging around open-source projects, similar to how corporate branding strengthens customer loyalty (Interview Tom Dietel).

4_CONCLUSION

In the transition to a circular economy, open-source hardware provides critical support by accelerating innovation, enabling local and regenerative production, and lowering barriers to entry for material development. Especially in fields traditionally dominated by high R&D costs and industrial machinery, OSH has the potential to democratize access and empower a broader range of innovators. By enabling individuals and communities to contribute to sustainable design, open-source hardware not only complements but also catalyzes the shift towards a resilient, regenerative economy.

Through accessible, inclusive design and strong community facilitation, designers play a pivotal role in this transition. By embedding open-source principles into circular design, they can help build a system that transforms products from waste into resources. As the saying based on Buckminster Fuller goes, "Don't fight the system; make a new system that makes the old one obsolete."

5_BIBLIOGRAPHY

INTERVIEW with Tom Dietel, Co-Founder of Librewater (Helsinki, 15 October 24)

ELLEN MACARTHUR FOUNDATION (2022): An introduction to circular design. Availabe at: https://www.ellenmacarthurfoundation.org/news/an-introduction-to-circular-design (Accessed: 15 October 24)

TED (2018): A healthy economy should be designed to thrive, not grow | Kate Raworth. Availabe at: https://www.youtube.com/watch?v=Rhcrbcg8HBw&ab_channel=TED (Accessed: 15 October 24)

BIOMIMIKRY INSTITUTE (2024): DesignLens: Life's Principles, Available at: https://biomimicry.net/the-buzz/resources/designlens-lifes-principles/ (Accessed: 15 October 24)

BIOMIMIKRY INSTITUTE (2020): The Nature of Fashion, P. 5, Available at: https://fibershed.org/wp-content/uploads/2020/05/2020_05_20_Fashion_as_an_Ecosystem_Fibershed_webinar.pptx-1.pdf (Accessed: 15 October 24)

PREFERRED FIBRES & MATERIALS MARKET REPORT (2022) Availabe at: https://textileexchange.org/app/uploads/2022/10/Textile-Exchange_PFMR_2022.pdf (Accessed: 16 October 24)

ELLEN MACARTHUR FOUNDATION (2022): The Circular Economy and Open Source, Ep. 102 Availabe at: https://www.ellenmacarthurfoundation.org/podcasts/ep-102-the-circular-economy-and-open-source (Accessed: 17 October 24)

OPEN SOURCE HARDWARE ASSICOATION (2024) Availabe at: https://www.oshwa.org/definition/ (Accessed: 19 October 24)

RENEGATE INC. (2017): Kate Rawarth on Creating a Circular Economy, Availabe at: https://www.youtube.com/watch?v=dJ8DIn2vEV0&list=PLSuXP0APdJ1NxGNbPa6LKtUs_jD4bcflg&index=5&ab_channel=RenegadeInc. (Accessed: 19 October 24)

OPEN FUNK (2024): Availabe at: https://www.openfunk.co/de/blogs/news/open-funk-goes-open-source (Accessed: 21 October 24)

JOHN MAYNARD KEYNES (2024) Available at: https://principles.design/examples/wikihouse-10-design-principles (Accessed: 21 October 24)

WIKIHOUSE (2024) Available at: https://www.wikihouse.cc/ (Accessed: 21 October 24)

HILO TEXTILES (2024) Available at: https://www.hilotextiles.com/case-study-stem (Accessed: 21 October 24)

BUCKMISTER FULLER INSTITUTE (2024): System Change, Available at: https://www.bfi.org/about-fuller/big-ideas/systems-change/ (Accessed: 21 October 24)