FRAUNHOFER TWIN TRANSITION SERIES – IMPULSE

# »Green beginnings 2.0: Digitalized circularity for batteries«

In a nutshell:

- Batteries are essential for both the digital transformation and the green transition to store energy sustainably and efficiently.
- The Battery Regulation on circularity, performance, durability, and due diligence is key to reduce raw materials and create a sustainable value chain.
- Digital twins are efficient, consistent, and sufficient means for advancing the battery production and for implementing future regulations accordingly.
- A consistent information structure (also known as knowledge graph) is needed as an interface between the real world with all its complexity and the digital world.
- Political and industrial support is necessary to create and implement fair data spaces and to shape an enabling framework for a successful twin transition.

Storing energy in batteries for later use is a physical concept essential for many technological applications. Batteries are a key enabling technology for a smart and connected mobility sector, an affordable and secure energy system, and a sustainable industrial production. With the new EU Battery Regulation, batteries need to be sustainable, durable, efficient, and circular. To implement the Battery Regulation, we need innovative and digital solutions, which serve as key enablers for a sustainable battery production.

» *It would be much easier if all the information was available in a digital infrastructure, which will be better and more feasible to handle.* «
Chris Eberl, Fraunhofer IWM

In this edition of our Fraunhofer Twin Transition Series, researchers from the Fraunhofer Battery Alliance (represented by Fraunhofer Institute for Mechanics of Materials IWM, Fraunhofer Institute for Production Technology IPT and Fraunhofer Institute for Silicate Research ISC) built on the Twin Transition Webinar on Green Beginnings 1.0, and discussed the usage of standardized digital twins and comprehensive semantic information structures for batteries as a foundation for a successful twin transition. The sustainable production of batteries requires common digital infrastructure, standardized regulations, and support from the industry to implement new data spaces and create suitable business models.

Chris Eberl highlighted that the digital transformation – a key element of the twin transition – is a vital element of the battery production of the future. Green data storage, a sustainable and secure usage and maintenance, as well as the reuse or upcycling of batteries turn into a societal need and a long-term goal for the scientific community, industry partners and policy makers.

» *Information is essential for making the circular economy happen.* «
Anna Cavazzini, MEP

The success of the Green Deal relies on a progressive development of a circular economy and on resilient and sustainable global value chains. For these to succeed, standardized sets for the circularity, performance and regularity of the battery production are necessary. Our patron of the webinar, Member of the European Parliament Anna Cavazzini, stressed that the addition of new

raw materials needs to be reduced as much as possible by creating a full product cycle and by relying on secondary materials.

The introduction of the battery passport will put these regulations into a standardized form, explaining the production costs and guaranteeing longer life cycles and higher durability.

Our Fraunhofer experts, Alexander Kies and Guinevere Giffin, took a deep dive into the technical implementation of digital twins and a comprehensive semantic information structure to achieve the twin transition in the battery production.

## Interaction of Digital Twins in a sustainable battery cell production

A digital battery twin is – in simplified terms – the digital representation of a battery, capturing both state information and behavior. Alexander Kies underscored that the usage of a digital twin enables a reduction in complexity through abstraction of the physical world while increasing the efficiency, consistency and sufficiency and thus making battery cell production more sustainable. Having a digital counterpart of the physical object also facilitates technical and standardized solutions for product related data to be used for the battery passport or life cycle assessment (LCA). Overall, the digital twin leads to more transparency and a better target orientation, making circular models and open data approaches possible.

## Towards a comprehensive semantic information structure in the battery value chain

A circular economy relies heavily on information: in addition to the question about "what is in the product?", the information about the production process increases in importance. A comprehensive semantic information structure along the entire battery value chain answers this question. The result is a human and machine-readable knowledge graph, acting as a digital information twin of both the battery and the value chain. This semantic layer overlaying all materials and processes does not only provide the connection to model based digital twins but also automated access to all information required for upcoming regulations like the battery passport and LCA applications.

## The future is green and circular: Support for research and production

Standardized digital twins and semantic information layers form the foundation for the twin transition in the battery ecosystem. The combination of all processes in the value chain will be used for the development of suitable and target-oriented solutions, as well as for the creation of a fair data space. It is up to the industry to implement these usable data spaces and develop new business models for a green battery production. **Policy makers need to create a regulatory environment for standardized approaches. The framework conditions and funding situation for research and innovation need to level the complexity of the ecosystem**.