INSIGHT SERIES

FROM EXPERTISE TO IMPACT

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Scaling Up Solid-State Batteries | The HyLiST Project's Path from Lab Innovation to Industrial Production

Abstract

Solid-state batteries are widely recognised as a key enabler for the next generation of high-performance, safe, and sustainable energy storage systems. Yet, moving from laboratory concepts to industrial-scale manufacturing remains one of the most critical challenges. This article explores how the HyLiST project addresses this gap by defining the boundary conditions for producing solid-state battery cells at a scale of up to 1 GWh per year. By comparing laboratory-scale processes with large-scale manufacturing concepts, the article highlights the technical constraints, scalability challenges, and critical process parameters that shape industrial feasibility. From electrode fabrication and solid electrolyte processing to stacking, sealing, and formation, the analysis provides a clear picture of what it takes to translate advanced materials into manufacturable battery cells. Written to engage both technical and non-technical audiences, this blog illustrates how HyLiST is laying the groundwork for reliable, scalable, and competitive solid-state battery production in Europe.

Solid-state batteries (SSBs) promise a step change in energy storage, offering higher energy density, improved safety, and greater thermal stability compared to conventional lithium-ion batteries. These advantages make them particularly **attractive for demanding applications** such as electric mobility and aviation. However, while material innovations continue to progress rapidly, manufacturing scalability remains a decisive bottleneck.

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Aspect	EV KPI
Cell Energy Density (grav.)	>500 Wh/kg (future target)
Volumetric Energy Density	>700 Wh/L (cell)
Fast Charge	<20 min
Rate Performance	≥90% retention @ 3C
DCIR	<2 mΩ (20Ah)
Cycle Life	>1000 cycles
Thermal Stability	>180°C; nail penetration
Swelling/"Breathing"	<5% over 1000 cycles
UN 38.3	Mandatory

Aspect	Aviation KPI
Pack Installed Energy	400 kWh (350–450)
Nominal Voltage	≥850 V
Total Weight	≤1200 kg
Thermal Propagation	<3 min
Temp Range	–40 to +70°C
Certifications	FAA/EASA, CS23

Table 1 main KPIs for aviation and ev cells

The **HyLiST project tackles this challenge by bridging the gap between laboratory development and pilot production**. A key milestone in this effort is the definition of production boundary conditions for solid-state battery cells designed for large-scale manufacturing. Understanding these boundary conditions is essential to ensure that advanced cell designs can be produced reliably, safely, and at competitive cost.

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From Laboratory Cells to Industrial Reality

At laboratory scale, solid-state battery production **relies heavily on manual operations and small-format cells**, such as coin cells. These environments allow for high flexibility and precise control of individual parameters but offer limited throughput and reproducibility. In contrast, industrial production requires continuous, automated processes capable of delivering consistent quality across millions of cells. **The fine tuning of the process to reach quality consistency and process validation requires intermediate steps for pilot production**.

HyLiST addresses this transition by analysing both lab-scale and large-scale production routes for pouch-type solid-state batteries, to have a broad overview of the pathway required to achieve a **complete industralisation of solid-state cell manufacturing**.

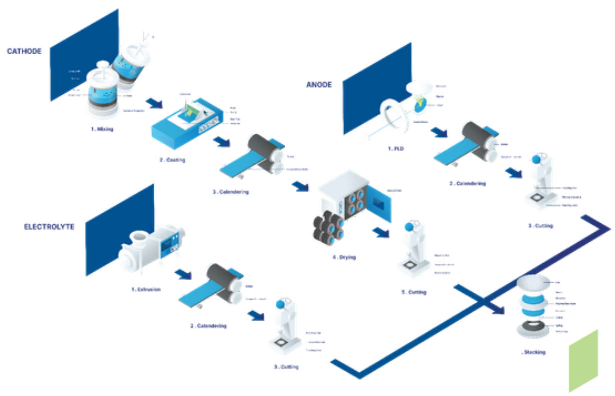

Figure 1 – Lab scale production process

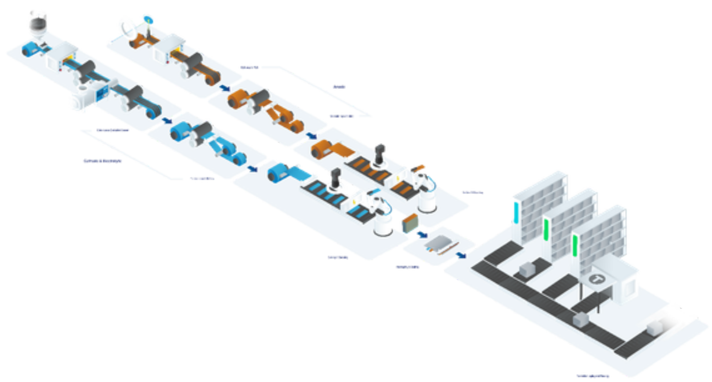

Figure 2 – large scale production process

Electrode and Electrolyte Production

The **first phase** of production involves **manufacturing the cathode, anode, and solid electrolyte as independent components**. In HyLiST, the cathode is based on high-voltage, cobalt-free LNMO material combined with single-ion conducting polymer binders. This design supports high areal loadings while maintaining electrochemical stability.

At laboratory scale, cathode fabrication typically uses batch mixing, blade coating, and vacuum drying. **Scaling this process requires continuous extrusion coating, integrated drying, and in-line calendering**, with strict control of thickness, porosity, and solvent removal.

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For the anode, HyLiST explores ultrathin lithium metal layers protected by inorganic barrier coatings. While **pulsed laser deposition (PLD)** is effective at lab scale, its scalability to roll-to-roll industrial operation represents a **major technical challenge** for gigafactory-level production. Establishing pilot lines to trial the process at an intermediate stage can help achieve the desired objective. Within HyList the first examples of this technology have already been developed.

The solid electrolyte is another critical element. **HyLiST focuses on hybrid single-ion solid polymer electrolytes that can be processed using solvent-free extrusion methods**. Achieving uniform ionic conductivity, mechanical integrity, and stable interfaces at high throughput is essential for industrial viability.

Cell Assembly and Finishing

Cell assembly in solid-state batteries resembles conventional lithium-ion processes but with specific conditions. The **materials require special attention to stacking precision, pressure control, and environmental conditions**, as these can become increasingly critical when handling solid electrolytes and lithium metal anodes.

In large-scale concepts, **automated cutting and stacking systems replace manual handling**, enabling sub-millimetre alignment accuracy and high throughput. **Packaging and sealing operations benefit from the absence of liquid electrolytes**, eliminating filling and degassing steps while improving safety. The final stages - formation, aging, testing, and grading - remain essential to stabilise interfaces and verify cell quality. While solid-state batteries are expected to require shorter formation and aging times than liquid-based cells, optimised protocols are still under development to meet stringent performance and safety requirements.

Scaling Challenges and Limiting Factors

HyLiST's analysis highlights **several limiting factors** in scaling solid-state battery production to 1 GWh per year. These include ensuring uniformity across wide-format coatings, maintaining interface integrity over large areas, industrialising lithium metal deposition, and implementing fast, non-destructive quality control.

Even **small variations in process parameters can lead to significant yield losses at gigawatt scale**. As a result, robust process monitoring, automation, and in-line inspection are not optional but fundamental enablers of industrial success.

The transposition from **lab to gigawatt scale requires an adaptation** of the process parameters that can only come from process industrialization **through pilot plants**, especially in highly innovative process steps such as pulse laser deposition or extrusion of the solid electrolyte.

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Conclusion

HyLiST's approach to defining production boundary conditions is a strategic effort to bridge laboratory research and industrial-scale manufacturing in solid-state battery development. By creating a unified technical framework, the project enables consortium partners to collaborate effectively across materials, equipment, and pilot-line implementation. This work informs downstream activities - especially pilot-scale production and system integration - by identifying risks and gaps, guiding technology choices, and establishing priorities for process development. HyLiST's structured methodology **strengthens Europe's role in solid-state battery manufacturing by focusing on scalable production processes** as much as materials innovation. Ultimately, the project provides a **roadmap for transitioning advanced battery designs from the lab to gigafactory scale**, paving the way for safer, high-performance batteries and future commercial deployment of next-generation energy storage technologies.

About the authors

Susanna Beltrame *is Head of MBA Market & Business Operation at ANDRITZ Sovema, where she leads global marketing and business operations for battery manufacturing solutions within the ANDRITZ Battery Division. With over 10 years of experience in the battery industry, she has built a strong combination of industrial knowledge and strategic expertise, working across both lead-acid and lithium-ion technologies.*

Her career has evolved from operational and market-focused roles into a leadership position with responsibility for international marketing strategy, cross-functional coordination, and business development activities. She plays a key role in positioning advanced battery manufacturing technologies, supporting innovation projects, and translating technical developments into market-relevant solutions.

In EU-funded initiatives such as HyLiST, Susanna contributes to the dissemination and industrialisation perspective, ensuring alignment between technical developments and market needs. Her work focuses on enabling the transition from research to scalable industrial solutions, supporting the growth of a competitive and sustainable European battery ecosystem.

Nicola Benoni *is a Design Engineer at ANDRITZ Sovema, specialising in battery manufacturing equipment and industrial process development. He holds a Master of Science in Mechanical Engineering from Politecnico di Milano, where he developed a strong foundation in mechanical design, production systems, and process optimisation. His early career focused on production process engineering and industrial systems, including roles involving both European and international manufacturing environments.*

Since joining ANDRITZ Sovema, Nicola has been actively involved in the development of machinery and processes for lithium-ion battery production, also focusing on emerging solid-state technologies. His work combines equipment design with process understanding, covering key steps such as cell assembly, and scale-up considerations. Within EU-funded projects such as HyLiST, he contributes to defining scalable manufacturing routes, analysing critical process parameters, and bridging the gap between laboratory development and industrial implementation.

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