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BioBoosters Impact Review 2025

Outlook on a Year of Innovation, Integration, and Interregional Impact

Edited by Heli Väliaho

Jamk University of Applied Sciences

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Bioeconomy business accelerator, BioBoosters by Jamk and the BioBoosters community aroud the Baltic Sea Region are employing a business-driven hackathon concept to boost circular transition of the bioeconomy sectors. This publication explores nine innovation journeys of leading bioeconomy companies around the Baltic Sea that shared their challenges at the BioBoosters Hackathons organized in autumn 2024 and spring 2025. With the support of the BioBoosters, these companies apply open innovation to find co-operation partners and solutions for greater circularity, sustainability, and profitability of their operations.

BioBoosters hackathon leverages the networks and knowhow of nine regional bioeconomy innovation systems connecting cross-sectoral and international expertise whit open innovation excellence. The nine impact stories highlight the barriers, enablers, and success factors of circular transition on the bioeconomy sectors of the Baltic Sea Region. They also showcase the impact of open innovation and inter-regional co-operation. The lessons learned from the hackathons boosted by the international innovation community are recounted and the conclusion is clear-BioBoosters Hackathon is making an impact!

Keywords: bioeconomy, hackathon, sustainable development, innovations, circular economy, open innovation

Foreword: Year of Innovation, Integration and Interregional Impact

Anni Hintikka, Jamk University of Applied Sciences, Finland
Anna Aalto, Jamk University of Applied Sciences, Finland

As 2025 draws to a close, the BioBoosters innovation community offers a compelling case study in how smart and sustainable bioeconomy is evolving —not just through technology and innovation, but through collaboration, experimentation, and systems-level thinking (BioBoosters, 2023).

We've seen the ecosystem mature from pilot initiatives into a dynamic platform for innovation, collaboration, and real-world impact. By bringing together startups, industry leaders, researchers, and regional actors, we've built a community that doesn't just respond to challenges—it anticipates them. The integration of cutting-edge technologies with practical testing environments has accelerated the development of scalable solutions for sustainable agriculture and bioeconomy (Jamk University of Applied Sciences, 2025d).

We are especially impressed by how seamlessly research and business have been combined—this synergy is generating tangible results and shaping the future of circular bioeconomy

BioBoosters Programme 2025 Unites Seven Growth Companies with Industry Leaders

The second year of BioBoosters programme continued connecting innovative growth companies with a valuable network of leading industrial corporations, investors, potential customers, and end users (Jamk University of Applied Sciences, 2025d). Operated together with leading industrial partners Valtra, AGCO Power, Neste, Lantmännen, and Innovestor this year's special focus was on smart farming solutions for data-driven farm operations, future energy sources and powertrain solutions for agricultural machinery and farming equipment and emission calculation and ESG reporting in food value chain.

Over 900 European growth companies were reviewed for the programme during the spring. Approximately 20 most suitable companies were interviewed together with the partners of which seven now join the programme.

Technological innovations include e.g. AI-controlled batteries, chemical-free weed and pest control using lasers and microwaves, tools to simplify

critical emissions measurement and reporting, and quantum computing that helps simulating complex natural phenomena (Jamk University of Applied Sciences, 2025d). The companies selected under the 2025 BioBoosters programme are:

- Batemo, Germany: High-precision simulation software for lithium-ion batteries
- Delta Cygni Labs, Finland: optimised industrial connection and connectivity
- Escarda Technologies, Germany: Laser-based weeding robot
- Improvin, Sweden: Operating system that measures, reports and reduces greenhouse gas emissions from the agricultural value chain
- Mavarick, Ireland: Platform that automates the full lifecycle of Scope 3 emissions reporting
- Quanscient, Finland: Multiphysics simulation platform using quantum computing algorithms to model complex scenarios
- WinterLeap, Norway: The world's first solution for removing pests and weeds during winter

The programme partners are impressed by the solutions offered by the participating companies.

> I'm really happy with the outcome. There are great innovations, and they are well prepared to further develop their solution. I'm looking forward to continuing discussions with these companies. It looks really promising so far. – Tommi Terävä, head of business development at Valtra, at the beginning of the programme.

The year began with a strong emphasis on technological convergence. The integration of microwave technology, multiphysics simulation, and artificial intelligence into agritech solutions signals that innovation in agriculture is becoming increasingly interdisciplinary. Lantmännen, an agricultural cooperative and one of Northern Europe's leading players in agriculture, machinery, bioenergy, and food sectors, joined the programme's partner team—bringing even more real-life testing and development opportunities. Building on the insights gained from last year's programme, this year inspires confidence that the emerging smart agrotechnology ecosystem will begin to foster meaningful collaboration and co-creation of new innovations in the market.

Agriventure Finland: A Meeting Point for Agritech Evolution

The Agriventure Finland 2025 event brought together nearly 450 international participants, creating a space where startups, researchers, and industry leaders could engage in meaningful dialogue (Jamk University of Applied Sciences, 2025b). The event served as a reminder that innovation is not only about new products—it's about shared understanding and cross-sectoral learning. The diversity of perspectives present underscored the importance of building inclusive innovation ecosystems.

This year's event focused on more sustainable food production chain emphasizing phenomenon and issues related to data-driven agriculture, business and productivity and reducing carbon dioxide emissions. The latest agrotechnology was showcased in the Farming 3.0 technology demonstrations with practical field demos and at various exhibitor stands. The field demos included an autonomous field robot, drone technology supporting agriculture, and precision weed identification using sensor technology.

17 startups from across Europe participated the startup's pitching competition. The competition winner was NPHarvest, whose solution for converting wastewater into fertilizer exemplifies the kind of circular thinking that BioBoosters aims to foster (Jamk University of Applied Sciences, 2025c). Their success was not just about technical feasibility—it reflected a broader shift toward rethinking value creation in agriculture, where waste becomes a resource and sustainability becomes a business driver.

> Sustainable use of natural resources and the utilisation of technology in solving climate issues are key. Therefore, it is important to highlight new innovations and provide a place for networking for companies, financiers, researchers, farmers, and future experts. The impressive international turnout and enthusiastic feedback from the event show that there is clearly a demand for event like this. – Minna Lappalainen, Director of the Bioeconomy Institute.

Hackathon Model: Piloting Open Innovation Across Borders

Year 2025 marked the closure of two-year piloting of the BioBoosters Hackathon model in international cooperation (BioBoosters, 2023). Designed to match competence with business needs, the Hackathon process has proven to be a powerful tool for addressing the challenges bioeconomy businesses face in transitioning to circular models.

Spanning 9 regions across the Baltic Sea, the Hackathon model facilitated cross-sectoral knowledge transfer, connecting SMEs, startups, and research groups with companies in an open innovation framework18 business-driven Hackathons validated 120+ solution ideas for circular transition challenges. Over the course of the two-year pilot:

- 246 teams from over 20 countries applied to participate.
- 23 RDI and business collaborations were initiated, including 13 international partnerships.
- More than 500 specialists actively contributed, with 1,800+ members now part of the BioBoosters LinkedIn community.

The feedback has been overwhelmingly positive:

- 98% of challenge providers reported receiving a promising solution.
- 95% of solution providers gained valuable knowhow through mentoring.
- 94% agreed the Hackathon is a strong tool for building partnerships and testing ideas.
- Among mentors and organizers, 94% believe the Hackathon supports the green transition, 93% see it as supporting growth in bioeconomy sectors, and **92% recognize its role in transferring best practices across the region.

These results suggest that the Hackathon model is not only effective—it's scalable and transferable. It offers a blueprint for any innovation hub seeking to support regional business networks in their green or digital transitions.

European Collaboration and Real-World Testing

BioBoosters also contributed to the selection of 12 European agritech startups for the EIT Food Test Farms programme, enabling real-world testing of innovations in farm environments (Jamk University of Applied Sciences, 2025a). This initiative reinforces the importance of grounded experimentation and cross-border collaboration in scaling sustainable solutions. As a university, we play a meaningful role as the Nordic coordinator of the EIT Food Test Farms programme, bridging research and practice to support innovation in agriculture.

Looking Ahead: From Pilots to Practice

The lessons from 2025 are now being translated into sustainable practices within participating organizations. The BioBoosters network is consolidating its operational model to ensure that the momentum built this year continues beyond the project lifecycle (BioBoosters, 2023).

What emerges from this year is a clear message: innovation in bioeconomy is not just about solving problems—it's about building relationships, sharing knowledge, and creating structures that allow good ideas to grow. The proven demand-driven innovation excellence of BioBoosters stands out as a springboard for circular bioeconomy cooperation—not just in the Baltic Sea Region, but potentially far beyond.

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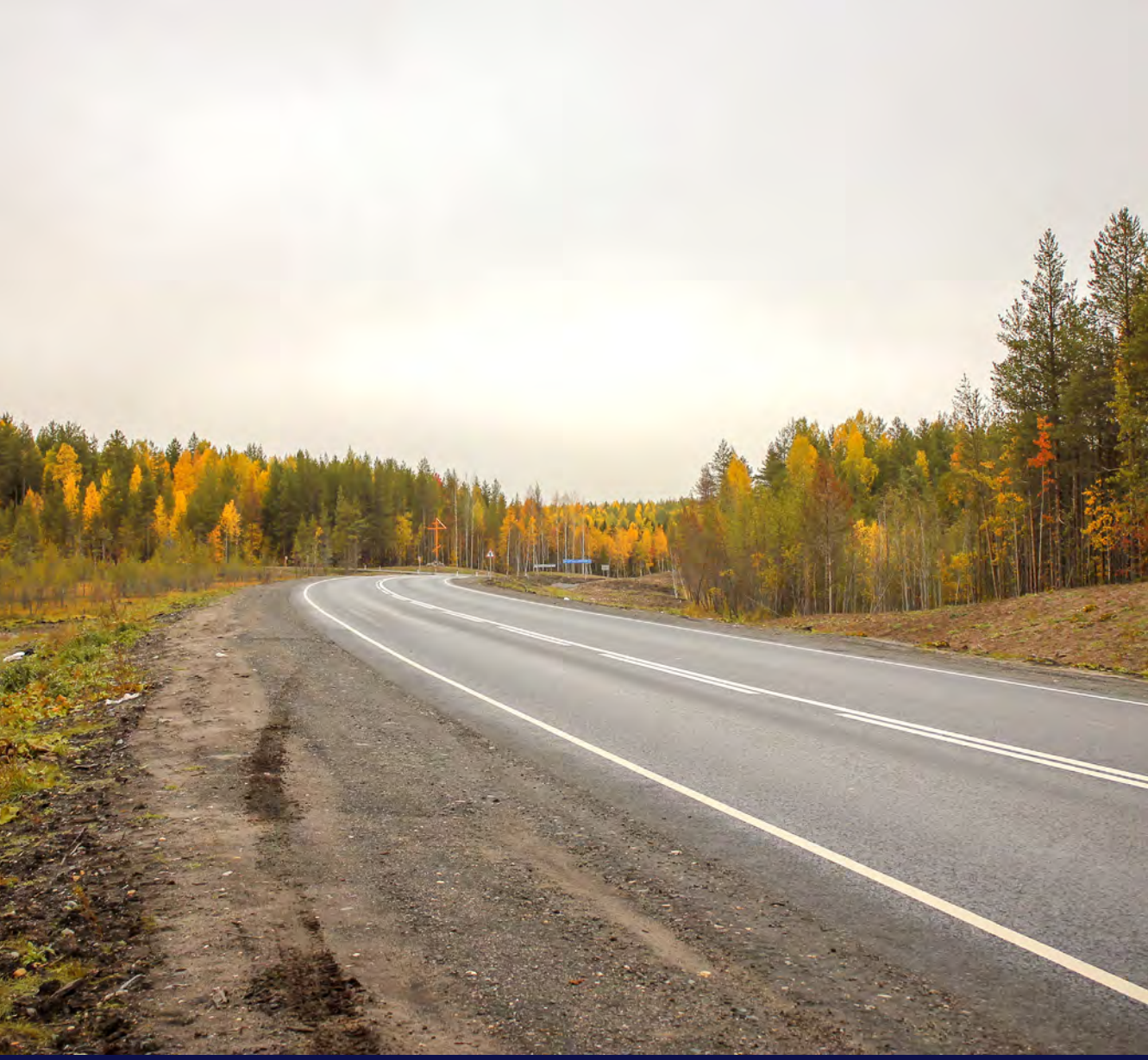


Theme 1

Twin Transition, Digitalisation for Sustainability

LiukasHackathon: Smart Logistics for a Circular Future

Matti Räsänen, Jamk University of Applied Sciences

Biogas is a cornerstone of Finland's green transition, but its growth brings new challenges. As production scales up, nutrient recycling logistics must keep pace—ensuring that recycled nutrients move efficiently from plants to fields without creating unnecessary emissions or costs. This is not just an operational issue; it is an environmental one. Reducing phosphorus runoff into the Baltic Sea and improving resource efficiency depend on smarter logistics systems that can handle seasonal peaks, dispersed locations, and complex documentation. Scaling up biogas means scaling up logistics capacity and digitalisation to ensure that energy growth does not decouple from nutrient stewardship.

Picture 1. A slurry tanker on the left pumping digestate from a storage tank on the right during nutrient recycling operations (Photographer: Tero Liukas Oy)

Briefing the Bottleneck

Finland aims to reach 4 terawatt-hours of biogas annually by 2030—about four times today's output, with technical-economic potential roughly tenfold the current level (Biokaasu2030, 2024). For a logistics operator like Kuljetus Tero Liukas Oy, this ambition turns recycled-nutrient transport from a background routine into a strategic capability. Rather than commission a closed IT build, the company turned to BioBoosters by Jamk and opened its challenge to international innovators—seeking a modular, data-driven solution that would make every kilometre and every load count (Jamk University of Applied Sciences, n.d., 2024a).

Biogas growth materialises in the real world as more frequent, seasonal and geographically dispersed movements of slurry and digestate. These flows depend on plant operations, weather and farm capacity—factors that rarely align neatly. As movements scale up, fragmented information on tank levels, route options and documentation can undermine operational efficiency and environmental performance (Jamk University of Applied Sciences, 2024a).

The logistics provider already works at this interface, serving hundreds of farms and biogas plants in Southern Finland. Crucially, the company uses NIR (Near Infra-Red) nutrient measurement during loading to capture NPK values, building evidence for on-field dosing and plant-to-farm transfers. This practice also supports regional phosphorus balancing—moving nutrients from surplus to deficit areas—when paired with traceable documentation at the point of dispatch (Kuljetus Tero Liukas Oy, n.d.; Suomen Biokierto ja Biokaasu ry, 2024).

The specification called for a smart, integrated solution that could:

- digitise waybills, invoicing and reporting,
- interface with existing fleet systems such as Mapon, and
- incorporate NIR-based nutrient data in a practical workflow for dispatchers, drivers and farmers (Jamk University of Applied Sciences, n.d).

This is exactly where CiNURGi enters. CiNURGi is an Interreg Baltic Sea Region project advancing a circular nutrient economy by improving infrastructures and standards and piloting solutions across agricultural, municipal and industrial biomass streams. Its objectives—traceability, safety and agronomic efficiency—depend on logistics workflows that can prove what moved, where and with what nutrient content (Interreg Baltic Sea Region, n.d.; Research Institutes of Sweden [RISE], n.d.). The hackathon brief was fully aligned

with these aims: without data-rich transport, even state-of-the-art recycling technologies cannot deliver their environmental promise in the field.

Why NIR Data Matters

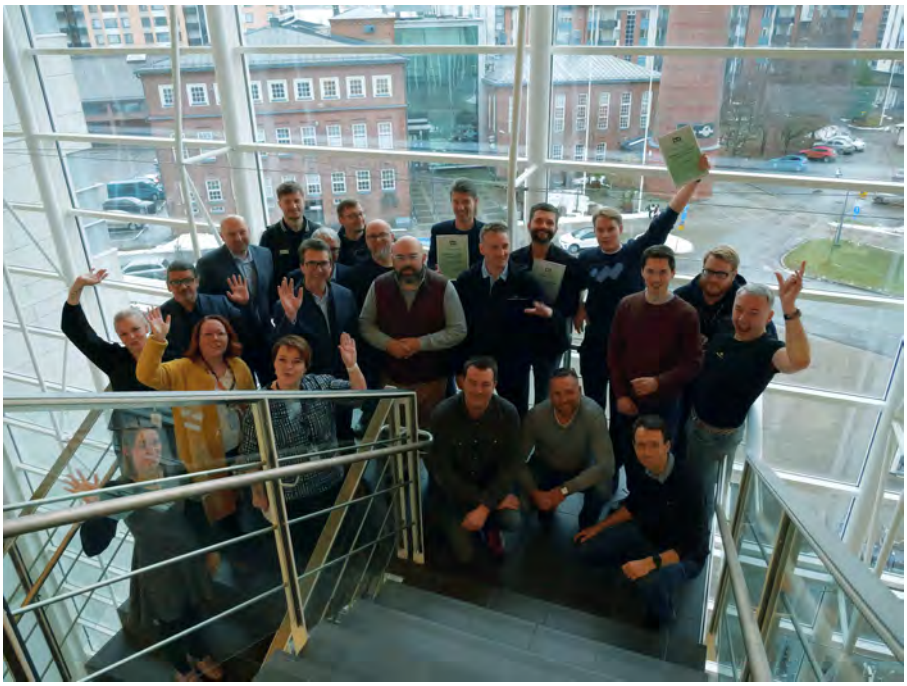
NIR turns nutrient logistics from volume-based hauling into value-based distribution. Analysing slurry or digestate at loading enables:

- Targeted application: matching nutrient supply to crop demand, reducing over-application and leaching risks.
- Verifiable documentation: providing nutrient content data that supports compliance and farm advisory services and strengthens trust with plants and authorities.
- Regional redistribution: underpinning transfers from phosphorus-surplus to deficit areas with measured content, not estimates (Suomen Biokierto ja Biokaasu ry, 2024).

For farms, this translates into better fertilisation decisions and potential savings on mineral fertilisers. For the environment, it means lower runoff and improved water quality as nutrient surpluses are managed more precisely. For the logistics provider, NIR creates a service advantage—logistics becomes a data-enabled advisory function, not only a movement of tonnes (Kuljetus Tero Liukas Oy, n.d.; Interreg Baltic Sea Region, n.d.). For instance, real-time nutrient data can help farmers adjust application rates on the same day, reducing the risk of runoff during heavy rain. This capability supports adaptive management, which is increasingly important under variable weather conditions.

How We Ran the Process

LiukasHackathon took place on 25–26 November 2024 at Jamk's Bioeconomy Campus in Saarijärvi. The open call attracted 15 applications from across the Baltic Sea Region, with finalists representing Finland, Estonia, Sweden and Poland. Over two days, teams worked alongside mentors to refine concepts for scalability, sustainability and market fit (Interreg Baltic Sea Region, 2024; Jamk University of Applied Sciences, 2024b).



Picture 2. Participants of LiukasHackathon at Jamk's Dynamo Campus staircase, with winning teams holding diplomas (Photographer: Jamk, Veeti Väänänen)

Two design choices shaped the process:

1. Practical evaluation criteria. Usability and ease of implementation ranked alongside technical merits. Readiness to interface with Mapon, ability to digitise waybills and invoicing, and capacity to handle nutrient data as operational inputs were explicit assessment points (Jamk University of Applied Sciences, n.d).
2. Clear line to piloting. The organiser communicated that top solutions would move beyond slide decks toward a pilot phase, supported by the national Programme for Nutrient Recycling (Interreg Baltic Sea Region, 2024; Jamk University of Applied Sciences, n.d).

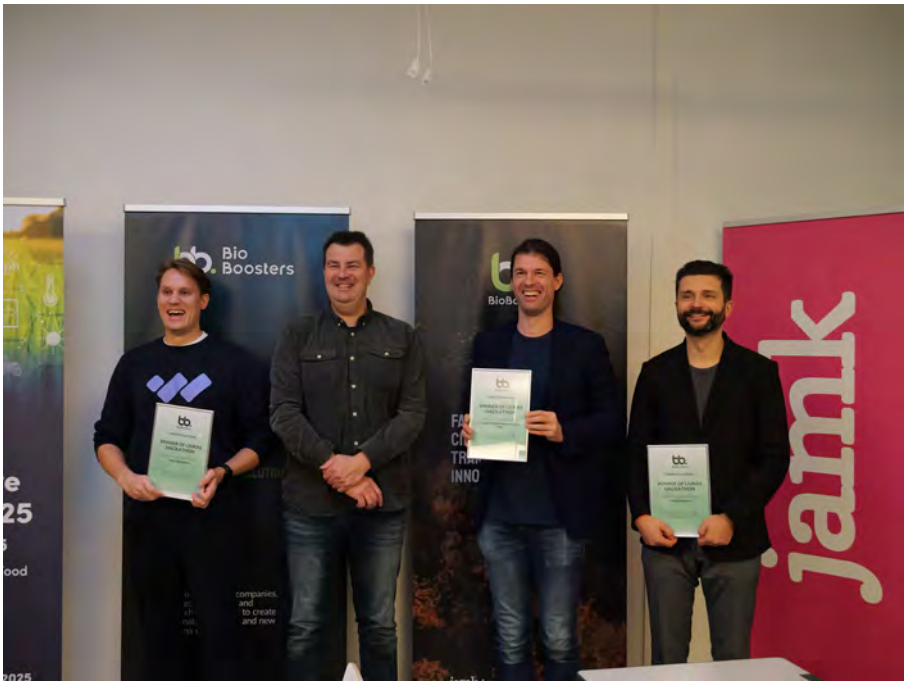
Mentors from business, innovation and digitalisation guided teams to reduce complexity without compromising traceability. The hackathon highlighted the value of an open innovation setting at Jamk's Bioeconomy Campus, where regional and international experts collaborated using real-world testing facilities.

One key learning was that a single, monolithic platform would not meet SME needs. Instead, a modular approach—combining routing, documentation and nutrient data—proved more feasible and scalable. This insight shaped the decision to select three complementary winners rather than one.

Outcome: Three Pieces, One System

On 26 November 2024, the jury selected three complementary winners—Aiseemo (Poland), Freight Automation by Hogs (Poland) and Waybiller (Estonia)—with the explicit plan to combine their strengths into a modular solution (Interreg Baltic Sea Region, 2024; Bioeconomy , 2024). This composition covers the core operational flow:

- Routing and dispatch optimisation to reduce dead runs and align routes with capacity windows.
- Digital waybills and invoicing to eliminate duplicate data entry and paperwork lag.
- Capacity and status visibility to shorten feedback loops between dispatch and on-farm operations.



Picture 3. Winning teams Waybiller, Freight Automation by Hogs and Aiseemo presenting their diplomas at LiukasHackathon day 2. (Photographer: Jamk, Veeti Väänänen)

As Tero Liukas, CEO of the challenge-providing company, explained: ”It was not worth selecting a single winner, because combining the solutions of three of the teams involved in the competition will create a truly impressive solution.” (Bioeconomy, 2024).

Connected Agendas: CiNURGi & Biogas 2030

CiNURGi seeks to build a circular nutrient economy across the Baltic Sea Region by improving infrastructures, quality assurance and uptake for recycled nutrient fertilisers, and by piloting practical solutions (Interreg Baltic Sea Region, n.d.). The RISE project page confirms a broad partnership—including the logistics provider—underscoring that the pilot is embedded in a regional coalition, not a one-off test (RISE, n.d.). CiNURGi’s emphasis on agronomic efficiency, economic viability and environmental safety aligns directly with data-rich logistics workflows that can verify nutrient movements and qualities. The LiukasHackathon outcome illustrates how these goals translate into

practice: creating traceable, data-driven logistics workflows that can serve as a model for other regions facing similar nutrient management challenges.

Running in parallel, Biokaasu2030 provides the demand signal: scaling biogas in Finland entails scaling recycled-nutrient logistics—not just more trucks, but more data-enabled movements that underpin precise targeting and verifiable environmental benefits. The hackathon's combined solution is designed to bridge operations and evidence so that energy growth does not decouple from nutrient stewardship (Biokaasu2030, 2024).

Scaling Up: What Comes Next

The next phase is about moving from concept to practice through real-world piloting. The combined solution will integrate three core elements—routing optimisation, digital documentation and nutrient data—into a single operational workflow. This means replacing paper-based waybills with digital records, linking NIR measurements directly to transport data, and providing dispatchers with real-time visibility of fleet and storage capacity.

For customers, this translates into faster turnaround times and more accurate nutrient documentation that supports farm-level planning. For biogas plants, it means better coordination and predictable capacity use. For the environment, the impact could be significant: by enabling precise nutrient transfers and reducing unnecessary trips, the system helps curb phosphorus runoff—a critical step toward improving the status of the Baltic Sea.

Technology capacity has already expanded, with multiple NIR devices now in use across the fleet. These upgrades strengthen the ability to capture real-time nutrient data and prepare the ground for broader adoption of data-driven logistics in nutrient recycling.

LiukasHackathon	
Challenge	Smart logistics for recycled nutrients: integrating routing, digital documentation and nutrient data to improve efficiency and traceability.
Target groups	Logistics operators, biogas plants, farms, digital solution providers, agritech companies, research groups, students.
Organiser	Jamk University of Applied Sciences, BioBoosters by Jamk
Mentors	Jamk University of Applied Sciences (Finland), iToDEV (Lithuania), Sunrise Tech Park (Lithuania), Pärnu County Development Center (Estonia), Pro Civis Foundation (Poland), Finnish Biocycle and Biogas Association (Finland), RISE – Research Institutes of Sweden (Sweden)
Hackathon days	25–26 November 2024, Bioeconomy Campus, Saarijärvi, Finland
Applicants	15 applications. 6 from Finland, 2 from Estonia, 1 from Sweden, 3 from Poland, 1 from Spain, 1 from Lithuania, 1 joint team from Denmark and Finland
Selected teams	Finalists from Finland, Estonia, Sweden, Poland
Winners	Aiseemo (Poland), Freight Automation by Hogs (Poland), Waybiller (Estonia)
Impact	The hackathon initiated the development of a modular solution combining routing optimisation, digital waybills and nutrient data integration. The approach supports more efficient logistics, reduces empty runs and enables traceable nutrient flows—critical for reducing phosphorus runoff and improving the status of the Baltic Sea.
UN Sustainable Development Goals	

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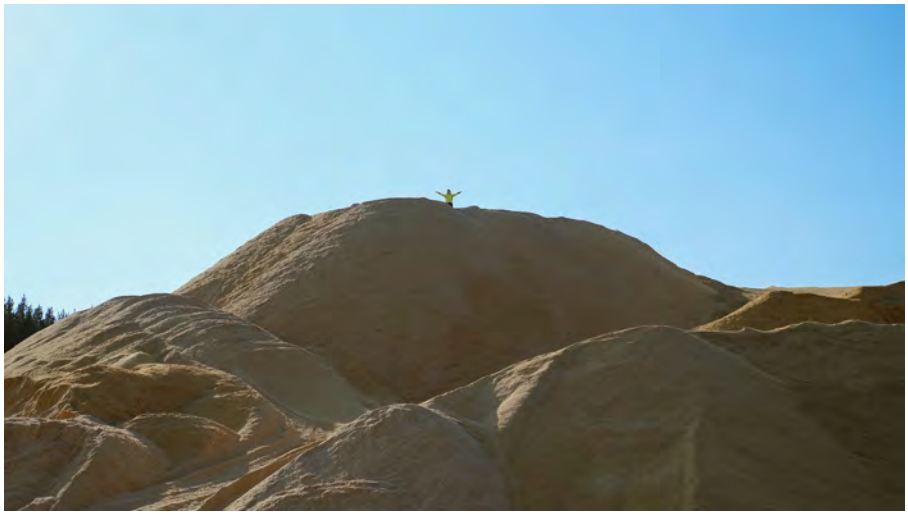
Skellefteå Kraft Hackathon: Approaches to Forest Residue Optimization

Eva Fridman, BioFuel Region, Sweden
Ida Norberg, BioFuel Region, Sweden
Moa Jonsson, BioFuel Region, Sweden

For decades, Skellefteå Kraft has been a driving force for both energy and regional development in northern Sweden. As one of the country's largest energy companies, it supplies heat, cooling, and electricity to tens of thousands of households and businesses – powered by raw materials sourced from the forest. At Hedensbyn, one of Skellefteå Kraft's CHP (combined heat and powerplant), 500 000 tons of sawdust, wood chips, and bark are transformed into reliable warmth in homes and hot water in the tap, yearly. During storage of the material the decomposition varies depending on different physical properties of the raw material e.g. moisture and fraction size.



Picture 1. The biomass piles. (Photographer: Henson)

District heating is the most common form of heating for blocks of flats and commercial premises in Sweden. All major cities and towns have district heating systems (District heating, n.d.), and in 2023 there were 266 CHP plants in the country (Svebio, n.d). District heating means that water is heated at a large plant and then distributed through pipes in the ground to reach houses and flats in a city. The cold water in the houses is heated through heating exchangers by the warm water coming from the pipes, resulting in warm houses inside and warm water in the shower (Rydegran, n.d).

Biofuel plays a major role in district heating production, and from the years 1980 to 2000, district heating production went from a share of 90 percent fossil fuels to 90 percent biofuels. This has reduced Sweden's dependence on oil, reduced climate emissions and has also been positive for the economy (Swedish Energy Agency, n.d). Biomass are stored in piles and there are recommendations on how different assortments should be stored and how to best avoid fire in piles (Svebio, 2021). Examples of assortments commonly used at CHP-plants are sawdust, wood chips, recovered wood chips, bark and branches and tops (GROT).

New climate and environmental policies, new industries competing for green carbon and the war in Ukraine have a major impact on the supply and price of bio-based raw materials. This will affect the available amounts of biomaterials, define which products and raw materials are considered renewable and sustainable, resulting in an increased need for efficient management of biomass (Wennberg, 2023). This lead Skellefteå Kraft, to launch its challenge "Track the Stack". The aim was to start the journey for a more raw-material efficient and traceable operation to minimize losses due to e.g. decomposition and at the same time address the risks of fire due to self-combustion. The starting point was digitalizing the raw material characteristics, volumes and placements at their CHP plant in Hedensbyn.

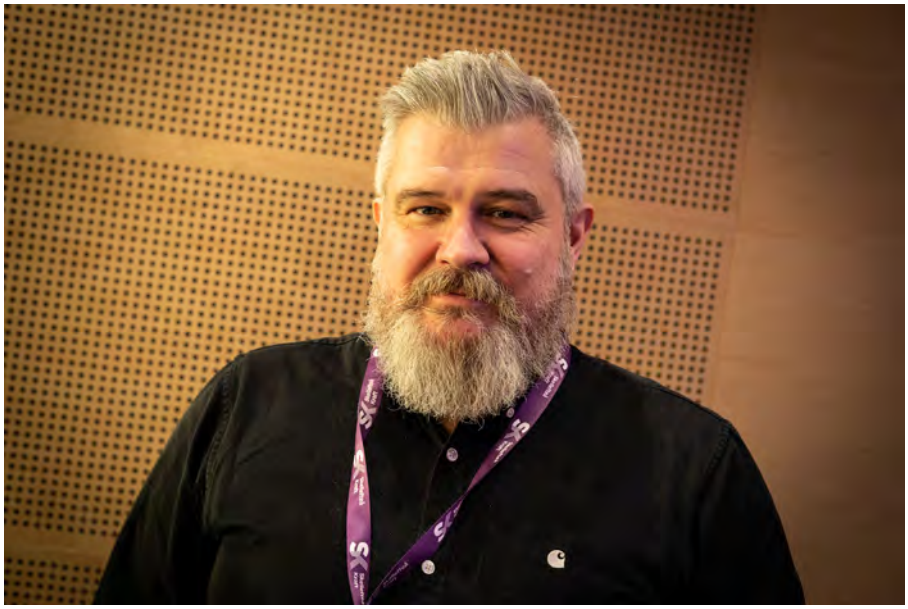
Picture 2. Anna Säfvestad Albinsson, Skellefteå Kraft and the biomass piles. (Photographer: Henson)

Ass. Professor Dan Bergström at the Swedish University of Agricultural Sciences, SLU, who's research spans over a broad spectrum of the forest biomaterials value chain, states that the challenge is relevant for all CHP plants in Sweden. His colleague, Ass. Professor Erik Anerud, a keynote speaker at the launch webinar of "Track the stack", showed that getting reliable data on the fuel quality of the biomass i.e. chemical, physical and mechanical properties would help to minimize e.g. storage losses, improve the calculation of energy content and optimize the final feed to the boiler. This was shown by performing large scale trials across Sweden on how to improve the storage of biomass, for example to cover the piles (Anerud, Bergström, Routa & Eliasson, 2021) or to remove fines by sieving (Anerud, Bergström, Routa & Eliasson, 2022).

International Relevance of the Challenge

The challenge has international relevance, which is described by Senior Researcher Gilbert Ludwig, one of the mentors from Jyväskylä University of Applied Science (Jamk) in Finland. He thinks that the hackathon serves as a practical and strategic benchmark for Finnish energy and bioeconomy actors. It demonstrates how targeted innovation challenges can accelerate digital transformation, enhance sustainability, and foster cross-border collaboration.

Finnish companies and municipalities could benefit from replicating similar hackathon models to address local biomass and energy optimization needs. This challenge and its outcomes are also relevant for Finland due to several shared characteristics and strategic priorities, such as similar biomass use in district heating, climate and operational parallels, digitalization and AI in bioeconomy and the strategic fit with circular economy goals. The hackathon highlights cross-border collaboration and the potential for Finnish companies to adopt or adapt the winning solutions.



Picture 3. Gilbert Ludwig, Jamk. (Photographer: Per Strömbro)

The Challenge Wanted to Keep Track of the Stacks

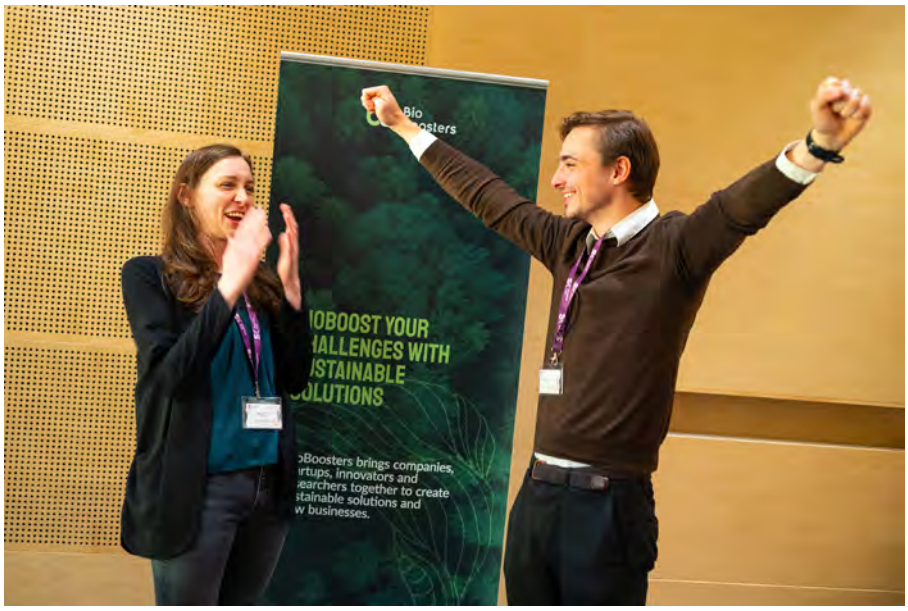
Skellefteå Kraft faces the same challenge in the raw material handling and storing as many other companies as possible in the energy sector. Data on the biomass piles is currently collected partly manually, and partly via automated systems, depending on the parameter. The collected data is used to calculate the energy value of the biomass, inventory balance, deliveries and keep track on location. Moreover, the prize of the biomass has increased drastically, leading to higher costs of decomposition and risk of theft. Skellefteå Kraft

wanted to improve their methods to get accurate, quality assured and up-to date physical and geometric data on the biomass stacks into digital format. It was also important to get alerts on dangerous changes in and around the piles. Relevant facts they wanted to digitalize were weight, moisture, volume, degree of compaction/density, fraction size, level of impurity and geographical location. Alarms should prevent fire or unauthorized access. They were aware of that no all-inclusive solution was able to find on the shelf for all this. The urgency of the challenge made them decide that only solution providers with commercial products and services were of interest to them.

A Multitude of Different Solutions

In total, the hackathon attracted 12 different solutions from large companies, SMEs and start-ups in Sweden, Finland and Germany. The attending solutions consisted of both different equipment and measurement tools as well as software-based solutions. Measurement tools dealt with radar and radio-based technology measurement of moisture content combined with modern geoinformatics which enables digitalized control of biofuel storage for increased safety, efficiency and reduced emissions. Other solutions used drones for inventing the amount of biomass in the piles and cameras for fire prevention with a 180 degrees field of view. The software-based solutions involved simulation by accurately modelling complex material handling processes. This solution could improve efficiency, enhance biomass utilization, and boost profitability, as well as optimizing and quality assure the already existing data.

During the hackathon days, the discussions and networking were intense between all participants. Several of the solution providers started discussing joining forces in some way to be able to provide an overall solution for CHP plants. It was clear they all had a piece of the puzzle that needed to be done. The mentor session was highly appreciated by the solution providers, which enabled them to develop and improve their solutions and, on the 2nd day, perform impressive, good pitchers. In the end, Elvenite was appointed winner. Their solution focused on quality assurance of the data at hand, to be able to move forward with supplemented data (BioFuel Region, 2024).



Picture 4. The winning team Elvenite (Photographer: Per Strömbro)

Cooperation Including New Work Processes that Saved Money

The collaboration between Skellefteå Kraft and Elvenite started directly after the hackathon days. Elvenite provided a quote to conduct a review of Skellefteå Kraft's data before deciding to possibly purchase new, expensive measurement systems, and the quote was accepted Targets, timeframes, responsibilities, risks and communication were decided in the first digital kick off in January. During spring 2025, recurring digital and physical meetings have been held, and cooperation has been intense.

Christian von Koch, one of the team members, notes that this proved to be a winning concept considering that Skellefteå Kraft currently had very good data.

> Most often, it is not a matter of companies collecting their data with poor systems, but rather that they need to create order and structure and utilize the value hidden in the data they collect. This is something we at Elvenite see examples of in many of the companies we work with. – Christian von Koch, Elvenite.

When asked what the cooperation has resulted in, Anna Säfvestad-Albinsson, project manager at Skellefteå Kraft highlights the the learning process:

> It has given us a very good start on our digitalization journey. It has not been easy, but very educational. We have learned so much about how to manage our own data. Instead of having to pay for software that calculates our data we can now do it ourselves. [- -] We are incredibly impressed by how Elvenite have been able totackle a process they didn't had much knowledge about. – Anna Säfvestad-Albinsson, Skellefteå Kraft.

About six months after the hackathon, Elvenite revealed that they have completed their proposed data proofing by scanning of Skellefteå Kraft's data. They have also built a prototype and defined an approach for how to keep track of the energy content in Skellefteå Kraft's storage piles. The next step is to move on to implementing the solution and integrating it with Skellefteå Kraft's source system during autumn 2025. They hope to continue the collaboration even after this specific project.

Legal, Operational and Broader Benefits for Skellefteå Kraft

As a publicly owned company, Skellefteå Kraft must comply with public procurement rules, ensuring that all participating companies compete on equal terms (Konkurrensverket, n.d.). The open call clarified that the results of the winning solution would be published, giving every tender the same information. Elvenite's contract fits the direct procurement rules, and the results will be shared once the integration of the energy content solution is delivered.

Beyond legal compliance, participating as a challenge provider in the BioBoosters hackathon generated additional operational and strategic benefits. During the formulation and delimitation of the challenge, Skellefteå Kraft gained a deeper understanding of its own production and processes, uncovering new insights for internal collaboration. Furthermore, the winning solution has attracted interest from colleagues in other energy companies, highlighting the broader relevance and potential impact of the project. In this way, the hackathon not only addresses a concrete technical challenge but also contributes to environmental and societal objectives, offering replicable approaches for energy efficiency, cross-industry collaboration, and sustainable resource management.

Skellefteå Kraft Hackathon	
Challenge	Track-The- Stack
Target groups	SMEs, Startups, large companies
Organiser	BioFuel Region, Sweden
Mentors	BioFuel Region (Sweden), Skellefteå Kraft (Sweden), Jamk (Finland), Fridhs Utvecklings AB (Sweden), Witeno (Germany)
Hackathon days	11–12 December 2024 in Skellefteå, Sweden
Applicants	12 applicants from Sweden, Finland and Germany.
Selected teams	8 selected teams, 7 from Sweden and 1 from Finland.
Winner	Elvenite, the solution idea was to qualify the large amount of existing data collected by Skellefteå Kraft.
Impact	Intense collaboration between Skellefteå Kraft and Elvenite, and development of data systems that will be piloted in autumn 2025.
UN Sustainable Development Goals	

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Protecting Wood, Preserving Tomorrow: What Stora Enso Learned by Opening its Doors to Innovation

Inguna Kucina, Vidzeme Planning Region, Latvia
Marta Riekstina, Vidzeme Planning Region, Latvia

When 76% of a sawmill's annual water use is tied to keeping logs wet, every drop matters. The entire Baltic Sea region would benefit from a replicable model for sawmills that directly supports global sustainability targets. Could a hackathon find a smarter way to protect wood quality—without turning on the tap?

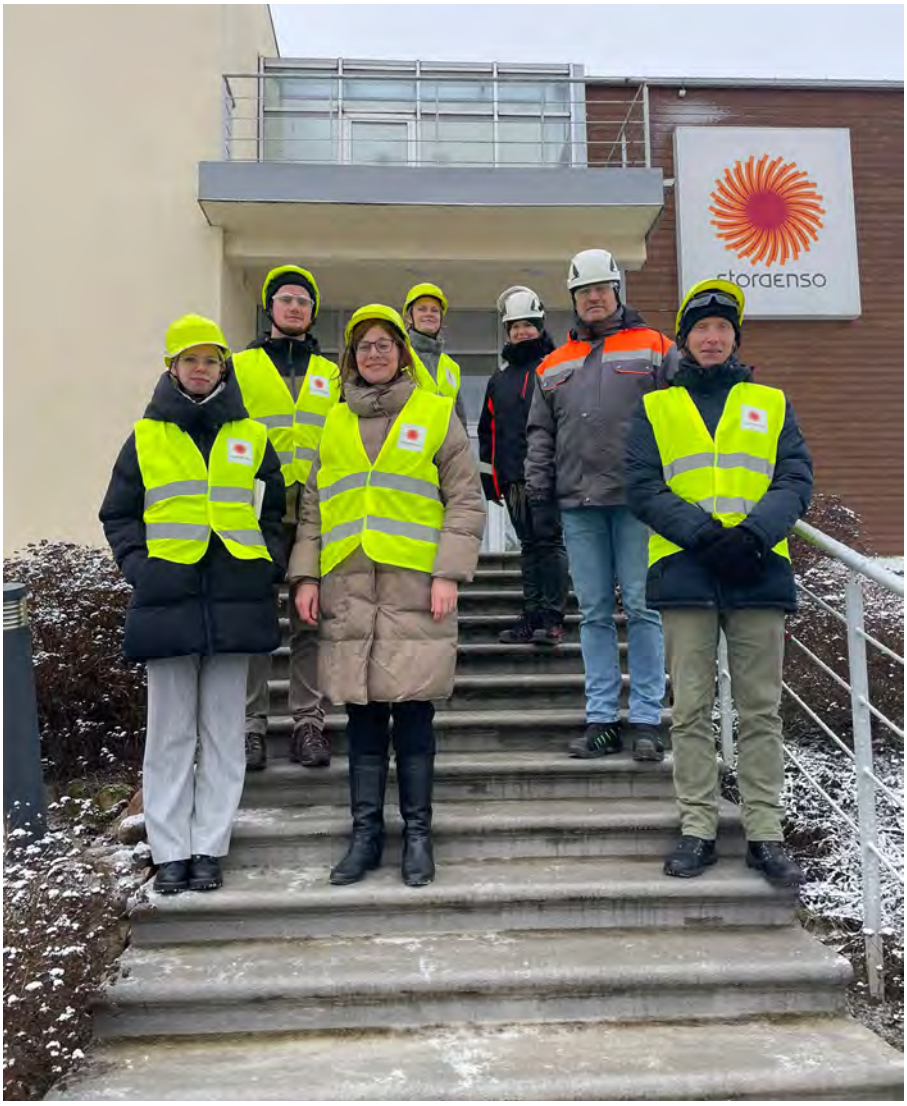
Turning a Local Challenge into a Global Call for Solutions

Climate change is bringing longer droughts, but also heavier rainfalls and storms, often in the same growing season (IPCC, 2023). These changing conditions pose significant challenges for forestry and wood processing industries across Europe, affecting log quality, pest prevalence, and water management practices (Kauppi et al., 2018; Linder et al., 2014). EU regulations, such as the Water Framework Directive (2000/60/EC), set targets for sustainable water use and discharge, adding a legal dimension to these operational challenges (European Parliament and Council, 2000).

On 5–6 December 2024, Vidzeme University of Applied Sciences in Valmiera, Latvia became the meeting ground for foresters, researchers, and entrepreneurs from across Europe. The occasion was the Stora Enso Hackathon, organized by Vidzeme Planning Region — a two-day open innovation event where international teams took on one of the region's most pressing industrial challenges: how to protect wood quality in sawmills while using far less water.

For Stora Enso's Launkalne sawmill, the challenge was urgent and tangible. Every summer harvested logs are vulnerable to blue stains, a fungi-induced discoloration, and to wood-damaging insects that thrive in warm months (Vidzeme, 2025a). The traditional response is to keep logs moist through continuous watering, but this comes at a steep cost. In Launkalne, watering accounted for more than three-quarters of all water consumed in 2023. By autumn 2024 the figure had eased to around 57%, but the need for

smarter, less resource-intensive practices remained urgent. With company-wide water stewardship targets in place — including a 17% reduction in water discharges per saleable tone by 2030 (Stora Enso, 2025c) the search for innovative solutions could not wait.



Picture 1. Hackathon participants visiting Stora Enso's Launkalne sawmill to see first-hand where their solutions could be implemented — turning abstract ideas into practical, site-ready innovations. (Photographer: Marta Riekstiņa)

Stora Enso: A Purpose-Driven Renewable Materials Company

Stora Enso describes itself as a company with a clear and bold purpose: ”Do good for people and the planet. Replace non-renewable materials with renewable products.” This purpose underpins its strategy and defines its values: to lead and to do what is right (Stora Enso, 2025a). The company aims to accelerate the transition to a circular bioeconomy by placing forests and wood fibre at the heart of its operations. Its strategy focuses on renewable packaging, supported by biomaterials and wood products, all built on a foundation of sustainably managed forests. Stora Enso has set ambitious targets, including cutting its absolute emissions by 50% by 2030 from the 2019 baseline, aiming for 100% regenerative solutions by 2050, and contributing to biodiversity restoration and climate resilience (Stora Enso, 2025b; Stora Enso, 2025c).

The challenge faced by the Launkalne sawmill is not just an operational issue but an expression of these broader ambitions. Reducing water use in log treatment aligns with Stora Enso’s commitment to resource efficiency and circularity, ensuring that renewable materials are processed with minimal waste and environmental impact (Stora Enso, 2025a). Optimising water consumption also supports the company’s climate goals by reducing the energy used for pumping and irrigation, which contributes to emission reductions. Addressing issues such as blue stain and insect damage ensures healthier wood, less waste, and better overall forest management, strengthening Stora Enso’s role in supporting biodiversity. Ultimately, solving this challenge helps Stora Enso demonstrate that its purpose is not just an aspiration but a daily practice across its operations.

Why This Matters for the Circular Bioeconomy

Stora Enso has positioned circularity and water stewardship at the core of its strategy, including a target to reduce process water discharges per saleable tonne by 17% by 2030 (vs. 2019) and to continue decreasing total withdrawals (from a 2016 baseline). In the sawmill context, tackling blue stain and insect damage without defaulting to blanket watering directly reinforces these goals—aligning operational decisions with SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), SDG 9 (Industry, Innovation and Infrastructure), and SDG 15 (Life on Land) (United Nations, 2025).

The regional dimension is equally important. Forestry remains the backbone of Vidzeme’s economy, supporting local employment, SMEs and research

institutions. By hosting an international hackathon, the region demonstrated its role not only as a supplier of raw materials but also as a hub of innovation in the circular bioeconomy. It created new networks between local expertise and global solution providers, strengthening Vidzeme's reputation as a credible testbed for sustainable industry practices. Looking ahead, the focus will turn to piloting and measuring. If demand-controlled irrigation and complementary monitoring can cut water use significantly while reducing summertime downgrades of logs, the impact will extend far beyond Launkalne.

Perhaps the most significant outcome of the hackathon was its spirit of collaboration. Stora Enso could have kept its operational challenges behind closed doors. Instead, it chose transparency and collaboration, inviting external teams to propose and test ideas. That openness unlocked fresh perspectives and accelerated solutions that might otherwise have taken years to reach the mill. The hackathon framed the challenge not as a single fix but as a portfolio of complementary interventions—combining behaviour-of-nature insights (insects, fungi, weather) with demand-controlled technologies, data, and smart yard practices.

Open Innovation in Action

The hackathon attracted nine applicants, of which six finalist teams from Latvia, Sweden, Finland, Ukraine, and Turkey were selected. Some proposed biological methods, such as deploying beneficial insects to control pests or using surplus wool in water-efficient treatments. Others focused on AI-assisted monitoring, data-driven risk mapping, and integrated pest management strategies (Vidzeme, 2025b). Mentors from the local forestry sector ensured the solutions were grounded in real mill operations. Stora Enso managers engaged as co-creators, sharing data and providing feedback during the development process.

> The invitation to join the hackathon was a fantastic opportunity to expand our knowledge. We're now inspired to implement not just the winning idea but also other innovative concepts we discovered. The outcome was better than expected.
> – Uldis Deisons, Director, Stora Enso Wood Products, Launkalne Mill

Among the six finalist teams was the State Forest Resources Agency of Ukraine, who joined despite the immense challenges facing their sector. War has caused extensive damage to Ukrainian forests — from wildfires triggered by shelling to restricted access for forest management. At the same time, the

country is aligning its forestry and hunting legislation with European law as part of its EU integration process, making innovation and collaboration more critical than ever.

Picture 2. The State Forest Resources Agency of Ukraine shared solutions and gained inspiration for rebuilding and modernising their forestry sector amid challenging wartime conditions. (Photographer: Marta Riekstiņa)

> Participating in the hackathon was an excellent opportunity for knowledge and idea exchange. The format allowed us to present our solutions and receive feedback, which was instrumental in adapting ideas to meet the needs of end users. We gained numerous insights that we can use in our work – even if implementation is delayed due to the current war situation. – Maryna Bohush, State Forest Resources Agency of Ukraine

For the Ukrainian team, the hackathon was as much about building networks and resilience as it was about solving a technical challenge. Engaging with Baltic Sea Region peers gave them access to mentors and expertise, helping

to shape solutions that could work under difficult conditions. Even though large-scale implementation must wait, the experience laid a foundation for future cooperation and demonstrated that innovation can be a bridge between crisis recovery and long-term sustainability.

A Smarter Way to Water: The Winning Solution

The winning solution came from KAGON AB (Sweden), whose ProLog 3 system transforms traditional log watering into a demand-controlled, weather-adaptive process. Instead of irrigating continuously, the technology monitors conditions and delivers water only when needed to prevent stain or insect damage. The result is a precise, sustainable method that promises to cut unnecessary water use while maintaining wood quality.

> Participating in the hackathon as a supplier is a valuable experience. Engaging directly with decision-makers and arriving with a well-tested idea is crucial to making a meaningful impact. – Daniel Otterbeck, KAGON AB

Picture 3. Sweden's KAGON AB wins with their ProLog 3 solution — a demand-controlled irrigation system that could cut unnecessary watering by aligning irrigation to real weather and risk data. (Photographer: Marta Riekstiņa)

Why did it win? Technology has been developed with sawmills and pulp mills over the years and is recognised by environmental authorities as a sustainable approach. For Launkalne, this promises better protection of raw material with measurably less water, easier monitoring, and a pathway to align yard practices with Stora Enso's water strategy. In a yard where watering historically drove up to three-quarters of site water use, demand-controlled regimes can reduce total run-time and match irrigation to actual risk periods—supporting Stora Enso's 2030 targets while reducing energy and labour associated with watering cycles.

When the hackathon took place in December 2024, Latvia had just experienced one of its hottest, driest summers — perfect conditions for blue stain fungi and insect damage, and a strong case for more efficient irrigation. But in the following year 2025, conditions have been completely different: a rainy, soggy summer has meant high soil moisture, flooded log yards, and very different risks for forest companies. Such seasonal instability is becoming the new normal.

> What worked last summer might not work next summer. Stora Enso challenge showcased the need for the solution that can adjust automatically to conditions – not only saving water when it's dry but also preventing unnecessary watering when rain has already done the job. – Inguna Kucina, Stora Enso Hackathon organizer, Vidzeme Planning Region

For sawmills and forestry companies, this means operational strategies must become far more flexible ready to protect raw materials in both extremes, not just in dry heat. A demand-controlled system such as ProLog 3 is well-suited for this reality. By tying irrigation to real-time weather data, mills can reduce run-times during wet years and still respond quickly during hot, dry spells. The same approach can also lower energy use and prevent yard flooding that could otherwise damage infrastructure or increase safety risks.

For Stora Enso, the Launkalne challenge is now a test case for developing a climate-adaptive operating model — one that reduces unnecessary watering in wet years, prevents quality losses in dry years, and supports both biodiversity and economic performance. For Vidzeme and the wider Baltic Sea Region, the hackathon shows that a resilient forestry sector is built not on one-off fixes but on continuous innovation and cooperation.

Conclusion: A Replicable Model for the Region

The Stora Enso Hackathon proved that innovation flourishes when industry, researchers, and entrepreneurs meet at eye level. For the company, it created a pathway to conserve water, protect material value, and move closer to its 2030 sustainability targets.

The hackathon did not end with the selection of a winner. Stora Enso and KAGON AB are now exploring a pilot implementation at Launkalne to test water savings, energy consumption, and quality outcomes under real operating conditions. In parallel, complementary solutions proposed by other teams — such as insect hotspot mapping and AI monitoring — are being considered as add-ons to further optimise watering schedules and reduce unnecessary cycles.

For Vidzeme Planning Region, this outcome also reinforces its mission to position the region as a testbed for bioeconomy innovation, connecting local expertise with international solutions and creating opportunities for SMEs and research institutions.

The lessons learned extend beyond one company: they show that open innovation is a powerful tool for regional competitiveness, enabling faster progress on sustainability challenges that no single actor could solve alone. For sawmills across the Baltic Sea region, Launkalne now offers a replicable model for balancing quality, resource efficiency, and environmental stewardship.

Stora Enso Hackathon	
Challenge	Protecting Wood, Preserving Tomorrow. The challenge is to reduce the blue stain and wood-damaging insects in the sawn logs in an environmentally friendly way, meanwhile reducing the amount of water that is used for these purposes.
Target groups	SMEs, start-ups, research institutes, sustainable product developers, educational institutions, forestry experts, experts in sustainability and resource utilization and other actors interested in solutions for wood industry.
Organiser	Vidzeme Planning Region, Latvia
Mentors	Stora Enso Launkalne Mill (Latvia), New Building School, Vidzeme University of Applied Sciences (Latvia), Institute of Energy Systems and Environment of Riga Technical University (Latvia), Valmiera Development Agency (Latvia)
Hackathon days	5–6th December 2024, Vidzeme University of Applied Sciences, Valmiera, Latvia
Applicants	9 applications (1 from Latvia, 1 from Estonia, 2 from Sweden, 1 from Latvia + Sweden, 2 from Finland, 1 from Ukraine, and 1 from Turkey)
Selected teams	6 teams (1 from Latvia, 1 from Sweden, 1 from Latvia + Sweden, 1 from Finland, 1 from Ukraine, and 1 from Turkey)
Winner	KAGON AB, Sweden, ProLog 3 demand-controlled irrigation system
Impact	By switching to demand-controlled irrigation, Stora Enso Launkalne Mill could cut watering run-time by 30–50%, saving an estimated 30,000–50,000 m^3 of water annually — enough to supply up to 1,000 households — while reducing energy use, CO_2 emissions, and timber downgrades.
UN Sustainable Development Goals	

Spin-off story: Mapping insect hotspots to cut ”insurance watering”

Seasonal insect pressure often drives conservative ”insurance watering” to protect log quality—consuming water even when risk is low. The SLU & Silava team proposed a field- and yard-level monitoring regimen (traps + visual inspections) to pinpoint when and where insects actually colonise harvested wood. When integrated into yard operations, the approach can trigger time- and zone-specific responses—including targeted irrigation via ProLog, IPM measures, or no action when pressure is negligible.

What makes this compelling for Launkalne is its operational fit. Yard teams already track deliveries and stock rotation; adding a simple hotspot protocol taps into existing routines. Over time, the dataset trains a risk calendar—which, coupled with weather inputs, can inform dynamic set-points for irrigation and reduce the need for blanket watering. Crucially, this does not require a full-scale digital overhaul on day one; a staged rollout can prove value, build staff confidence, and generate evidence for broader automation.

The anticipated impacts are twofold: (1) water avoided by eliminating non-essential cycles, and (2) value preserved via fewer stain- or insect-related downgrades. For Stora Enso, this dovetails with its 2030 water-discharge target and broader circularity goals; for the BioBoosters community, it is a replicable template for other mills tackling seasonal quality risks.

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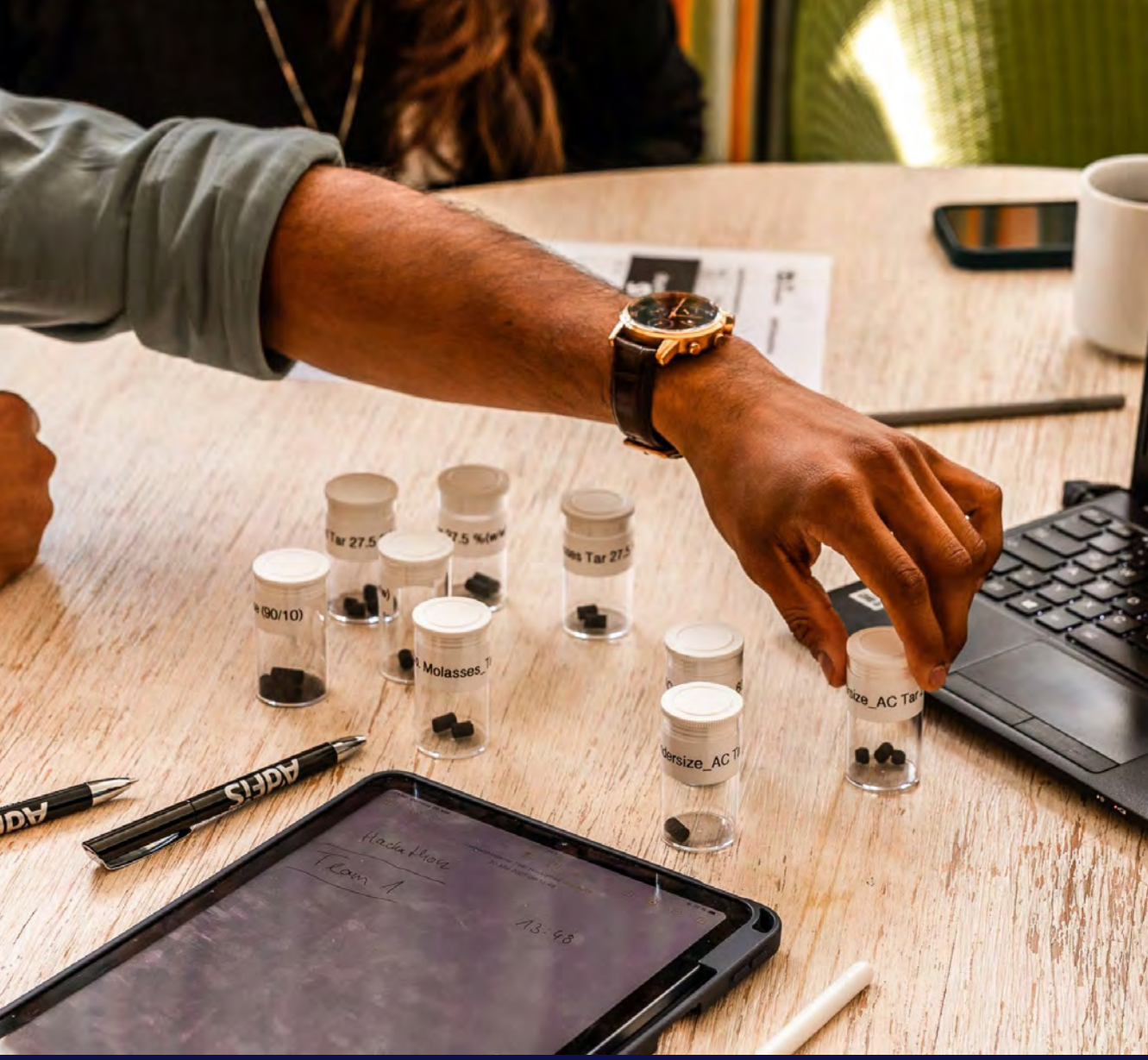


Theme 2

Transition to Biobased Industries, Materials & Ingredients

AdFiS Hackathon: Driving Sustainable Activated Carbon Production in Europe

Gudrun Mernitz, Witeno GmbH, Germany
Matti Räsänen, Jamk University of Applied Sciences, Finland

As Europe looks to decarbonise its industries and build more resilient supply chains, a small German company is leading by example. Through an open innovation hackathon, AdFis Products GmbH catalysed a collaborative leap forward in sustainably activated carbon production – developing innovative material solutions, lowering energy needs, and charting a path to strategic independence.

Activated Carbon: A Strategic Material in an Unstable Global Market

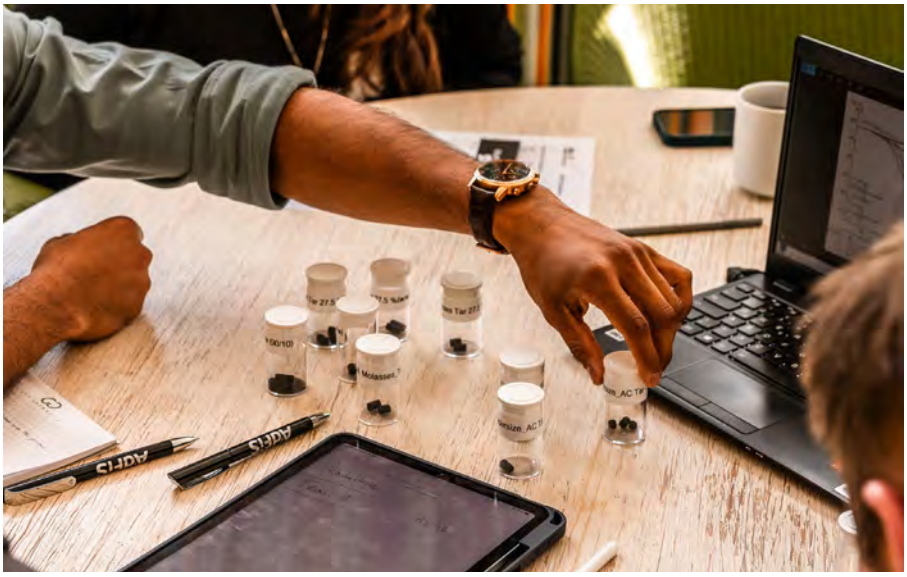
Activated carbon is indispensable for a wide array of purification applications: it cleans drinking water, reduces different types of emission of liquids and gases, cleans biogas by removing hydrogen sulfide, filters siloxanes and ammonia from landfill and wastewater emissions, and supports industrial air purification. The market is large and growing, valued at over USD 6.5 billion in 2023, it is projected to surpass USD 10 billion by 2030, driven by environmental legislation, the spread of biogas technologies, and rising industrial filtration needs (MarketsandMarkets, 2025).

However, over 65% of the world's activated carbon is produced in Asia – especially in China and India. Europe remains structurally dependent on these imports. Given current geopolitical tensions, supply chain disruptions, and mounting climate obligations, European industries face both strategic and ecological pressure to localise and green their activated carbon production.

At the same time, the traditional production process is energy- and resource-intensive. Producing activated carbon from coal or coconut shells involves high-temperature activation (700–900°C), chemical activation using acids or bases, and emissions that must be tightly controlled. Innovation in the sector is long overdue.

A Regional Company with a Global Vision: AdFiS Products GmbH

AdFiS Products GmbH, based in Teterow, Mecklenburg-Vorpommern, has been Germany's leading activated carbon producer since 2014. With over 1,800 tons produced annually, AdFiS plays a central role in the domestic market and supplies clients in industrial gas purification, wastewater treatment, and biogas desulfurisation.



Picture 1. Small Sample Containers (Photographer: FilmVision – Marten Kählert)

Looking to the future, AdFiS faced a twofold challenge: first, to reduce the energy intensity of its activation process; and second, while already using sustainable binders in its production, to identify an innovative binder solution for so-called "undersized material"- small particle fractions generated during production that are otherwise difficult to pelletise efficiently (AdFiS, 2025).

To tackle this challenge, AdFiS partnered with WITENO GmbH and launched an international hackathon as part of the EU Interreg-funded BioBoosters project. The aim was to scout promising technologies, unlock scientific know-how, and establish innovative partnerships that could move quickly from lab to pilot scale (AdFiS, 2025).

Picture 2. Presentation by Dr. Gudrun Mernitz (WITENO GmbH, 2025).

Designing the Hackathon: From Research to Industry

Organised over six weeks in spring 2025, the AdFiS Hackathon sought to bring in a wide range of external expertise. The call for participation was structured around two sub-challenges:

- Reducing energy-activated in the production process
- Developing an innovative biobased binder capable of processing undersized activated carbon material

These sub-challenges addressed both the process and the input materials, inviting multidisciplinary teams from chemical engineering, materials science, biotechnology, and environmental sciences.

Picture 3. Factory tour with the CEO of AdFiS (Photographer: FilmVision – Marten Kählert)

Following a competitive selection process from nine applicants, four teams advanced to the final event held at Gut Gremmelin, Germany, on May 20–21. Two winning teams were ultimately chosen:

- Team LuMiB (Luleå University of Technology, Sweden & University of Milan, Italy): Their concept leverages lignin-based nanomaterials capable of enhancing porosity and functionality of biochar upon thermal treatment. This innovative approach transforms residual biomass into high-value materials, promoting sustainable carbon utilization.
- Team Bio4Act (University of Kassel, Germany): This team suggested using bio-oil and tar byproducts of biomass pylolysis as alternative binders for more energy-efficient production of activated carbon pellets. This could reduce the need for external chemical inputs while simultaneously increasing the pellet's carbon yield.

Picture 4. Winning team "LuMiB" (Photographer: FilmVision – Marten Kählert)

Picture 5. Winning team "Bio4Act" (Photographer: FilmVision – Marten Kählert)

Technical and Market Potential of the Solutions

The solutions proposed by LuMiB and Bio4Act are notable for their alignment with market needs and policy directions. If successfully implemented, these innovations could lead to:

- 20–40% energy savings through process optimisation and alternative activation techniques
- lower burn-off, due to pore generation from within the material and thus increased yields by mass
- Improved circularity via the valorisation of side-streams from forestry and bioenergy sectors
- Lowered production costs over time due to reduced reliance on imports and energy

According to initial internal assessments by AdFiS engineers, implementation of such innovations could reduce production-related CO_2 emissions by 30–50%. Moreover, using lignin – a by-product of paper pulping – as a base material could reduce the environmental footprint of pellet production while creating synergies with northern Europe's forestry sector (Calvo-Flores & Martin-Martinez, 2022).

Strategic Independence Through Science and Regional Collaboration

The hackathon results drew attention not just for the scientific merit of the proposals, but also for their strategic implications. Mecklenburg-Vorpommern's Minister of Economic Affairs, Dr. Wolfgang Blank, emphasised the broader vision:

According to AdFiS, 2025, the AdFiS hackathon is a powerful example of how we can reduce dependency on imported materials while building regional innovation ecosystems.

This regional aspect is not incidental. With industrial facilities, forestry biomass, and a growing bioeconomy cluster, northeastern Germany is well positioned to serve as a testing ground for sustainable materials innovation. The hackathon format – offering a clear challenge, external teams, mentoring, and an evaluative jury- proved to be an efficient mechanism to identify scalable, near-market innovations (Aalto & Manerus, 2024).

Open Innovation as a Pathway for SMEs

WITENO, the regional innovation agency behind the hackathon implementation, highlighted the strategic role of SMEs in driving transformation:

Dr. Gudrun Mernitz of WITENO GmbH emphasised that this was not just a competition. It was a learning process for all sides – a platform where scientific creativity met industrial urgency...

The format enabled AdFiS to go beyond internal R&D limitations, connecting with academic groups and startup-like teams that might otherwise not have been accessible. Mentorship from internal staff and external advisors allowed for rapid iteration of ideas, and post-hackathon debriefs are now laying the groundwork for joint development projects and funding applications under German and EU innovation schemes (Interreg Baltic Sea Region, 2025).

Next Steps: From Pilot to Product

Picture 6. Teamwork at the table (Photographer: FilmVision – Marten Kählert)

Both winning teams are now entering a phase of feasibility validation, including lab testing, process integration studies, and material characterisation. AdFiS plans to develop pilot-scale trials in 2026, potentially followed by demonstration-scale integration in its Teterow facility.

The BioBoosters network is supporting these developments by facilitating access to funding, transnational partners, and public visibility. Similar hackathons are planned with other bio-based industries across the Baltic Sea Region, using the AdFiS format as a reference model.

VTT's Role in Shaping the Future of Activated Carbon

VTT Technical Research Centre of Finland is one of Europe's leading applied research organizations, driving innovation in energy, materials, and circular economy solutions. In the AdFiS Hackathon, VTT experts acted as mentors, providing scientific guidance and evaluating technical feasibility.

Beyond the hackathon, VTT plays a central role in rethinking activated carbon production for a low-carbon future. Traditional processes are energy-intensive and rely on fossil-based raw materials. VTT's research focuses on three priorities: improving energy efficiency, replacing fossil inputs with biomass side-streams, and developing high-value applications.

Through the BioCarbonValue project, VTT explored how agricultural and forestry side-streams can be upgraded into high-value carbon products. The research demonstrated that lignin-based activated carbon can match the performance of fossil-derived alternatives, opening opportunities in water purification, energy storage, and advanced materials (Salo & Siipola, 2022). VTT is also advancing thermochemical conversion methods to optimize carbon yield while reducing energy demand (Coronado, n.d.).

These efforts align with the EU's Circular Economy Action Plan, which calls for reducing waste and creating markets for secondary raw materials (European Commission, 2020, Chapter 4). By combining Research Excellence with industry collaboration, VTT is helping Europe reduce its reliance on imports and build a more resilient, sustainably activated carbon industry.

Conclusions: Building Europe's Circular Carbon Economy

The AdFiS Hackathon illustrates how targeted open innovation can address strategic supply chain vulnerabilities while advancing environmental goals. The innovations presented not only offer technical solutions but also align with Europe's broader policy agenda – including the European Green Deal and the Circular Economy Action Plan (European Commission, 2020, Chapter 4).

As demand for activated carbon continues to grow, the ability to produce it sustainably and independently will become a defining factor of industrial resilience. Thanks to initiatives like the AdFiS Hackathon, Europe is taking important steps toward a more circular, science-driven, and self-sufficient materials economy.

AdFiS Hackathon	
Challenge	Making activated carbon production more energy-efficient and sustainable
Target groups	Start-ups, academic teams, applied scientists, engineers, innovators from the bioeconomy and materials science sectors
Organiser	WITENO GmbH – Regional innovation agency supporting technology transfer and SME innovation. (Mecklenburg-Vorpommern, Germany) and AdFiS Products GmbH – Germany's leading producer of activated carbon, located in Teterow.
Mentors	AdFiS Products GmbH (Germany), WITENO GmbH (Germany), University researchers (University Kassel, Jamk University of Applied Sciences, Umeå University), Pro Civis and independ technical advisors (Kayser-Group, VTT Technical Research Centre of Finland Ltd)
Hackathon days	20–21 May 2025, Gut Gremmelin, Germany
Applicants	9 applications (3 from Germany, 2 from Sweden, 1 from Sweden & Italy collaboration, 1 from Finland, 1 from India & 1 from Singapore)
Selected teams	4 teams from Germany, Sweden & Italy
Winners	Team LuMiB (Sweden & Italy): Lignin-based nanomaterials to enhance porosity and surface functionality of activated carbon & Team Bio4Act (Germany): Bio-oil and pyrolysis tar as sustainable binders for more energy-efficient production of activated carbon pellets.
Impact	Significant emissions reduction: Innovative activation methods are expected to cut process-related CO_2 emissions by 30–50%, according to initial engineering assessments. Lower energy demand: Process optimisation and low-energy activation techniques could reduce energy use by 20–40%, helping to lower operational costs while improving sustainability. Enhanced circularity: By turning biomass side-streams such as lignin and pyrolysis tar into valuable inputs, the process contributes to a more circular production model. Stronger regional resilience: The innovations support a shift away from dependence on Asian imports, strengthening local supply security and creating opportunities within regional value chains.
UN Sustainable Development Goals	

Spin-off story: Written by Matti Räsänen

HATTU Project: Building Capacity for Carbon Innovation

The HATTU project complements initiatives like the AdFiS Hackathon by addressing systemic challenges in carbon production. Implemented by VTT and Jamk University of Applied Sciences—both involved in the hackathon as mentors—the project focuses on creating an operational model that integrates bio- and activated carbon production with local district heating networks.

This approach links directly to the AdFiS challenge: while the hackathon explored energy efficiency in activation, HATTU achieves similar goals through energy circularity. District heating, common in Nordic countries, distributes heat from a central source to multiple buildings, enabling efficient use of waste heat from industrial processes.

The project examines the entire value chain, from biomass collection and pre-treatment to quality assurance and market deployment. A bio- and activated carbon reactor at Jamk's Bioeconomy Campus will serve as a testbed for process optimization and application development.

HATTU's objectives include bringing stakeholders together, identifying barriers to industrial-scale production, and creating profitable business models for circular economy side-streams. Innovation competitions, including hackathons, are part of their toolkit for accelerating idea generation and connecting research with market needs.

More information: Scan the QR code below for full project details

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Sustainable Recycling for Wine Corks from Karlstads Energi Hackathon

Malin Hildén, Paper Province, Sweden
Magnus Persson, Paper Province, Sweden
Per Myhrén, Paper Province, Sweden

Each year, billions of wine bottles are sealed with natural cork. Finding sustainable ways to reuse this valuable material can help reduce waste and support circular economy solutions.

Karlstads Energi Is on a Journey

Karlstads Energi is a municipal company that offers products and services that make it easier for the residents of Karlstad to live a more sustainable life. Karlstads Energi has business areas in Recycling, Heating and Cooling, City Network, and Electricity Network. “The municipality of Karlstad has the responsibility to take care of the waste from the citizens and Karlstads Energy has been given the task of taking care of it” (Pettersson, 2024).

Sweden has difficulties meeting several of the goals in the waste area. Important key players need to gain better insight into what they can and should do. Sorting is an important first step in waste management. This means that the waste must be sorted by the waste producer and that the sorting must be maintained by the collector and, to an extent possibly even improved. Lack of or inadequate sorting means that waste cannot be fully utilised by being prepared for reuse or recycled into high-quality raw materials. Moving higher up in the waste hierarchy is an important part of the work to increase circular economy, (Naturvårdsverket, 2024).

The foundation of EU waste management is the five-step ”waste hierarchy”, established in the Waste Framework Directive in 2008 (Official Journal of the European Union, 2008). It establishes an order of preference for managing and disposing of waste. It explains when waste ceases to be wasted and becomes a secondary raw material, and how to distinguish between waste and by-products. The Directive also introduces the ”polluter pay principle” and the ”extended producer responsibility”.

Picture 1. Illustrating the Waste hierarchy (Paper Province)

To comply with the objectives of the Waste Framework Directive, EU countries shall take the necessary measures to achieve the following targets (Official Journal of the European Union, 2008):

- By 2020, the preparation for re-use and the recycling of waste materials (such as paper, metal, plastic and glass) from households shall be increased to a minimum 50 % by overall weight
- By 2020, the preparation for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight
- By 2025, the preparation for re-use and the recycling of municipal waste shall be increased to a minimum of 55 %, 60% and 65% by weight by 2025, 2030 and 2035 respectively

In 2023 the Commission published a report to follow up the progress in the member state in fulfilling the targets, the assessment carried out by the European Environment Agency, (European Commission, 2023). Sweden was identified as being at risk of missing the target of 55 % preparing for re-use and recycling of municipal waste by 2025. One of the recommendations regarding municipal waste was to work with awareness-raising activities. That is essential to enhance citizens' participation in better waste management. They can be tailored to different target groups (such as households, students, or tourists), (European Commission, 2023).

That was one of the driving forces for Karlstads Energi to participate in the BioBoosters hackathon. Next step was, together with Paper Province, to

choose a challenge that fits the concept and was easy to communicate. The choice fell on natural cork. A small fraction of the total waste, but a fraction that many potential solution providers can have ideas about.

Natural Corks

In Sweden, the state has a monopoly on selling alcohol to residents, which is carried out through the company Systembolaget. They have 452 stores around Sweden and at least one in every municipality. Their supply chain is very complex with approximately 1200 suppliers and thousands of producers. The number of bottles sold at Systembolaget known to have natural cork is around 41 million per year. But they also sell 16,5 million glass bottles registered with ”unknown sealing” so it could be up to 58 million corks/year (Häckner, 2024).

Based on the data available, it is estimated that in Karlstad municipality, the number of corks generated from wine bottles would be around 500,000 annually.

Natural corks are a renewable material, and they can be harvested throughout the tree’s lifetime. Cork harvesting is an environmentally friendly process during which not a single tree is cut down. It takes 20 years for the tree to be ready for harvest. Portugal, which has one-third of the overall area of oak trees, is the world’s largest cork producer. 374,000 tons of cork are produced annually in the world but even though cork is compostable and recyclable most ends their life as waste (Löfgren, 2024).

Cork has good material properties. It is light and elastic, can easily be compressed and rapidly recover. It is insulated and has low conductivity of electricity, heat and sound. Cork is also characterized by high chemical stability and low friction, which results in good surface properties (Löfgren, 2024).

The Road to Finding a Solution

The cluster organization, Paper Province, with 112 member companies helped Karlstads Energi in their search for a solution provider by using the BioBoosters hackathon process. First step was to formulate the challenge to attract many solution providers. The title was ”Sustainable Recycling for Wine Corks” and the evaluation criteria:

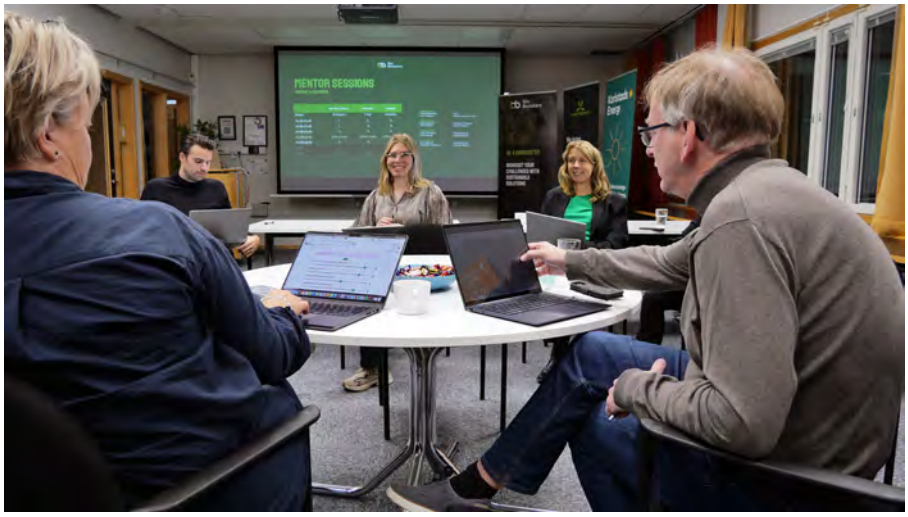
- Feasibility to use all collected corks for industrial use
- Capability of the team

- Business and scale-up potential in Sweden
- Sustainability of the new product life cycle

Karlstads Energi was looking for an end product where wine corks are recirculated in a production chain. With the aim to increase circularity and not have incineration as the destination after only one use. It was also important for the solution providers to consider the environmental/climate benefits of circulating instead of incinerating. Karlstads Energi aims to solve the efficient collection of corks by their own (Paper Province, November 2, 2024).

Systembolaget has done a small project on the collection of cork and came up with some criteria for where and how it could be done at their stores. The design of the cork collection needs to be practical in daily operations, has no resemblance to waste collection and is easy to empty for staff. There is also an opportunity to sell recycled cork products in their stores e.g. in gift assortment or use them as furniture. But they think that to get larger volumes of collected cork more actors like restaurants need to be involved also. It´s important for Systembolaget to be able to follow what happens with the collected cork. So, due to low volumes and hard to track what happened with the collected cork the project was closed (Häckner, 2024).

The open call attracted 11 suggestions of solutions from students, start-ups and SMEs. The contributors of potential solutions came from France, Lithuania, Poland and Sweden. Three teams participated in the hackathon days (ReKorek, Nordic Surface and Reselo). The proposed solutions had a wide range. ReKorek, which already has its own collection operations in Poland, wanted to expand in Sweden and produce various simpler cork products like yoga rollers. Nordic Surface, which today manufactures cork playground surfaces, wanted to see if they could use recycled cork instead of raw cork. Reselo, which develops biobased materials to defossilize the footwear industry, wanted to use the cork in that segment. At the end ReKorek from Poland was selected as winner.



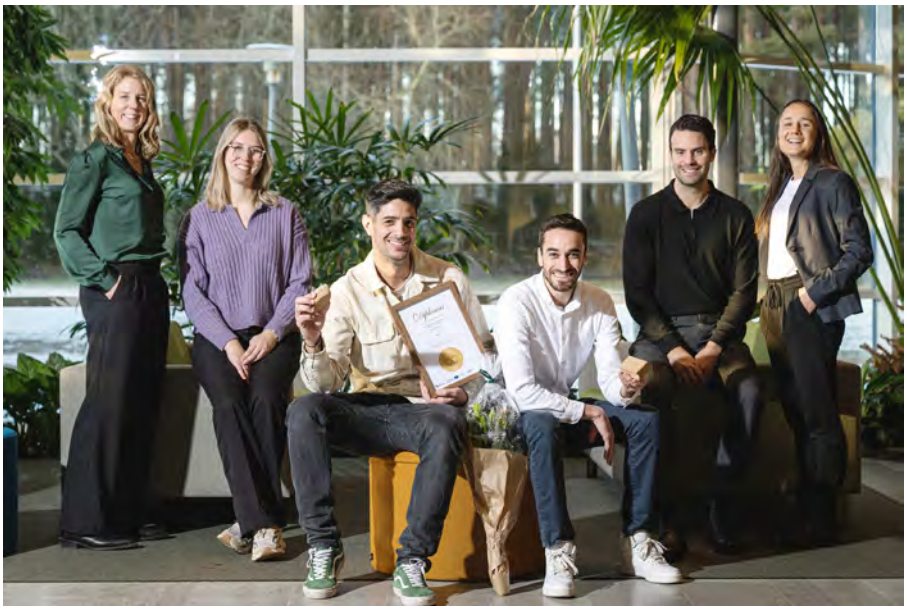
Picture 2. Feedback from mentors to jury (Photographer: Fredrik Karlsson, Solsta Foto)

The Winner is Society

At the hackathon days, in beginning of December 2024, Karlstads Energi selected ReKorek from Poland as their collaboration partner.

ReKorek is a foundation that collects used wine corks across Poland including restaurants, wine shops, and other establishments. Today they have almost 200 drop-off locations. Once collected, these are stored in a warehouse, where the entire recycling process is managed. The mission is to give these corks a new life and prevent them from being incinerated. ReKorek transformed used wine corks into a variety of innovative and sustainable products, everything from yoga rollers and blocks to mobile phone holders. This makes them perfect to help solve the challenge.

> ReKorek presented a sharp and concrete solution that clearly demonstrates it is possible to create an efficient collection process for the reuse of natural corks. We see great potential in the concept and look forward to exploring the opportunities for future collaboration. – Malin Pettersson, Karlstads Energi, December 12, 2024.



Picture 3. Celebrating Success (Photographer: Fredrik Karlsson, Solsta Foto)

The winning participant also has a great opportunity to scale up a business both nationally and internationally if it has a replacement area that is profitable. There is an international goal to reduce waste volumes, and it will become increasingly important to detect new areas to find circular flows as climate impact needs to decrease (Paper Province, December 12, 2024).

If the solution works in Karlstad municipality it will probably also work in most of the remaining 290 Swedish municipalities.

Looking at the gains of the BioBoosters hackathon, even the companies that did not win had much to gain from the process and were glad they joined. The hackathon offered a chance to make new contacts, refine their ideas, and promote solutions. To sum it up the gain was as follows:

- Wider network of companies and specialists with interest in the same field.
- The possibility to test an idea with feedback from a potential client and discover how to fit the solution to the needs of end-users.
- Develop the commercialization potential of an idea and discover new business opportunities with expert mentors' support.

- Get international recognition and visibility through nine regions' social media platforms.
- Inspiration from the innovation process and new learnings.
- Promotion through Paper Province network.

First Testing Phase under Development

The prerequisite for the collaboration between Karlstads Energi and ReKorek to take off is that a certain amount of cork is collected per week. Karlstads Energi therefore needs to test how the collection itself will work and begin work on changing the behavior of the residents of Karlstad so that they start handing in their corks.

The first step for Karlstads Energi to decide was if they would go on with the winning solution. After that was decided and a rough budget was allocated the next step was to start the discussion with Systembolaget if they wanted to attend a pilot project. Systembolaget, that had earlier experience in testing the cork collection, was positive to the new collaboration with Karlstads Energi and a pilot project was planned. Karlstads Energi has visited and looked at the stores Systembolaget has in Karlstad to see how the collection can work. They have also looked at how the collection at Karlstads Energi's own recycling centers can work. In a first step, they will target the inhabitants of Karlstad Municipality. The first pilot project will start in November, i.e. less than a year since the hackathon days were held. The pilot project will last for six months and then be evaluated.

> For Karlstads Energi, the hackathon presented an easy way to bring together different actors who can help us become more circular. Actors with experience of the residual cork stream and with good ideas on what to do with the collected material. In addition, the support of business development experts was valuable. – Christoffer Henriksson, Recycling Strategist at Karlstads Energi.

Karlstads Energi Hackathon	
Challenge	Karlstads Energi Hackathon – Sustainable recycling of wine corks
Target Groups	Companies and startups developing market-ready applications for natural cork or its components, especially as substitutes for fossil-based materials.
Organiser	Paper Province, Värmland, Sweden Paper Province has been driving forest-based bioeconomy in Sweden for 25 years. As a cluster organisation Paper Province main purpose is to connect actors who can contribute to the development of the bioeconomy linked to the forest. To help do so Paper Province has 112 member companies and at least as many partners. The cluster brings together large and small companies, consultants, start-ups, test facilities, municipalities, the region, research, and academia.
Mentors	Paper Province and Karlstad university (Sweden), Karlstad Innovation Park and ALMI Business partner (Sweden) & Karlstads Energi (Sweden)
Hackathon days	December 03–04, 2024, at Karlstad Innovation Park in Karlstad, Sweden.
Applicants	6 submissions from Sweden, 1 submission from France, 3 submissions from Poland, 1 submission from Lithuania
Selected teams	5 teams: 3 from Sweden, 1 from Poland and 1 from France. 3 teams attended hackathon days: 2 from Sweden and 1 from Poland.
Winner	ReKorek, Poland. Polish startup-company ReKorek was the winning team. ReKorek presented a sharp and concrete solution that clearly demonstrates it is possible to create an efficient collection process for the reuse of natural corks and convert into new products.
Impact	The BioBoosters Hackathon was the spark that got Karlstads Energi to start collaborating with Systembolaget on collecting wine corks in Sweden. It is very likely that this will spread to the whole of Sweden in the not-too-distant future.
UN Sustainable Development Goals	

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BioBoosting Soil Health: Toksika Hackathon Tackles Petroleum-Contaminated Soil

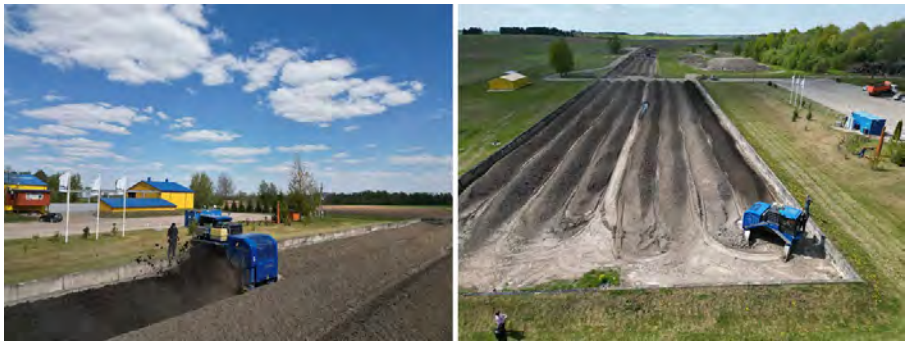
Lina Stanionyte, Sunrise Tech Park, Lithuania
Anna Aalto, Jamk University of Applied Sciences, Finland
Rimas Meištininkas, UAB Toksika, Lithuania

Across Europe, millions of sites remain contaminated, with petroleum hydrocarbons among the most common and persistent pollutants posing serious risks to both the environment and human health. Left to nature alone, these substances can take hundreds of years to break down. But what if we could help nature accelerate the process – without harming the vital microbes that sustain healthy soils? That's precisely the mission of the Toksika Hackathon. Inspired by nature and powered by science, this challenge invited innovators to rethink how we tackle pollution – finding smarter, greener, and more efficient solutions.

Soil Contamination Calls for Solutions

The EU's Soil Deal for Europe aims to restore soil health by 2030, yet contamination remains a critical challenge (Directorate-General for Research and Innovation [DG RTD], 2023). Across the EU, an estimated 2.8 million sites are potentially polluted, many linked to former industrial zones, oil processing facilities, ports, and landfills. The most common contaminants are heavy metals (37.3%) and petroleum hydrocarbons (33.7%) (European Environment Agency, 2020). which degrade soil quality, threaten ecosystems, and endanger water resources, creating long-lasting risks for both the environment and human health (Panagos et al., 2013).

In Lithuania, this challenge is particularly significant. Since the 1990s, authorities have worked to map and assess contaminated land, uncovering more than 12,500 potential pollution hotspots. Strikingly, around 40% of these sites are linked to petroleum-related activities such as fuel stations, oil storage depots, and vehicle maintenance yards. Altogether, they affect 600–700 hectares of land, illustrating how widespread petroleum pollution is—and why tackling it is vital for safeguarding the country's natural resources and future well-being (Gregorauskienė & Slavinskas, 2022).



Picture 1. UAB Toksika soil remediation activities (Photographer: UAB Toksika)

Lithuanian state-owned company UAB Toksika decided to join BioBoosters hackathons with the challenge on accelerated remediation of petroleum contaminated soils. Toksika is a licensed hazardous waste management company whose operations include the collection, transport, storage, incineration, and landfilling of hazardous materials (Toksika UAB, 2025). The company places particular emphasis on biological soil treatment and is seeking innovative solutions to accelerate the cleanup of petroleum pollution while preserving the delicate balance of microorganisms essential for natural soil recovery.

Toksika Challenge – Contribution to EU Soil Mission

With petroleum hydrocarbons ranking among the most common pollutants in Europe, and thousands of hotspots identified in countries such as Lithuania, Toksika's work represents a practical contribution to the EU Soil mission's goals. By developing faster, more effective cleanup solutions, the initiative not only supports the EU's broader soil restoration agenda (European Commission, 2021) but also helps safeguard ecosystems, water resources, and public health from the long-term impacts of petroleum pollution.

This hackathon's challenge focuses on accelerating biological soil treatment for petroleum-contaminated (especially long-chain petroleum hydrocarbons) sites while preserving the viability of the microorganisms responsible for breaking down pollutants. By addressing this challenge, participants can contribute to a cleaner, healthier environment and create scalable solutions for soil remediation efforts, not only in Lithuania but across Europe and beyond.

Biological soil remediation offers a major advantage over chemical methods by harnessing natural microorganisms to break down pollutants, making it more sustainable, less harmful to ecosystems, and better suited for long-term soil health. Although chemical remediation is often simpler and faster to apply, providing a more immediate solution, it can leave toxic residues or disrupt soil structure, whereas biological treatment restores ecological balance and supports biodiversity (Eslami & Seyed Joodat, 2018).

Certainly, biological treatment is more complex and challenging. According to Rimas Meištininkas, Manager of Jonava soil treatment site at Toksika, one of the main difficulties lies in breaking down long-chain petroleum hydrocarbons, which are not easily accessible for microbial degradation. This slows the process, inhibits microbial growth, and ultimately reduces the efficiency of bioremediation (Interreg Baltic Sea Region, May 16, 2025). Therefore, the aim of Toksika's hackathon challenge was to find ways to accelerate the breakdown of these hydrocarbons without harming the microorganisms that drive the treatment process.

Research Know-how Meets Business Needs

Meeting Toksika challenge required not only innovative business thinking but also strong scientific research. Through the BioBoosters network, the hackathon gained an international dimension, attracting 20 applications from 10 countries (Lithuania, Finland, Sweden, Estonia, Poland, Germany, Spain, Italy, Turkey, and Canada). With 75% of participants coming from outside Lithuania, the event achieved a high level of diversity, enhancing the breadth and creativity of the proposed solutions. Most teams represented knowledge-based SMEs and startups closely collaborating with universities, research institutes, and laboratories. Their interdisciplinary expertise included environmental engineering, soil biology, biotechnology, and chemistry, ensuring that solutions are backed with solid research and practically applicable. (Interreg Baltic Sea Region, June 11, 2025).

The scientific competition showcased a wide range of bioremediation strategies. Proposed approaches included phytoremediation, microbial augmentation using beer-waste bacteria, biostimulation with biosurfactants and nutrients or electricity-stimulated microbes. Additional solutions leveraged biobased materials such as biochar and vermicompost, as well as nanobubbles to further enhance microbial efficiency. Many teams proposed integrating advanced digital tools, such as IoT sensors, satellite monitoring, and predictive analytics to precisely track soil conditions, enable adaptive

real-time responses, and model treatment scenarios. As Marius Busilas, Development Manager of Toksika and jury member, noted that the Hackathon exceeded expectations, offering very comprehensive solutions, and many new insights (Interreg Baltic Sea Region, May 16, 2025).

Picture 2. Toksika hackathon participants (Photographer: Agne Popiere)

After a careful evaluation process, five different solutions with the greatest potential for practical application by Toksika entered for the final competition. Five teams from Germany, Finland, Poland, Spain, and Lithuania presented their solutions to the problem, showcasing a range of innovative approaches:

- Advanced biobased remediation technologies (Sensatec GmbH, Germany),
- Real-time microbial optimization via sensor technology (Deep Scientific, Lithuania),
- AI-driven soil biodiversity monitoring (Microfy Systems, Spain),
- Genetic insights to enhance bioremediation efficiency (Oil Degrading Microbes and Genes team, Finland),
- Eco-friendly enzymatic treatments for faster hydrocarbon breakdown (Bioprocess Development Laboratory, Poland).

The final hackathon days, organized by Sunrise Tech Park took place in Vilnius on 6–7 of May, 2025. Teams were supported with experienced mentors, which together with Toksika and Sunrise Tech Park, included experts from six institutions, bringing together highly competent chemists, biologists, environmental specialists, and innovation consultants. Multidisciplinary and international support came from the diversity and expertise of the participants were highly valued by both mentors and teams, fostering meaningful connections, enriching discussions, and contributing to the improvement of proposed solutions.

From Lab to Market

Many participants emphasized that the hackathon created a unique platform for researchers to connect directly with business stakeholders. For young scientists, it provided a chance to broaden their perspective beyond academia, to better understand industry needs, and to learn how to communicate ideas effectively to potential beneficiaries outside the research community.

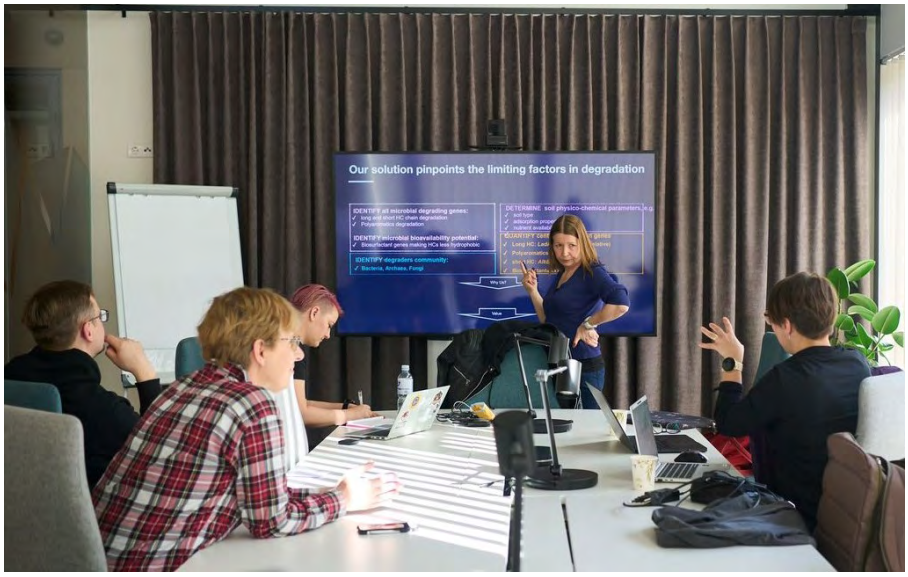
According to Johanna Muurinen from the Bionautit cooperative in Finland, the hackathon experience clearly demonstrated how research-based expertise can be translated into business services with recognized market potential. Aušra Baradokė of DeepScientific, also agreed that participation in the Toksika hackathon provided a valuable opportunity to explore how their technology, 3D-printed sensor, could be adapted for measuring soil parameters in petroleum-contaminated sites. Each new application of innovation to different sector requires specific adaptations and new insights.

As noted by Eglė Malachovskienė, mentor from the State Scientific Research Institute's Nature Research Centre, working alongside mentors and other teams enabled her to deepen her understanding of innovative methods for enhancing the biodegradability of petroleum hydrocarbons in soil. Meanwhile, Katarzyna Zimowska of the Jerzy Haber Institute of Catalysis and Surface Chemistry confirmed that expert advice allowed their team to refine their approach, strengthen their concept, and significantly expand their capacity for innovative biotechnological problem-solving, interdisciplinary collaboration, and rapid solution development.

Taken together, these perspectives underline the hackathon's value as a bridge between research and business. It not only fostered commercialization of scientific know-how but also empowered researchers to design practical, scalable solutions to urgent environmental challenges.

Finnish Soil Detectives

The Toksika Hackathon call for innovations attracted strong participation from Finland thanks to the well-targeted scouting efforts of the Jamk team and the communication support of the Finnish Association for Soil Research and Remediation (Mutku, Maaperän tutkimus- ja kunnostusyhdistys ry). Among the five Finnish teams, the selected team – Oil Degrading Microbes and Genes (OMG) – stood out by demonstrating a strong synergy between cutting-edge research and practical business expertise, the cooperation of highly competent specialists in their respective fields. The Finnish team calling themselves ”Soil detectives”, aimed to uncover hidden factors that could limit bioremediation and to identify strategies for making the remediation process more efficient. The team brought together specialists from four organizations: the internationally operating company Afry Ltd, the Bionautit cooperative, and the startups Soilventure Ltd and Aluke Ltd. By combining expertise in soil science, microbiome analysis, and DNA extraction, the team bridged research and business knowledge in a complementary and mutually reinforcing way, showcasing the potential of cross-sector collaboration.



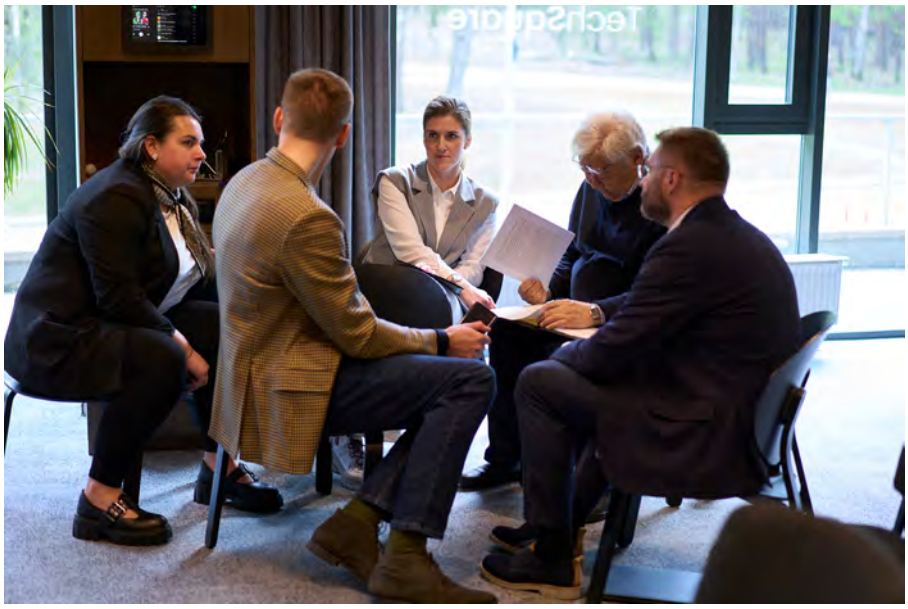
Picture 3. Oil Degrading Microbes and Genes (OMG) Team in action at Toksika Hackathon (Photographer: Agne Popiere)

The cooperation was initiated by Aura Nousiainen, Chairperson of the Mutku association and representative of Afry Ltd, who had previously collaborated with the other team members on a demanding oil contamination remediation project. The hackathon offered a chance to deepen this shared interest, turning prior connections into a focused collaboration. While the members were already familiar with each other through earlier activities, working together on a clearly defined challenge unlocked fresh opportunities and revealed new potential for long-term cooperation.

OMG team described the Toksika Hackathon as a valuable learning and networking experience. Collaborating in a cross-organizational team that combined diverse areas of expertise not only accelerated the learning process but also laid a strong foundation for future cooperation. According to Salla Venäläinen of Soilventure Ltd, while the team gained new international contacts, the most valuable outcome was the strengthening of their internal collaboration.

Jury Decisions between German Expertise and Polish Research Excellence

For the jury, selecting a winner was a difficult decision, as the evaluation results showed only a small difference between the two leading teams: Sensatec GmbH from Germany and the Bioprocess Development Laboratory team from Poland. Ultimately, the hackathon concluded with Sensatec GmbH being declared the winner. An experienced company with extensive expertise and strong competencies, Sensatec operates in a field similar to Toksika, applying comparable methods and practices for the remediation of contaminated soil. The company's representative presented the most comprehensive solution, combining advanced in-situ remediation technologies and services with products such as microbes, biopolymers, and reagents to ensure effective contamination cleanup. The second place went to the Bioprocess Development Laboratory team from Poland, which excelled in demonstrating a solution that combines enzymes and biosurfactants to accelerate the degradation of long-chain hydrocarbons.



Picture 4. Jury work at Toksika Hackathon (Photographer: Agne Popiere)

Sensatec approach emphasized practical applicability, operational readiness, and scalability, reflecting the expertise of a company already having an established experience in soil remediation. As Marius Busilas, Toksika's Development Manager mentioned, the solution impressed with its completeness and integrated approach: combining advanced technologies with tailored products like microbes, biopolymers, and reagents for effective soil decontamination (Interreg Baltic Sea Region, May 16, 2025)

However, the Polish team, excelled in research depth and innovation. Their approach focused on cutting-edge biotechnological methods, with detailed laboratory studies on microbial consortia, DNA-based microbiome optimization, and bioaugmentation strategies. While slightly less complete in terms of ready-to-deploy services, their solution showcased novel scientific insights with high potential for future development and commercialization.

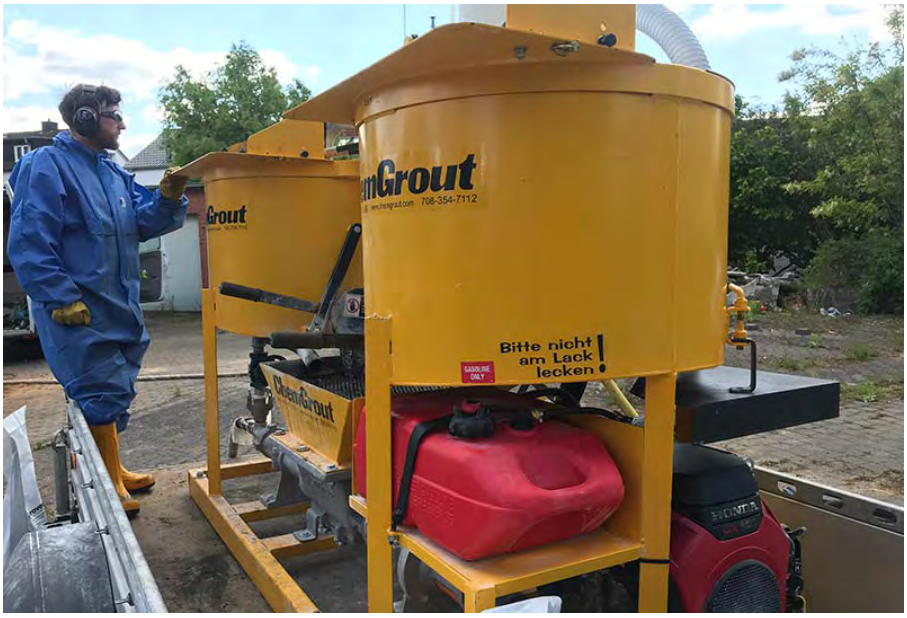
In summary, Sensatec offered a market-ready, comprehensive solution with immediate applicability and measurable impact, whereas the Polish team brought research excellence and innovative methodologies that could drive future breakthroughs in bioremediation. The jury's decision reflected a balance between practical completeness and scientific innovation, recognizing both contributions as highly valuable to addressing petroleum-contaminated soils.

Both solutions demonstrated strong alignment with sustainable practices and circular economy principles, reducing reliance on energy-intensive or chemical-heavy methods.

From Hackathon to International Collaboration

Toksika's cooperation with Sensatec GmbH began immediately after the hackathon, with both companies exchanging experience and outlining directions for future joint projects. Both sides see strong potential in combining their expertise, particularly in applying Sensatec's innovative methods for decomposing long-chain heavy hydrocarbons. On 12 May 2025, UAB Toksika and Sensatec GmbH formalized this partnership by signing a Letter of Intent focused on soil contamination remediation projects in Lithuania.

In July, the Toksika team visited Sensatec in Germany, where they explored five different sites showcasing various treatment technologies. During their visit to Sensatec, Toksika specialists had opportunity to examine advanced equipment and tools for managing contaminated sites — solutions that may soon be implemented in Lithuania's soil remediation efforts.



Picture 5. Sentatec's cutting-edge equipment (Photographer: Sensatec GmbH)

Another important step forward is planned long-term cooperation with the Jerzy Haber Institute of Poland. Here, biotechnology products developed in the institute's laboratories will be tested and approved, paving the way for Toksika to use them widely in soil remediation activities. This unique synergy between science and practice could lead to the creation of new, broadly applicable products that address not only contaminated land management, but also the goals of the EU Soil Strategy — ensuring that soil is not only remediated but restored to good condition as a vital component of the environment.

Toksika Hackathon successfully achieved its goal of fostering innovative, sustainable solutions for petroleum-contaminated soils. By bringing together market-ready technologies and cutting-edge research, the hackathon showcased approaches that are applicable and capable of driving future breakthroughs. Importantly, the winning solutions emphasized environmentally responsible practices, aligning with circular economy principles while accelerating soil remediation. The hackathon demonstrated its ability to catalyze meaningful collaboration, bridge science and practice, and advance smarter, greener approaches to tackling persistent environmental pollution.

BioBoosters Hackathons: Turning Challenges into Collaborations

The BioBoosters hackathons have proven to be a valuable platform for both teams and mentors, offering a unique space to connect with large companies, increase visibility, and validate new business ideas. These hackathons are distinguished by their well-structured organization and broad international participation.

> By participating in the hackathon, Toksika far exceeded its initial expectations – We sincerely recommend other companies facing challenges in their activities to take part in BioBoosters hackathons. These events stand out for their excellent organization and strong international scope, opening doors to meaningful and innovative collaborations. – Marius Busilas, Toksika's Development Manager

For companies aiming to reengineer their processes, access to specialized knowledge, advanced technologies, and research capabilities is often crucial, although these resources frequently lie beyond their internal expertise (Stanionytė & Aalto, 2025). This makes collaboration with external partners essential. One of the key challenges in fostering such collaboration lies in identifying suitable partners. Finding organizations with complementary needs

and goals can be a complex and time-consuming process, often limiting the speed at which new solutions can be developed and implemented. Here is where BioBoosters comes in by offering a structured platform that connects businesses with innovators, mentors, and international partners, the hackathons streamline the matchmaking process where challenges meet tailored solutions. With its international reach, the hackathon further enhances this process by bringing together participants from different countries, enriching the outcomes with diverse perspectives and expertise.

Toksika Hackathon	
Challenge	Accelerated remediation of contaminated soils: biological soil treatment for petroleum-contaminated sites
Target groups	Startups, established companies, research institutes, educational organisations with solution ideas for remediation of soils contaminated with long-chain petroleum hydrocarbons
Organiser	Sunrise Tech Park, Lithuania Sunrise Tech Park is a public business support organization that promotes the creation and growth of innovative, knowledge-driven business. With over 20 years of experience, it has become one of Lithuania's leading innovation and technology hubs, uniting startups, SMEs, researchers, and industry leaders to encourage collaboration in areas such as cleantech, deeptech and ICT.
Mentors	UAB Toksika (Lithuania), Sunrise Tech Park (Lithuania), Nature Research Centre (Lithuania), Vytautas Magnus University/ Biovala (Lithuania), Finnish Environment Institute (Finland), and Karlstad University (Sweden).
Hackathon days	6–7 of May 2025, Vilnius, Lithuania
Applicants	20 applications from: Lithuania (5), Finland (4), collaboration EE+FI+IT (1), Sweden (1), Poland (1), Germany (4), Italy (1), Spain (1), Canada (1) & Turkey (1)
Selected teams	5 teams: Deep Scientific from Lithuania, Microfy Systems from Spain, Sensatec GmbH from Germany, Bioprocess Development Laboratory team from Poland, Oil Degrading Microbes and Genes team from Finland
Winner	Sensatec GmbH (Germany) offering advanced in-situ remediation technologies and services that integrate tailored products such as microbes, biopolymers, and reagents
Impact	By adopting Sensatec's technology, it may be possible to remediate part of 5,000 sites in Lithuania contaminated by petroleum-related activities, such as fuel stations, oil storage facilities and vehicle maintenance yards, without excavating the contaminated soil or disturbing the landscape.
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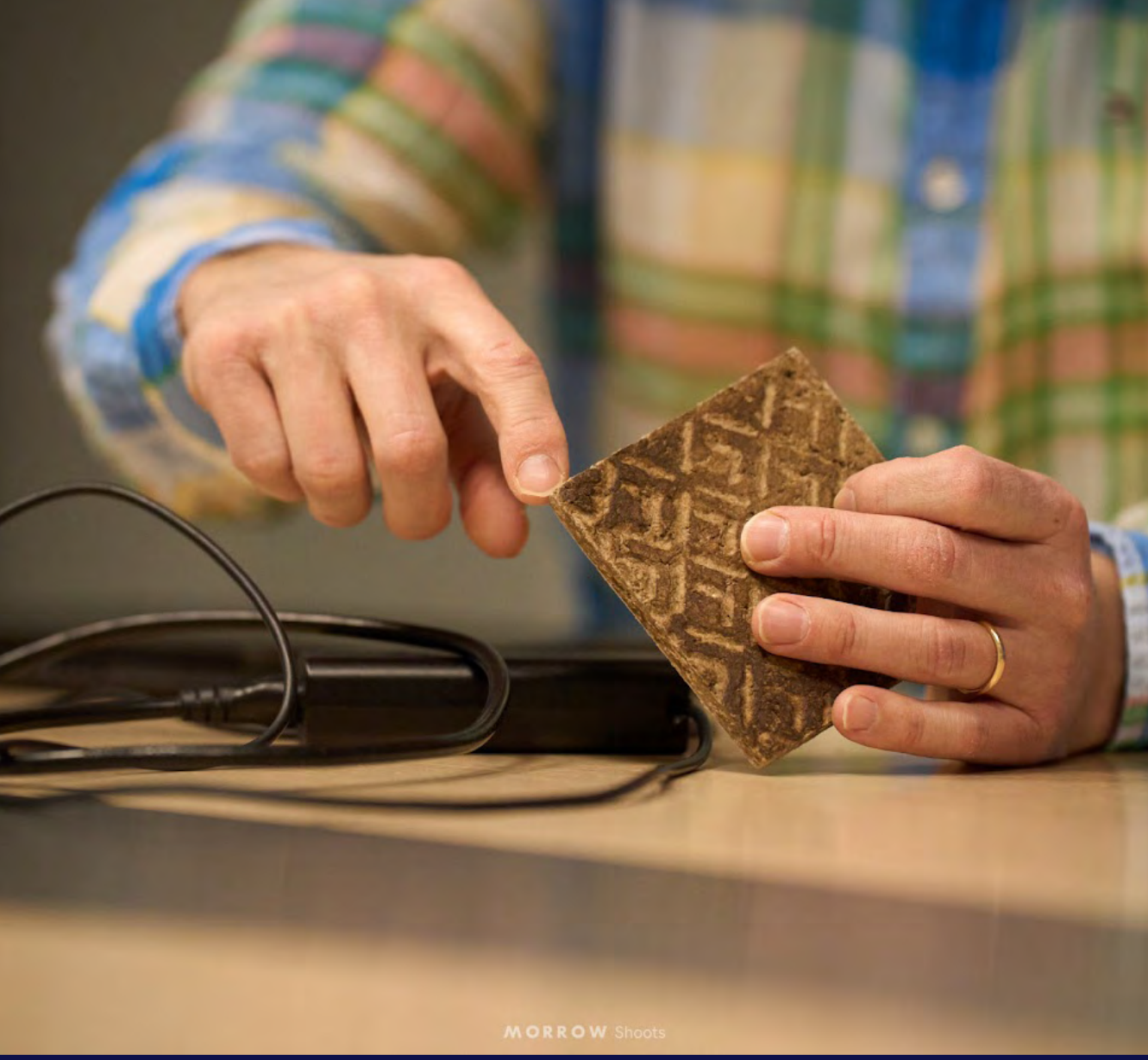


Theme 3

Valorisation of Biobased Sidestreams

Nordic Hemp Hackathon: 'Innovate to Elevate' – From Field Waste to Future Value

Matti Räsänen, Jamk University of Applied Sciences, Finland
Katrin Kepp, Estonian University of Life Sciences, Estonia
Lili Veesaar, Estonian University of Life Sciences, Estonia

In the heart of Estonia's hemp fields, a challenge was growing – quite literally. While hemp cultivation had scaled impressively, the fibrous stalks remained outside Nordic Hemp's commercial focus. To explore new value pathways for this biomass, the company launched a BioBoosters hackathon focused on sidestream innovation. The author participated in the hackathon as a mentor, supporting teams in their search for circular solutions and observing the creative process unfold from within.

Why Hemp Matters?

Hemp is more than a crop – it's a regenerative resource with the potential to reshape agriculture, industry, and climate strategies. According to the European Commission, hemp cultivation supports the goals of the European Green Deal by offering a wide range of environmental benefits (European Commission, n.d.). Its deep taproot, shown to reach deeper than any other cultivated plant (Guoyan et al., 1998), improves soil structure, reduces erosion, and enhances nutrient cycling, making it an ideal candidate for crop rotation and soil restoration (Matila, 2018).

In the European Union, hemp cultivation area increased by 60% between 2015 and 2022, while production volume rose by over 84% – a sign of growing interest in this versatile plant and its potential role in the green transition (European Commission, n.d.). Hemp grows rapidly, reaching heights of 2–4 meters in a single season, and produces high biomass yields even in northern latitudes. In Finland, average dry matter yields range from 4 to 8 tons per hectare, with carbon sequestration rates up to 13.5 tons of CO_2 per hectare – significantly more than coniferous forests in the same region (ProAgria, 2022).

Its environmental benefits extend beyond the field. Hemp has been shown to remove heavy metals from soil, reduce plant pathogens, and support biodiversity by providing pollen and shelter for pollinators and birds (Matila, 2018; O'Brien & Arathi, 2019). These qualities make it a valuable tool for ecological farming and land rehabilitation.

Industrial applications of hemp are equally diverse. Its fibers are strong, fire-resistant, and acoustically insulating, making them suitable for sustainable building materials. Hemp can also be used in textiles, bioplastics, paper, cosmetics, and even energy storage – with research showing that hemp-based carbon nanosheets outperform traditional materials in supercapacitors (Wang & Xu, 2013; Morgan, 2014). The plant's versatility is matched by its circular potential: nearly every part of the plant can be used, and many products are biodegradable or recyclable.

Despite its promise, hemp faces structural challenges. The lack of processing infrastructure and consistent supply chains creates a "chicken-and-egg" problem: without demand, investment in processing is limited, and without processing, demand cannot grow (Norokytö, 2010). This is where initiatives like the Nordic Hemp Hackathon play a role – by connecting stakeholders and showcasing hemp's broader potential.

Unlocking the Full Potential of Hemp

For Nordic Hemp, one of Europe's leading organic hemp producers, the vision of whole-plant valorisation is becoming a reality. While the company has traditionally focused on seed-based products such as oils, proteins, and hulled seeds, the fibrous stalks of the hemp plant have remained underutilised (Nordic Hemp, 2025). This gap in utilisation became the focus of a dedicated innovation challenge.

With hemp cultivation expanding across Europe and the environmental urgency of the green transition, Nordic Hemp recognised the need to find economically viable and sustainable uses for these sidestreams (Interreg Baltic Sea Region, 2025). The company's facilities, all located within 50 km of Tartu, Estonia, are well positioned to support new value chains. A planned decortication facility in Estonia will further reduce the need to transport hemp stalks to the Netherlands for processing, cutting both costs and emissions (Interreg Baltic Sea Region, 2025).

The Challenge: From Sidestream to Value Stream

The Nordic Hemp Hackathon "Innovate to Elevate", organised by BioBoosters and held in March 2025 at the Estonian University of Life Sciences in Tartu, set out to address a critical gap in the hemp value chain: the underutilisation of hemp stalks. Without a commercially viable end-use, there had been little incentive to collect or process this biomass (Nordic Hemp, 2025).

The challenge focused on valorising all parts of the stalk—fiber, hurd, and dust—each with distinct material properties and potential applications. These sidestreams had previously been overlooked in Nordic Hemp's operations, not due to lack of value, but because no scalable business case had yet emerged (Interreg Baltic Sea Region, 2025).

The hackathon aimed to identify innovative, scalable, and sustainable applications that could unlock new value from hemp sidestreams and justify future processing investments. Its timing reflected a broader shift in the bioeconomy and the green transition. Sidestream valorisation has become a key strategy in this transition, offering both environmental and economic benefits. Similar challenges have been tackled in previous BioBoosters hackathons, ranging from forestry to food processing (Aalto & Manerus, 2024, 99–137).

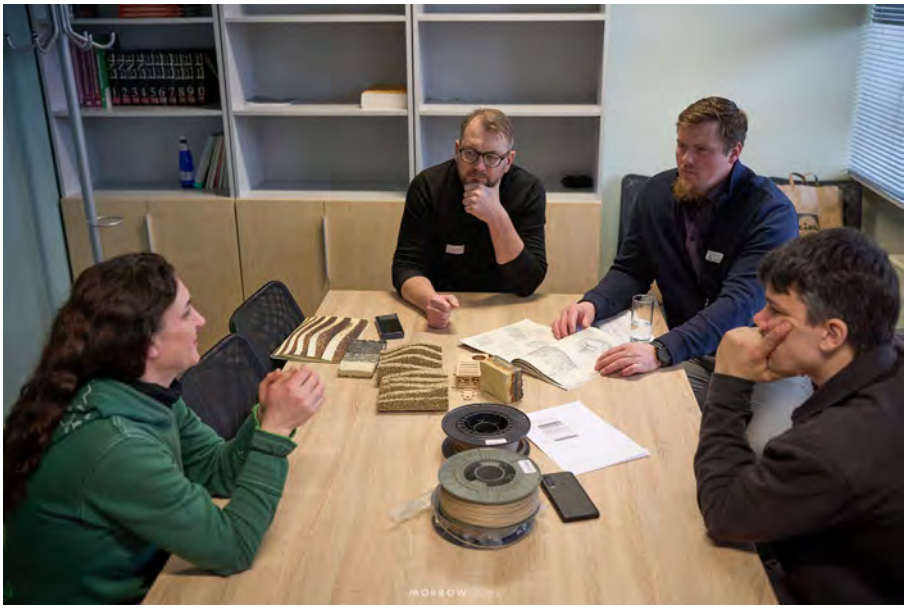
The challenge also highlighted a common issue in sidestream utilisation: economic viability in logistics and processing. For any solution to succeed, the value of the end product must outweigh the costs of collection, transport, and refinement. Turning raw materials into new business requires consistent quality, scalable logistics, and cost-effective processing (Jamk, 2025).

Open Innovation in Action

The Nordic Hemp Hackathon brought together a diverse group of innovators, each with their own expertise and perspective, to co-create solutions in a shared physical space. The event was designed to foster creativity and collaboration: teams worked side by side throughout the two-day workshop, engaging in spontaneous discussions and exchanging ideas across disciplines and nationalities.

Mentors played a key role in supporting the teams. Their input helped participants sharpen their concepts, refine their pitches, and consider practical aspects such as scalability, sustainability, and market fit. While the core ideas were largely in place before the event, the mentoring process helped teams communicate their value more clearly and identify potential development paths.

The atmosphere was energetic yet focused. The open innovation format encouraged experimentation and rapid iteration, allowing teams to test assumptions and receive immediate feedback. This dynamic environment – supported by expert facilitation and a shared commitment to sustainability – exemplified the strengths of the BioBoosters hackathon model.



Picture 1. Mentors and participants working (Photographer: Morrow Shoots)

Creative Solutions from Across Europe

The Nordic Hemp Hackathon brought together a diverse mix of teams exploring how hemp stalks could be transformed into valuable products. While the raw material was the same, the approaches varied widely—from construction and packaging to biotechnology and materials science.

One standout example was MB Ekopolimeras from Lithuania, which introduced hemp-based filament for 3D printing. Their goal was to replace traditional mined resources with biodegradable, plant-based alternatives. The team already offers filament and acoustic panels through its online store, demonstrating a clear path from concept to market (MB Ekopolimeras, n.d.).

Other teams explored biological and material innovations. Some used hemp as a substrate for mushroom cultivation, aiming to produce biodegradable packaging or wellness-related products. Others investigated fermentation-based processes to extract enzymes from hemp biomass, opening new possibilities for industrial applications. These ideas demonstrated how hemp can serve as a platform for circular solutions that span agriculture, biotechnology, and consumer goods.

Despite their varied approaches, many solutions shared a common advantage: they required minimal investment from Nordic Hemp—often just access to raw material—making collaboration both feasible and attractive.

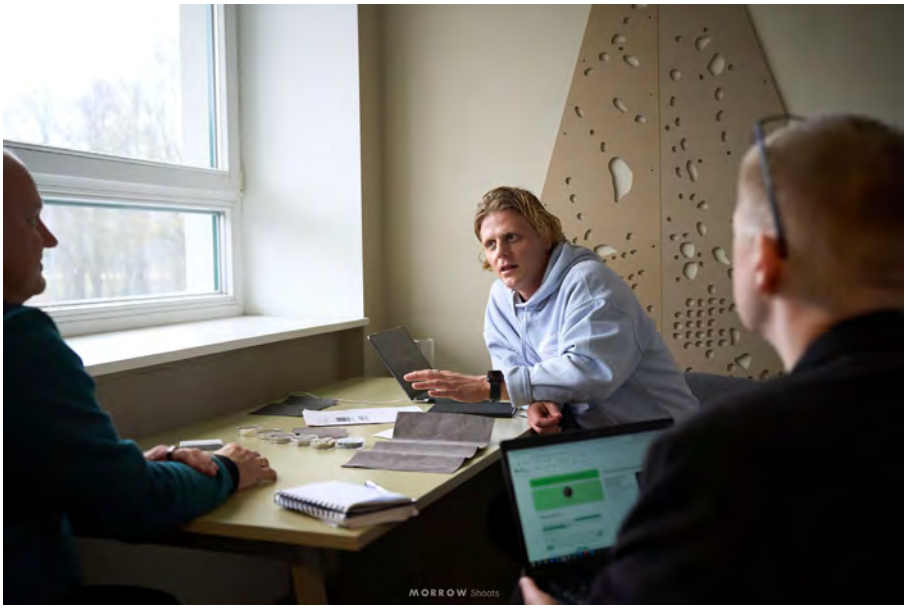
A Winning Solution with Circular Impact

Among the many promising ideas presented at the hackathon, one stood out for its technical maturity, market readiness, and alignment with circular economy principles. The winning team introduced LOVR, a patented, plastic-free, biodegradable, and vegan leather alternative made from hemp fibers and dust. Developed in collaboration with the Technical University of Darmstadt, the material is already gaining traction in sectors such as fashion, interior design, and automotive – with plans to integrate it into Volkswagen vehicles by 2028 (Interreg Baltic Sea Region, 2025).

What made the solution particularly compelling was its readiness for scale. The production process is already established, and the team had clear plans for commercial partnerships. From Nordic Hemp's perspective, the collaboration required no major investment – only a reliable supply of clean hemp fiber. This made the solution both feasible and attractive.

LOVR is designed for circularity: it is fully compostable, recyclable, and emits only 0.51 kg CO_2 per square meter – significantly less than conventional leather or synthetic alternatives (Revoltech, n.d.). However, the material requires pure textile-grade fiber, meaning that hurd or mixed biomass cannot be used. This specificity presents a logistical consideration, but not a barrier, especially with a decortication facility planned in Estonia.

The solution met all five evaluation criteria of the hackathon: it was innovative, technically feasible, environmentally sustainable, economically viable, and backed by a capable team. While the jury acknowledged the high quality of all participating teams, the decision ultimately reflected the solution's readiness to move from concept to implementation – and its potential to demonstrate how agricultural sidestreams can become high-value, climate-positive materials.



Picture 2. Mentoring session & material samples on the table (Photographer: Morrow Shoots)

Strengthening Regional Expertise and Networks in Central Finland

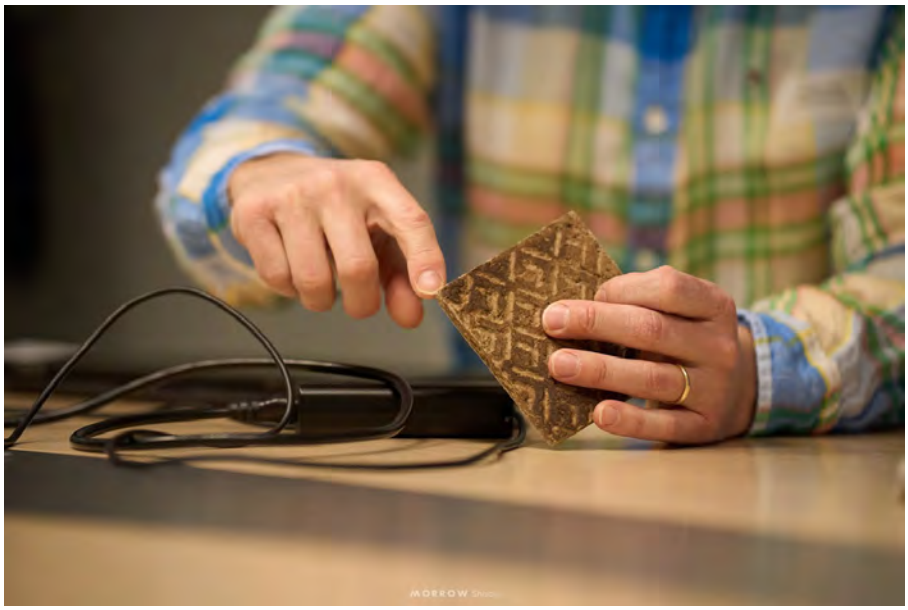
The Nordic Hemp Hackathon also reflected the growing interest in sustainable bioeconomy solutions in Central Finland. The region was well represented, with two mentors and two participating teams contributing to the event. Through their involvement, participants gained valuable insights into hemp-based innovations, sidestream utilisation, and circular design—knowledge now feeding back into regional development.

The Bioeconomy Campus, coordinated by Jamk University of Applied Sciences, plays an important role in this transition through projects such as TURBITS, which develops circular economy models for biosidestreams and explores new crops for former peatlands. While hemp is not a direct candidate for these soils, its versatility and high biomass make it a promising source of multiple high-value products from sidestreams (Jamk University of Applied Sciences, 2023).

Central Finland also has a long-standing hemp tradition. Jyväs-Hamppu, based in Oravasaari, continues this legacy with a strong focus on local

vitality and sustainability. The company promotes short supply chains and aims to make hemp a part of everyday diets while exploring its potential in food, textiles, and building materials. Its mission is to create an ecosystem where hemp's thousands of possibilities can be developed into products and services. By building networks and shared production resources for small producers, Jyväs-Hamppu lowers entry barriers, reduces environmental impact, and maximises the share of local production—ensuring that hemp remains a driver of sustainable growth in the region (Jyväs-Hamppu, n.d.).

One of the Central Finland teams, Natural Element, has expressed interest in launching industrial production of hemp-based construction boards in the region. Janne Salmela has highlighted the potential of hemp cultivation to bring new vitality to rural Finland (Salmela, 2025). Although the team was not selected as the winner, the hackathon experience and the connections formed may support future collaboration with Nordic Hemp and other teams.



Picture 3. Prototype of hemp-based construction board developed in Central Finland (Photographer: Morrow Shoots)

Conclusion: From Challenge to Change

The Nordic Hemp Hackathon exemplifies how open innovation can address real-world challenges in the bioeconomy. By bringing together diverse teams, expert mentors, and a forward-thinking company, the event generated practical solutions with long-term potential. It also laid the groundwork for enduring international partnerships, showing how collaboration across borders can accelerate the transition to a circular economy (Interreg Baltic Sea Region, 2025).

Participants from five countries worked side by side, exchanging ideas and expertise that would have been difficult to access within national boundaries. This diversity not only enriched the solutions but also strengthened the resilience of emerging value chains by connecting actors from different markets and sectors.

The hackathon demonstrated that even underutilised agricultural residues can become the foundation for scalable, circular solutions—when the right minds and motivations meet. From biodegradable packaging and enzyme production to natural building materials and circular textiles, the ideas presented were not only creative but also grounded in real-world feasibility. The experience highlighted that innovation thrives in networks, and that regional strengths—when linked internationally—can create impact far beyond the event itself.

The journey from field waste to future value is just beginning—and the lessons learned here will inspire future collaboration and innovation across the bioeconomy.

Nordic Hemp Hackathon	
Challenge	Creating scalable and sustainable applications for hemp stalk sidestreams – fiber, hurd, and dust – to reduce waste and unlock new value chains in the bioeconomy.
Target groups	Innovators, startups, companies, and researchers focused on circular bioeconomy and hemp-based materials
Organiser	BioBoosters by Jamk, Centre of Bioeconomy, Estonian University of Life Sciences
Mentors	Nordic Hemp (Estonia), Jamk University of Applied Sciences (Finland), Jyväs-Hamppu Oy (Finland), Estonian University of Life Sciences (Estonia), Pärnu County Development Centre (Estonia), University of Tartu (Estonia)
Hackathon days	13–14 March 2025, at Centre of Bioeconomy, Estonian University of Life Sciences, Tartu, Estonia (kick-off online, workshops in Tartu)
Applicants	15 teams (5 Estonia, 1 Germany, 5 Poland, 1 Lithuania, 2 teams from Finland and 1 Sweden)
Selected teams	7 teams (1 from Germany, 1 from Lithuania, 2 from Estonia, 1 from Sweden/Canada, 2 from Finland)
Winner	Revoltech (Germany) – LOVR circular leather alternative
Impact	The winning solution, LOVR, is a biodegradable and recyclable alternative to synthetic leather, made from hemp fiber and dust. Its adoption could reduce microplastic pollution and lower CO_2 emissions in material production. Other teams proposed enzyme extraction, biodegradable packaging, and hemp-based construction boards, all contributing to more sustainable production systems and circular value chains.
UN Sustainable Development Goals	

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Valorisation of Apple Pomace Through Open Innovation: A Case Study of the Piesta Hackathon in West Estonia

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Each autumn, Kuusikaru Farm produces tons of apple pomace—the skins, pulp, and seeds left after pressing apples for juice, jams, and syrups. At the Piesta Hackathon in West Estonia, teams came together to find creative ways to turn this by-product into valuable resources, overcoming the challenges small rural producers face in processing and reuse.

Introduction

The discussion on the circular bioeconomy is increasingly prominent, framed as both a strategic necessity and a significant opportunity for rural regions across Europe (Geissdoerfer et al., 2017). This is particularly true for agricultural side-streams and biomass residues—which represent a considerable, yet often untapped, source of value. While these byproducts hold immense potential, small and medium-sized enterprises (SMEs) frequently face considerable technical and financial constraints that prevent them from fully exploiting them (Shalini & Gupta, 2010). The BioBoosters Piesta Hackathon, held in May 2025 in Pärnu County, Estonia, stands as a compelling case study of how the principles of open innovation can be effectively harnessed to address these very constraints (Piesta Hackathon case description, 2025).

This article examines the BioBoosters Piesta Hackathon as a model for mobilising transnational knowledge and expertise to tackle a real-world, local challenge in a collaborative and creative manner. The hackathon, a short-term, high-intensity innovation event, has been widely recognized for its ability to foster creativity, diversity of thought, and rapid prototyping. Its application in the field of bioeconomy is a relatively recent but increasingly relevant development and the BioBoosters approach with its modified hackathon process clearly illustrates its benefits. Unlike traditional research and development projects, hackathons provide SMEs with a unique opportunity to pose concrete problems and benefit from a wide range of insights contributed by international solution providers, mentors, and researchers.

In the case of the Piesta Hackathon, the core challenge centered on finding sustainable use for apple pomace—a nutrient-rich byproduct of juice and cider production. Despite containing valuable components such as fiber, polyphenols, oils, and fermentable sugars (Tsoupras et al., 2024), the pomace has historically been composted, representing a cost burden and a significantly missed economic opportunity for local producers. By embedding this challenge within the BioBoosters open innovation framework, the Piesta Hackathon transformed what was initially a local waste issue into a broader opportunity for innovation in rural bioresource valorisation.

Crucially, the hackathon did not operate in a vacuum. Piesta's specific problem has also been contextualized within broader, pre-existing policy frameworks, notably the Estonian Bioeconomy Roadmap (Ministry of Regional Affairs and Agriculture of Estonia, 2023) and the EU Bioeconomy Strategy (2022). This strategic alignment ensured that the solutions explored were not only technically promising but also directly relevant to current regional and European priorities in circular and bio-based development. The hackathon served as a practical mechanism for operationalising these high-level policy goals at the grassroots level.

Apple Pomace and Its Valorisation Potential

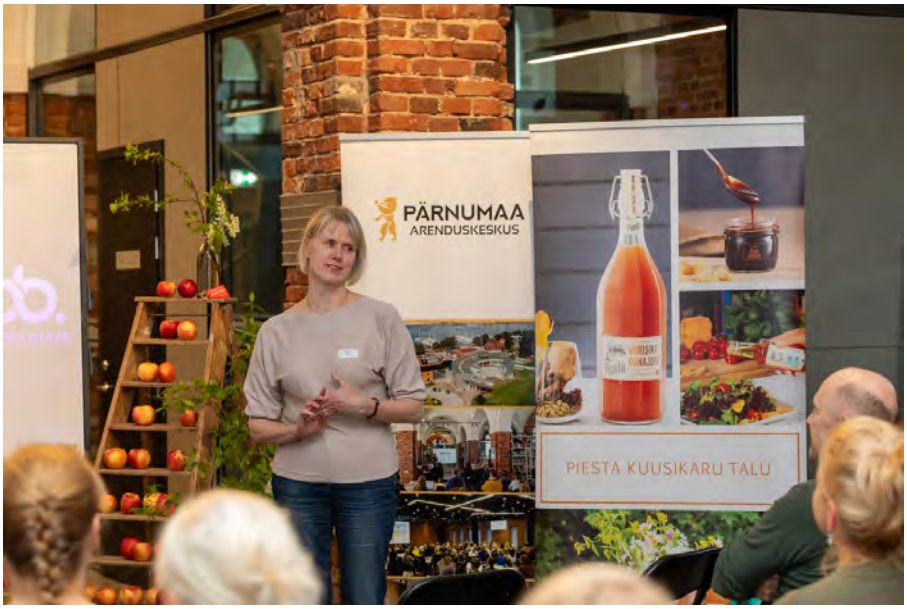
Piesta Kuusikaru Farm, the challenge provider for the Piesta Hackathon, is a family-run enterprise in Pärnu County, West-Estonia, known for producing artisanal juices, jams, stroops and syrups. Each autumn harvest brings not only bottles of high-quality beverages but also tons of apple pomace—skins, pulp, and seeds left behind after pressing. Traditionally, this material has been composted but rising logistics costs and tightening environmental regulations have increasingly turned disposal into both a financial and sustainability burden (Pärnumaa Arenduskeskus, 2025).

Apple pomace, the solid residue left after juice or cider extraction, constitutes approximately 20–30% of the total weight of processed apples (Shalini & Gupta, 2010). It is a rich source of dietary fiber, polyphenols, and essential oils, and has been studied for its potential applications in functional foods, nutraceuticals, cosmetics, and animal feed. Despite this, most small processors continue to dispose of apple pomace through low-value pathways such as composting or anaerobic digestion for biogas production.

This practice is largely due to systemic logistical, regulatory, and economic barriers, which are particularly pronounced for rural SMEs with limited internal resources. For many small enterprises, the capital investment required for

drying, extraction, or fermentation technologies is simply cost-prohibitive. Moreover, the seasonal and geographically dispersed nature of biomass makes it difficult to justify the establishment of full-scale, centralized processing facilities.

These systemic challenges are echoed in the Norden Industrial Symbiosis Report (Giacometti et al., 2025), which highlights that small, scattered biomass streams across the Nordic-Baltic region remain significantly underutilized. Addressing this issue requires not just technical innovation but also novel forms of cooperation between businesses, municipalities, and research institutions—precisely the kind of collaborative environment a BioBoosters hackathon model seeks to create.



Picture 1. Piesta owner (Photographer: Kristi Kuusmik-Orav, REK-Foto)

Regional and Policy Context

The West-Estonia Circular Economy Roadmap (Ministry of Regional Affairs and Agriculture of Estonia,2024) identifies agri-food side-streams, such as apple pomace, as a priority area for regional intervention in Estonia. The document explicitly recognises that SMEs often lack the internal capacity to test or adopt emerging solutions and calls for the creation of supportive ecosystems. Intermediary organisations, like Pärnu County Development Centre and Innovation Hub or the majority of the other BioBoosters project partners, are expected to play a key role in facilitating collaboration, building capacity, and supporting pilot initiatives. Piesta's challenge perfectly exemplifies the type of case addressed by the roadmap: a locally available but underutilized biomass resource obstructed by systemic bottlenecks. The hackathon approach, by connecting SMEs with solution providers and research institutions, offers a practical and immediate mechanism to overcome these barriers and operationalise the roadmap's strategic goals.

At the European level, the EU Bioeconomy Strategy (2022 update) stresses the pivotal role of regional innovation ecosystems in unlocking the value of local biomass streams. The strategy advocates for a place-based innovation approach, which emphasises that technologies and business models must be tailored to the specific characteristics of rural areas and their unique bioresources. In alignment with this, Estonia's RDIE Strategy 2021–2035 priorities sustainable food systems and the circular economy. It specifically highlights the development of high-value products from agricultural by-products as a key avenue for innovation and enhanced competitiveness. The Piesta Hackathon fits squarely within these overarching policy frameworks. It provided a structured, yet flexible, setting in which a micro-level challenge could be tackled with the input of transnational expertise. By situating a local problem within this larger strategic landscape, the hackathon not only advanced Piesta's specific goals but also generated insights and knowledge relevant to other rural SMEs across the Baltic Sea Region.

Instruments of Innovation Governance

Hackathons are increasingly recognized as dynamic tools of innovation governance—collaborative mechanisms that bring together diverse stakeholders to develop solutions within constrained timeframes (Komssi et al., 2015). Although it originated in the ICT sector, hackathons are now gaining traction in more complex fields like the circular bioeconomy.

The BioBoosters network has played a pioneering role in transferring the hackathon model to this domain. Previous BioBoosters hackathon events carried out in Pärnu County, such as the Võiste Hackathon seeking to valorise tomato biomass (organised in May 2024), and now the Piesta Hackathon (organised in May 2025), demonstrate how this model can effectively unlock innovation in rural settings. By doing so, hackathons provide a more agile and accessible alternative to traditional EU-funded innovation platforms or pilot projects, which often involve significant time, resources, and administrative bureaucracy. In this context, the Piesta Hackathon did more than address a technical problem; it operationalised key elements of EU and regional strategies and demonstrated how grassroots innovation can contribute to systemic transformation in a very traditional industry.

Hackathon as Open Innovation Laboratory

The Piesta Hackathon, held on 15–16 May 2025, was hosted by Pärnu County Development Centre in collaboration with the BioBoosters network. Following the BioBoosters hackathon model, it was meticulously designed as a multi-phase open innovation process, combining transnational participation, cross-sectoral mentoring, and digital dissemination. The hackathon not only brought together technical and entrepreneurial talent but also experimented with formats that fostered deeper European collaboration around rural circular economic challenges.

The hackathon process was structured into three distinct and interconnected phases:

1. **Pre-event collaboration** – A joint ”Apple Hack: Unlocking the Value of Apple Biomass” webinar co-hosted with PRO CIVIS Foundation, the organiser of BioBoosters Refal Hackathon in Poland, established a shared conceptual and methodological framework for apple biomass valorisation. This binational launch was both symbolic and strategic, linking a local challenge to broader European innovation dialogues.

2. **Main hackathon event** – A two-day intensive, in-person workshop held in Pärnu brought together five international teams to refine their proposed solutions with expert mentoring and feedback loops.

3. **Post-event engagement** – Promising concepts were funneled into next-step discussions, including potential lab-scale testing, partner matchmaking, and policy dissemination.

Picture 2. Organizers having fun (Photographer: Kristi Kuusmik-Orav, REK-Foto)

Cross-Border Synergy: The Apple Hack Webinar

The international ”Apple Hack: Unlocking the Apple Biomass” webinar that launched the apple-industry-related BioBoosters hackathon calls in Estonia and Poland represented a methodological innovation. Held jointly with PRO CIVIS Foundation, the organiser of Refal Hackathon in Poland, it framed apple pomace not merely as a local by-product but as a shared resource across European cider and juice industries. The open session featured keynote presentations from researchers, circular economy experts, and SMEs, offering multi-perspective insights into:

- The biochemical composition and extraction potential of pomace (polyphenols, pectins, dietary fibers).

- Opportunities for creating food, feed, cosmetics, and fertilizer products.
- Regulatory challenges and innovation funding instruments available in the EU.

Importantly, the webinar was not a one-way transmission of information. It also initiated a vital mentoring exchange: Polish experts later advised Estonian teams, and Estonian mentors supported their Polish counterparts. This cross-pollination of expertise laid the foundation for a transversal mentoring ecosystem defining feature of the BioBoosters approach. As Svea Uusen from the Pärnu County Development Centre noted: ”The joint start also had symbolic weight: it showed that small rural challenges deserve international attention.”

This collaborative kick-off signaled to PRO CIVIS, Piesta Kuusikaru, and the wider audience that a local waste issue could be reframed as a transnational innovation opportunity—capable of connecting policy, science, and entrepreneurship.

Results: Emerging Solutions and Strategic Pathways

The open call for solutions, launched at the joint Apple Hack webinar, attracted 15 applications from a remarkably diverse set of countries—Estonia, Sweden, Germany, Poland, Finland, Lithuania, Norway, and even as far as India. This wide response illustrated that the valorisation of apple pomace is not a niche or localised concern, but rather a globally relevant issue attracting attention from innovators across multiple contexts.

Applicants included startups, academic research teams, SMEs, and solo entrepreneurs. Such diversity highlighted the accessibility of the BioBoosters hackathon model, where even early-stage innovators can confidently put forward ideas alongside more established enterprises. It also demonstrated that the BioBoosters framework can bridge the gap between early conceptualisation and more advanced, market-ready thinking.

From this pool, eight teams were selected to advance to the virtual Kick-off event, which served as an important filtering and preparation stage. Following on-line mentoring and refinement in the Howspace environment, five teams advanced to the final hackathon days in Pärnu County.

These finalists represented not only geographical diversity but also a rich spectrum of technical approaches:

- Klareva (Estonia): insect bioconversion of pomace.
- I.L.U. (Germany): extrusion-based snack innovation.
- POMAVALOR (Finland, LUT University): mobile biorefinery for on-site processing.
- Biohumus (Sweden): vermicomposting into organic fertiliser.
- NPO Veggies Cultivation (Estonia): bokashi fermentation for biofertilisers.

Two of these solution providers – POMAVALOR and Margit Olle from NPO Veggies Cultivation – participated virtually, underlining the flexibility and inclusiveness of the BioBoosters format. Hybrid participation ensured that geographical distance posed no barrier to innovation, a crucial lesson for rural SMEs often disconnected from transnational networks. The ability to engage remotely was particularly significant for the Finnish LUT University team, whose POMAVALOR concept required a combination of highly technical knowledge and local adaptation.

At the conclusion of the two-day hackathon, the finalists pitched their concepts to a jury panel composed of representatives from academia, industry, and regional development organisations. The evaluation criteria were designed to be both transparent and balanced, ensuring that visionary ideas could be recognised without losing sight of practical feasibility. The criteria included:

- Circularity and sustainability impact – reducing waste, enhancing resource efficiency, and closing nutrient loops.
- Business potential – scalability, economic viability, and market attractiveness.
- Innovative character – distinctiveness from existing alternatives.
- Relevance to Piesta's operational context – feasibility for adoption by an SME-scale artisanal juice producer.

This multi-criteria framework ensured that solutions were not only assessed on their technical merit but also on their potential to be realistically implemented in rural contexts like Piesta Kuusikaru Farm. Among the five finalists, three concepts clearly stood out:

- **Klareva (Estonia):** proposed the bioconversion of apple pomace using *Hermetia illucens* (black soldier fly larvae) to produce high-protein animal feed, lipid-rich oils, and fertiliser substrates. This approach aligned closely with sustainability goals by directly recirculating nutrients into food and feed systems.

- **I.L.U. (Germany, Institute for Food and Environmental Research):** developed a concept for extrusion-based snack filling production using dried apple pomace, targeting health-conscious and sustainability-driven consumer markets. This solution provided a consumer-facing pathway that could bring visibility and revenue diversification to small producers.
- **POMAVALOR (Finland, LUT University):** designed a mobile, container-based biorefinery unit capable of processing apple pomace on-site (e.g. UAE and spray-drying). This approach offered flexibility, reduced logistics costs, and showcased how rural SMEs could participate in high-tech valorisation without requiring prohibitive infrastructure investments.

The jury ultimately selected Klareva as the overall winner, while the public livestream votes crowned I.L.U. as ”Audience Favourite.” POMAVALOR received special commendation for its systemic and cross-sectoral framing, particularly its potential to address not only Piesta’s challenge but similar bottlenecks across Europe’s rural regions. Together, these solutions embodied three complementary strategic directions in valorising biomass, sidestreams and residues:

- Biological valorisation: recirculating nutrients through natural processes into food and feed systems (Klareva).
- Consumer product innovation: transforming waste into value-added products for sustainability-conscious markets (I.L.U.).
- Logistical reconfiguration: decentralising biomass processing through mobile, containerised units (POMAVALOR).

The Piesta Hackathon thus catalysed a rich set of conceptual solutions addressing the central challenge of apple pomace valorisation. While the immediate outcome responded directly to Piesta’s operational needs, the broader lesson was clear: SMEs across the bioeconomy can engage in the circular transition when supported by networks, mentoring, and transnational collaboration.

Livestreaming: Democratising Innovation

For the first time in the BioBoosters network, the Piesta Hackathon's final pitching session was livestreamed on LinkedIn and Facebook. This digital innovation served several strategic purposes. It expanded visibility far beyond the physical venue, reaching researchers, entrepreneurs, and policymakers across Europe. It also introduced an interactive dimension, enabling remote viewers to cast votes in real time and directly shape the outcome. Finally, it demonstrated transparency, proving that rural innovation processes can be both rigorous and inclusive.

Although some technical challenges occurred, such as lag and synchronisation problems between intercontinental platforms, the overall outcome was highly positive. As Kaydi Tomson from the Pärnu County Development Centre noted: "Going live connected us instantly to a broader audience—our local challenge became an open dialogue."

The livestream not only elevated the profile of Piesta's challenge but also highlighted the BioBoosters network's leadership in blending digital outreach with grassroots experimentation.

The session attracted audiences from SMEs, universities, and policy institutions across Europe, and the public vote crowned the solution presented by I.L.U. from Germany as the "Audience Favourite." This outcome underscored the strong appeal of consumer-facing innovations to a broad set of stakeholders. As Külli Eller, the co-owner of Piesta Kuusikaru Farm, reflected: "It was so gratifying to realise that our small challenge turned out to be a big challenge for the whole sector, that truly resonated at an international level."

For small enterprises like Piesta Kuusikaru, such visibility can be just as valuable as the solutions themselves. By amplifying their reach and connecting them to new networks, funders, and potential partners, livestreaming extended the hackathon's impact far beyond the two-day final event in Pärnu. It also embedded the outcomes in wider European innovation dialogues, reinforcing the idea that small-scale challenges can have large-scale resonance.

Broader Implications

The Piesta Hackathon provides a compelling case study on how open innovation tools—and particularly hackathons—can be mobilised to address structural challenges in the rural circular bioeconomy. Three major insights stand out clearly from the process and outcomes.

Firstly, the event reaffirmed that logistics remain the critical bottleneck in biomass valorisation. Apple pomace, like many other side-streams, is bulky, wet, and highly seasonal. Transporting it to centralised facilities often negates potential economic and environmental gains. This aligns with earlier research that has demonstrated how dispersed biomass streams create systemic inefficiencies (Vendruscolo et al., 2008; Kazemi et al., 2023). Mobile and decentralised models, such as containerised biorefineries, offer a promising pathway to mitigate these constraints—although their scalability and cost structures still need to be proven.

In Piesta Hackathon, the mobile processing unit was explored especially as a part of the solution concept designed by POMAVALOR team from LUT University, Finland. The application of movable factories – such as shipping container based biorefineries and biomass processing units opens opportunities for shifting operations to different locations based on e.g. the seasonality biomass availability or to connect several biomass sources to the business model.

Kazemi, Rask, Gomes, Yildiz and Larsen (2023) explore some of the common challenges related to the movable factories include securing human resources, especially for the more demanding and knowledge-intensive operation management work. For example, it might be hard to find qualified labour for novel and complex biorefinery processes and training expenses need to be considered. Business models can be further challenged by increased operational expenditure due to the set-up and tear-down processes. Therefore, the operations can rarely compete e.g. with mass production and are often not economically attractive for SMEs. (Kazemi et al., 2023.)

Nevertheless, advances in digitalisation can help to make the movable units a more attractive option in the rural operating conditions. Emerging tools and technologies such as IoT, DTs, modelling and simulation, and additive manufacturing, etc. can help address some of these challenges. Digitalisation enhances remote monitoring and control of operations, supply chain management and process optimisation. (Kazemi et al., 2023.)

In other words, digitalisation can make the movable factory – such as a mobile biorefinery unit – more profitable and feasible option pending that the whole value chain is well connected and the business model makes (economic) sense for all involved actors. One example of this has been explored in LiukasHackathon and Nando Hackathon, where a Spanish startup, Agrolinera presented their solution. Agrolinera has developed and patented container-based, movable manure collection and processing technology. Technology and business models address the last mile problem in collection of manure for

valorisation in biogas plants. The Agrolinera technology digitalizes the manure collection process for small and medium dairy farms to make it efficient and traceable, creating a ”virtual sewage” for these dairy communities. Currently piloted in Asturias, the logistics service model makes the biogas value chain operate more efficiently cutting methane emissions and transportation costs. Farmers also benefit from separation of the filtered water from the manure; this liquid fraction can be used as fertiliser replacing spreading of manure directly to the fields. (Agrolinera, 2024.) The Agrolinera example is also a good example of how a resilient and circular local food system needs to integrate the nutrient and energy flow into the biomass production.

Secondly, the hackathon highlighted the tension between product diversification and systemic transformation. Near-market solutions, like I.L.U.'s snack innovation, demonstrate agility and strong consumer resonance, enabling quick entry into niche markets. At the same time, longer-term solutions such as Klareva's insect bioconversion or POMAVALOR's mobile biorefinery are more ambitious in their systemic impact, addressing dependencies on imported protein or the structural inefficiencies of rural logistics. This diversification–transformation dilemma is not unique to Piesta Hackathon; it is recognised widely in sustainability transition literature (Smith et al., 2005). The hackathon created a space where both immediate and long-horizon solutions could be considered side by side, allowing SMEs to evaluate short-term feasibility while also aligning themselves with systemic innovation trends.

Thirdly, the value of transnational collaboration and visibility cannot be overstated. By embedding Piesta Kuusikaru Farm's local challenge within a European framework—through joint launch events, international mentoring, and a public livestream—the hackathon amplified its impact far beyond the farm's own operations. What began as a problem of disposing of seasonal apple pomace became a European-level conversation on circular economy strategies, nutrient cycling, and rural innovation ecosystems. This demonstrates the power of BioBoosters hackathons not only to generate solutions, but also to reframe local challenges as international opportunities.

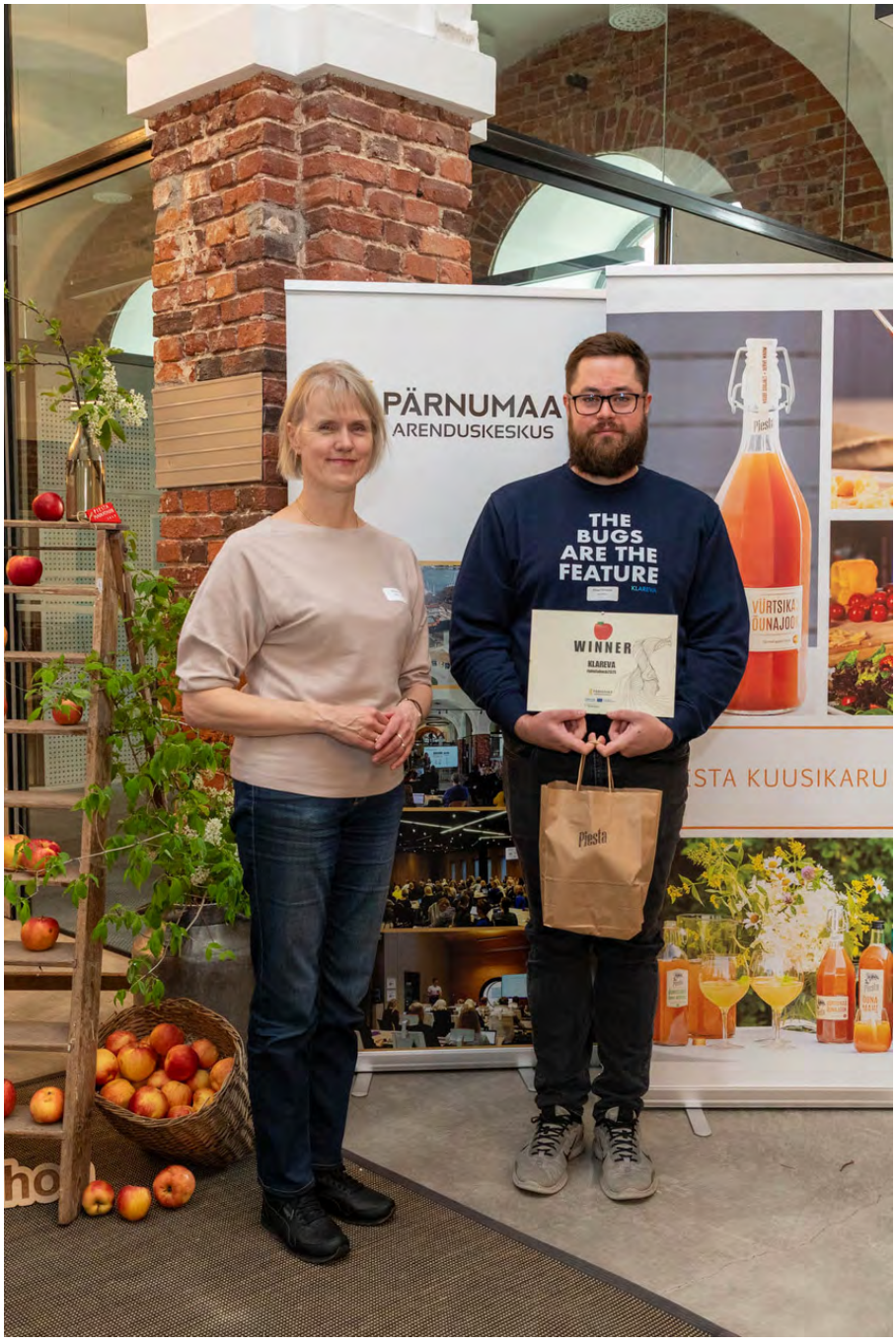
Looking Into Future

From a circular economic perspective, the winning proposal by Klareva is a prime example of biological looping—recirculating nutrients through insect bioconversion. The protein-rich feed could potentially reduce Europe's reliance on imported soy, while the oils extracted have applications in aquaculture and niche feed markets. Residual fertiliser substrates could be used locally,

closing nutrient cycles and reducing dependency on synthetic fertilisers. Yet regulatory and market barriers remain: EU frameworks for insect-based feed are still evolving, and successful scale-up will depend on a consistent supply of pomace and investment in processing infrastructure.

For Piesta Kuusikaru Farm, collaboration with these solution providers is not expected to deliver immediate revenue. However, it represents a strategic positioning step—aligning the farm with cutting-edge valorisation practices and embedding it within research and innovation networks. The forthcoming laboratory trials at the Estonian University of Life Sciences (EMÜ) are a critical next step, as they will provide empirical data on the feasibility of using pomace as a substrate for insect rearing and on the quality of the derived protein and oil fractions.

In this way, the BioBoosters Piesta Hackathon shows that open innovation does not only provides ideas but also creates pathways for SMEs to access scientific expertise, build international partnerships, and explore future-oriented business models. It bridges the gap between local challenges and European policy ambitions, ensuring that rural enterprises are not left behind in the transition to a circular bioeconomy.

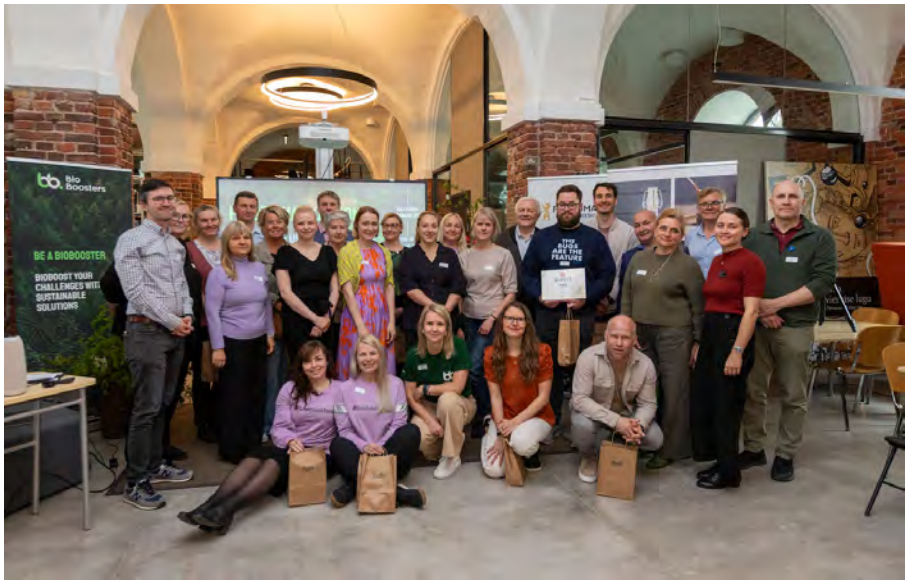


Picture 3. Winner KLAREVA (Photographer: Kristi Kuusmik-Orav, REK-Foto)

Reflections on Hackathons as Catalysts for Change

The Piesta Hackathon demonstrated that hackathons are far more than short-lived competitions. They function as living laboratories for rural symbiosis, where diverse stakeholders can reframe challenges that might otherwise seem too small, too local, or too fragmented into opportunities for collective innovation and transformation.

Several strengths of the hackathon design came to the forefront. First, inclusiveness: farmers, researchers, policymakers, and entrepreneurs all participated in equal footing. By lowering barriers to entry, the event created space for even the smallest actors to play a decisive role in shaping solutions. Second, speed and focus: within just four weeks from the launch webinar to the final pitching, solutions were proposed, reshaped, mentored, and presented—an innovation cycle that would normally require months in conventional R&D settings. Third, visibility: livestreaming amplified the event's reach well beyond Pärnu County, connecting Piesta's challenge to European researchers, SMEs, and policymakers. Finally, embeddedness: because the challenge stemmed directly from Piesta Kuusikaru Farm's operational struggles, every idea generated was grounded rather than abstract speculation.



Picture 4. Group foto of Piesta Hackathon participants (Photographer: Kristi Kuusmik-Orav, REK-Foto)

That said, hackathons are not without limitations. Their compressed timelines leave little room for deep technical development, and promising ideas can easily lose momentum if not supported by incubation, funding, or pilot opportunities after the event. Digital outreach, while powerful, does not fully remove barriers related to language, resources, or infrastructure, particularly for micro-SMEs in rural regions. For these reasons, hackathons should be understood not as end points but as entry gates into longer innovative journeys. Their true value lies in opening doors to incubation programs, matchmaking services, innovation vouchers, and laboratory partnerships that can ensure that ideas evolve into prototypes, pilots, and ultimately market-ready solutions.

Here, multiplier organisations such as Pärnu County Development Centre and other innovation hubs in the BioBoosters network play an irreplaceable role. By maintaining close links to both SMEs and research institutions, these organisations ensure that the hackathon process is not an isolated event but a steppingstone within a structured ecosystem of regional innovation.

Mentorship and Governance in the Piesta Hackathon

Mentorship proved to be one of the most critical factors in the Piesta Hackathon. Experts from across the Baltic Sea Region—including universities, applied research institutes, policy hubs, and industry—did more than provide technical advice. They inspired confidence in teams, challenged assumptions, refined business models, and facilitated valuable introductions. This cross-pollination of knowledge is one of the quiet strengths of the BioBoosters model: by mobilising a pan-regional mentoring pool, it creates a learning infrastructure that connects peripheries to centers, SMEs to laboratories, and rural innovators to international markets.

In addition to industry and business development professionals, the mentor and jury pool notably included four cider producers—two from Estonia and two from Latvia—who are facing similar challenges with apple pomace valorisation. Their participation was made possible by Piesta Kuusikaru's open and collaborative approach, which did not view them as competitors but rather as fellow changemakers on the same sustainability journey. Through their involvement, these SMEs also gained access to the BioBoosters network and ideas that they can now implement within their own businesses. At the same time, their practical expertise added valuable depth to the evaluation process by expanding the industry's perspective on feasibility, value chain alignment, and business relevance of the proposed solutions.

The Piesta Hackathon also offers insights into innovation governance. By livestreaming the final pitches and opening them to public voting, the event aligned with participatory models of innovation governance (Bason, 2018), where transparency and citizen involvement are not incidental but intentional design elements. This public dimension adds legitimacy, enhances accountability, and strengthens the link between innovation processes and society at large. From a governance standpoint, the lesson is clear: innovation does not only happen in labs or ministries, but it also emerges wherever problems are made visible, shared, and solved collaboratively. By embedding local challenges into European policy frameworks and transnational networks, hackathons create distributed processes of learning, trust-building, and co-creation that contribute to systemic change.

Conclusion

The BioBoosters Piesta Hackathon showed that when rural SMEs are given a platform, backed by supportive networks and amplified by digital visibility, they can become catalysts of transformation reaching far beyond their immediate locality. For Piesta Kuusikaru Farm, the event marked the beginning of a journey to explore new valorisation pathways for apple pomace, connect with international research partners, and align with global sustainability agendas. For the BioBoosters network, it demonstrated once again the power of hackathons as catalysts: not merely events, but entry points into systemic, collaborative, and sustainable innovation journeys.

The broader lesson is that circular bioeconomy transitions require not only technology, but also new governance models, collaborative structures, and inclusive platforms. BioBoosters hackathons—when embedded within supportive regional ecosystems—offer precisely this combination, enabling small rural enterprises to contribute meaningfully to European ambitions for circularity, resilience, and sustainable growth.

Piesta Hackathon	
Challenge	Sustainable Use of Apple Pomace
Target groups	Innovators, individuals, startups, SMEs, research entities from bioeconomy sector, solution providers, researchers, multipliers
Organiser	Pärnu County Development Centre – regional innovation hub for green transition & circular bioeconomy, Western Estonia, BioBoosters Network
Mentors	Academia: University of Life Sciences (Estonia) and Jamk University of Applied Sciences (Finland) Business support: NIFA Food cluster (Sweden), Karlstads Innovation Park (Sweden), BioFuel Region (Sweden), PRO CIVIS Foundation (Poland) Industry: Kodas (Estonia), Sabile Sidrs (Latvia), REFAL Group (Poland), Hasta (Sweden)
Hackathon days	15–16 May 2025, Pärnu (hybrid format in Pärnu, Estonia and online)
Applicants	15 applications from Estonia (3), Finland (3), Sweden (1), Poland (2), Germany (3), Norway (1), Lithuania (1) and India (1).
Selected teams	5 teams- 2 Estonia, 1 Sweden, 1 Germany, 1 Finland
Winner	Klareva (Estonia) BSF (Black soldier fly) larvae valorisation
Impact	Pilot lab trials with Klareva at EMÜ explore sustainable uses for over 20 tons of seasonal apple pomace, turning a by-product into valuable materials and reducing waste.
UN Sustainable Development Goals	

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Discovering the True Value of Apples with REFAL Hackathon

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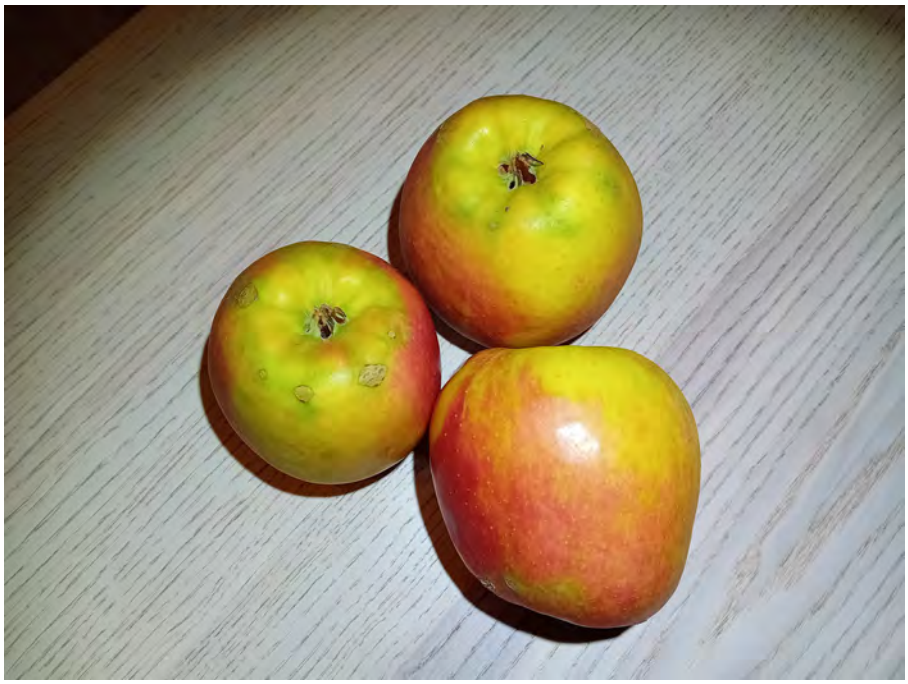
In Sandomierz, Poland, REFAL Group's 250+ hectares of apple orchards face climate threats like storms and hail, risking thousands of tons of fruit. Joining the BioBoosters hackathon, REFAL seeks ways to turn damaged apples into valuable products after a recent storm wiped out much of the season's harvest.

In the apple orchards of Sandomierz, a leading apple-growing region in Poland, REFAL Group brings together local farmers to store, sort and sell apples. With over 250 hectares of orchards, REFAL produces about 15,000 tons of apples each year. But climate change has made the business very demanding, with unpredictable weather like storms and hail, damaging apples and lowering their value. The farmers face a challenge: how can they keep the business going in these conditions? Without new ideas or innovative approaches, the realistic amounts of loses could lose up to 6 000 000 kilograms of apples every year, turning them into low-value product for juice production. To change this situation, REFAL decided to take part in the BioBoosters hackathon to find the ways to turn damaged apple biomass into valuable products. Just few weeks after the hackathon, a massive storm hit the region and brought a massive loss. Firefighters worked all night, clearing broken tree branches to reach homes with damaged roofs (Kobieta w Sadzie, 2025). That same night, a hailstorm destroyed crops across Sandomierz region, wiping out the season's profits of many farmers (Wrobel, 2025). This area, which had avoided earlier frost damage, now faced another blow that will affect their business.

Quest to Transform Damaged Apples into Sustainable Value

The agri-food sector is increasingly confronted by the dual pressures of climate change and the imperative for sustainable resource management. A very good example of this state can be found in the apple orchards of Sandomierz, Poland, where the REFAL Group, a major fruit and vegetable producer cooperative, faces a critical challenge that resonates across the industry. The core problem was the significant economic loss incurred from

apples damaged by unpredictable weather events like hail. While nutritionally sound, these apples are visually imperfect and therefore disqualified from the fresh market. Consequently, up to 40% of their annual harvest is transferred to low-price streams such as juice concentrate. The change REFAL was seeking is a shift in how this ”sub-optimal” produce is perceived and utilized. Instead of viewing it as waste, the company was aiming to unlock its hidden value by transforming it into high-value products.



Picture 1. Example of apples with damaged skin (Photographer: Stanisław Chachuła)

This challenge is relevant not only for REFAL’s economic resilience but also for the agricultural sectoral and broader bioeconomy. It directly addresses the pressing issue of food loss at the agricultural production stage, a problem with significant environmental and economic costs globally. As highlighted by the Food and Agriculture Organization (Food and Agriculture Organization of the United Nations [FAO], 2019), reducing food loss is a key target for sustainable development, making innovative valorisation strategies essential (FAO, 2019). By seeking solutions to create products like pectin, platform

chemicals, or cosmetic extracts from damaged apples, REFAL wanted to move towards a circular bioeconomy model. This approach aligns with the core of the framework, which emphasizes minimizing waste and maximizing the circulation of resources and materials at their highest value (Ellen MacArthur foundation, 2019). The REFAL Hackathon was not only a business initiative, but it represented the industry's larger quest to build resilient, resource-efficient value chains that can withstand environmental shocks and contribute to a more sustainable economic system.

Global Minds, Local Impact: How Open Innovation Unlocked Apple Biomass Potential

The BioBoosters open call successfully attracted 17 applicants from several European countries, including Poland, Finland, Germany, Norway and the Netherlands, creating a rich, international collaborative environment (Pro Civis, 2025). The participating teams represented a wide spectrum of backgrounds, from universities (Politechnika Lodz) and research institutes (Institute for Food and Environmental Research, Institute of Horticulture) to a small and medium-sized enterprise (Food4Future/Dar Ogrodu), an engineering company (GI Konstrubowski) and a startup (Pomex). This diversity brought varied perspectives to the challenge of apple biomass valorization, resulting in proposals that were exceptionally innovative (BioBoosters LinkedIn, 2025a). The solutions spanned a broad range of applications reflecting strong circular economic principles, including the creation of edible cups from pomace, the production of succinic acid and biodegradable biopolymers through fermentation and the conversion of waste biomass into energy via supercritical water gasification. Other notable approaches involved the extraction of high-value bioactive compounds for functional foods and cosmetics and the production of industrial enzymes. The high quality and creativity of the submissions genuinely surprised the challenge provider, far exceeding expectations and validating the effectiveness of the hackathon model in sourcing groundbreaking ideas.

To support the teams, the open innovation process connected them with a diverse group of international mentors from Finland, Estonia, Latvia and Poland. The executives of REFAL were also part of the mentoring group (BioBoosters LinkedIn, 2025b). From the very beginning REFAL representatives were very engaged in the process, putting the energy and openness into ambitious goals. This mentorship pool was structured to provide comprehensive support, featuring experts in chemical processes such as biorefining, biomass

conversion and fermentation, who brought deep scientific and academic experience. A second group of mentors specialized in innovation and circular bioeconomy, offering guidance on value chains, sustainable business models and commercialization strategies, with backgrounds in applied sciences and international project management. Further support was provided by specialists in business development, pitching and entrepreneurship, who had extensive experience in fundraising, market analysis and managing international projects.

The REFAL Hackathon was an intensive, sometimes exhausting, but valuable experience for the participants. Held in the specially adapted REFAL facility, the event created a unique ”hackathon bubble” where participants were immersed in solving a single challenge: maximizing the value of apple biomass. The unconventional setting (an agricultural warehouse transformed into a collaborative workspace) added a raw, authentic connection to the problem, inspiring participants to think creatively. Teams stepped out of their comfort zones, supported by structured mentoring sessions, interviews and pitching opportunities that clarified roles and goals. The organizers – Foundation for Education and Social Dialogue ”PRO CIVIS” and The Center for Business Promotion and Entrepreneurship in Sandomierz – presented a proactive approach, securing the process from the begging until the successful end. Real-time communication ensured a seamless transition from virtual planning (application surveys, webinars and kick-off events) to the in-person hackathon. This preparation fostered a sense of readiness and trust, allowing participants to focus on innovation. Evening networking events further strengthened bonds, enabling cross-sectoral learning between academia, startups and industry experts from across Europe. For instance, a Finnish team’s expertise in biorefining complemented a Polish startup’s focus on sustainable packaging, leading to unexpected synergies. This collaborative environment not only generated groundbreaking ideas but also built lasting networks, positioning REFAL and its partners as pioneers in the circular bioeconomy.

The open innovation process of the REFAL Hackathon revealed important lessons about addressing the challenge of apple biomass valorisation. First, it highlighted the untapped potential of damaged apples as a resource rather than waste, shifting REFAL’s perspective from loss mitigation to opportunity creation. The diverse solutions proposed (ranging from succinic acid production to energy generation via supercritical water gasification) demonstrated that cross-sectoral collaboration can unlock novel applications for agricultural by-products. Additionally, hosting the event in REFAL’s facility bridged the gap between theoretical solutions and practical application, grounding ideas in the realities of the apple industry. The hackathon’s international scope brought

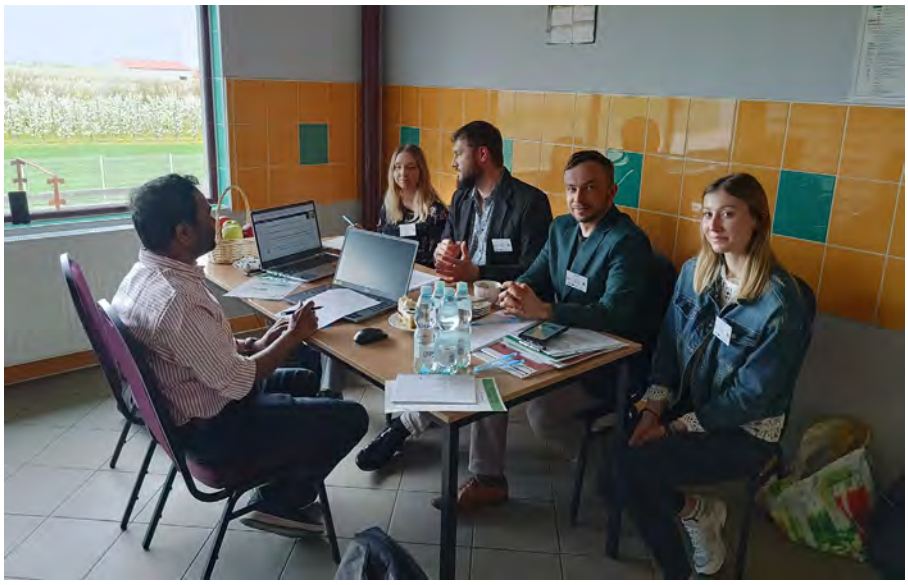
inter-regional insights, with teams from Germany and Finland introducing advanced biorefining techniques that Polish participants could adapt locally. Ultimately, the experience taught REFAL that embracing risk and inviting diverse perspectives can transform a traditional business into a hub for sustainable innovation, aligning with global bioeconomy goals.

The Winning Solution – Transforming Apple Pomace Into Biodegradable Biopolymers

The REFAL Hackathon's winning solution, proposed by the Polish Norwegian team Food4Future Technologies and Dar Ogrodu, offers a groundbreaking approach to valorising apple pomace through biotransformation into succinic acid and fully biodegradable biopolymers, such as polyhydroxyalkanoates (PHA) and polybutylene succinate (Bio-PBS) (BioBoosters LinkedIn, 2025c). This innovative process leverages a unique biomass blend—50–60% apple pomace, rich in fermentable sugars like glucose and fructose, combined with 20–30% pea protein concentrate waste for nitrogen and minerals and 15–20% brown algae waste for additional sugars and micronutrients. Using enzymatic hydrolysis with amylase and cellulase, followed by fermentation with a modified bacterial strain (M. succiniciproducens), the team produces succinic acid, a platform chemical, which is then transformed into Bio-PBS via polycondensation or used to synthesize PHA through bacterial modification. Dar Ogrodu's expertise in custom production lines ensures scalability, while Food4Future's biotechnology and commercialization experience guarantees efficiency. This solution addresses REFAL's challenge turning waste into high-value, biodegradable alternatives to fossil-based plastics for applications in packaging, agriculture and healthcare.

The Food4Future and Dar Ogrodu solution delivers profound benefits for sustainability and the circular bioeconomy, aligning with REFAL's goal of minimizing waste and maximizing resource value. By upcycling apple pomace (a by-product previously relegated to low-value juice production) into biodegradable biopolymers, the solution tackles plastic pollution, fossil fuel dependency and agricultural waste mismanagement. Unlike conventional plastics, which contribute to microplastic contamination and high CO_2 emissions, PHA and Bio-PBS are fully biodegradable, breaking down into harmless end products under environmental conditions. This aligns with the circular economy principles outlined by the Ellen MacArthur Foundation (Ellen MacArthur foundation, 2019), promoting resource circulation at its highest value. The process also reduces environmental impact by utilizing waste

streams (apple pomace, pea protein and algae waste), lowering dependency on virgin materials and reducing landfill waste. Economically, the solution taps into the growing biopolymers market, projected to reach USD 52.33 billion by 2034 with a CAGR of 10.43%, offering REFAL a high-margin revenue stream (Precedence Research, 2025). Socially, it strengthens the Sandomierz region by fostering innovation and creating opportunities for local biomass suppliers, such as juice producers, to integrate into new value chains. Environmentally, the solution mitigates the ecological footprint of plastic production and agricultural waste, supporting global sustainability goals, such as those outlined by the FAO for reducing food loss (FAO, 2019). Socially, it fosters job creation and knowledge transfer in Sandomierz, positioning the region as a hub for circular bioeconomy innovation. For REFAL, the solution diversifies revenue streams, reducing vulnerability to weather-related losses and enhancing long-term economic stability. By establishing a scalable model for biopolymer production, the solution paves the way for a next generation biorefinery in Sandomierz, potentially integrating regional apple producers and juice processors into a multi-output value chain. This transformative approach not only addresses REFAL's immediate challenge but also sets a precedent for sustainable innovation in the global agri-food sector.



Picture 2. Food4Future/Dar Ogrodu Team (the winners) during mentoring session (Photographer: Jean-Pierre Kisielewski)

Apple is Backed with Potential Ingredients for Biobased Industries

Responding to REFAL's interest in the extraction of high-value chemical compounds from apple biomass, the hackathon showcased interesting range of opportunities to produce high-value ingredients to meet the demands of various industries in Poland and beyond. Two of such solutions proposals came from international teams that were awarded honorary mentions from the jury for their innovative approaches and talented pitching. First, Institut für Lebensmittel- und Umweltforschung e.V., ILU, from Germany proposed to produce phycocyanin from the apple biomass. Secondly, a student team from Finland and Netherlands, Pomex, developed a proposal for the industrial pectinase production.

Looking from the mentor's perspective, both ILU and Pomex engaged full-heartedly in the hackathon process and truly capitalised the dialogue opportunities with REFAL and mentors during the solution development process. With previous experience of Cosun Beet Hackathon in 2024, ILU showed their competence in the creative process and managed to effectively adapt their offer to the needs of the challenge provider. Meanwhile, despite their student status, Team Pomex applied methodical background work and strategic dialogue with the mentors to compete on equal ground with the teams from companies and research institutes. Furthermore, both teams had proposals that showcased the great natural potential backed in the apple. Let us consider the potential of the proposals in further detail.

First, phycocyanin, an edible natural blue pigment, is the first natural blue colorant approved in the US, Europe and Asia. It is widely utilized as a nutritional supplement and pigment in food industry with potential to be applied for e.g. food preservation and emerging cultivated meat applications. Furthermore, it has antioxidant, anti-inflammatory, antiviral, anticancer and other functionalities. It has a wide range of prospects for application in the field of food and medicine. High purity phycocyanin has great potential and commercial value in the food industry – however, its availability is currently limited and pending on the production and processing of spirulina algae. (Mao et al., 2024.) As outlined, the market value for the phycocyanin is high – and the market potential is great and rising.

Secondly, a diverse group of enzymes, pectinases are broadly used in multiple industries including food processing, textiles and biofuel production. The global demand is growing significantly, e.g. due to the increased demand for organic products and plant-based extracts, but the commercial production

often relies on expensive substrates, contributing to economic inefficiency and environmental burdens. Studies show that valorisation of agro-industrial sides-streams or waste for pectinase production can be cost-effective and more sustainable option reducing environmental impact and resource dependency while boosting economic competitiveness and innovation. (Kaul et al., 2024.)

In both explored options, phycocyanin and pectinase, the technology is tested in laboratory scale, and a pilot plant would be the next step in road to full-scale commercial implementation. Piloting in real-world setting is an essential step in learning to optimise the process – not just at REFAL but also to connect other regional apple producers and processing companies etc. With established technology readiness, the extraction of high-value ingredients from the weather damaged apples, potentially utilising also e.g. pomace from local juice production, could transform the operations at REFAL or wider apple industry of Sandomierz.

In fact, many of the solution provider teams, including Team ILU and Pomex, emphasised that the biomass, nutrient and energy flows of the whole apple production and processing should be looked at holistically to achieve circularity and to maximise the value of the apple. As frequently discussed in the mentoring sessions, after extracting one ingredient, much more can be still done with the biomass – in other words, more value can be extracted. To develop the business model, it is essential to explore how to optimise this entire cascading process and which biomass sources from the region can be connected to the value chains at REFAL.

Elaborating the possibilities even further, the unique magnitude of apple biomass and agricultural production and processing activities in the Sandomierz area present a clear potential for development of multiple value chains or a next generation multi-output biorefinery – a new flagship for circular bioeconomy in the Baltic Sea Region. As we have learned previously from the case of Cosun Beet, the next generation biorefinery development calls for coordinated and committed long-term development work towards a joint vision as well as strategic RDI partnerships and investments (Mernitz et al., 2024). However, with the inherent regional strengths and developing RDI partnerships, the apple industry in Sandomierz has the key building blocks to initiate such development. All in all, this might be the most powerful and exciting insight gained from the REFAL Hackathon.

Waste to Value: Biotech Pathways from Apples

After the Hackathon, the company REFAL initiated discussions with the winners regarding the launch of succinic acid production based on biomass from non-standard apples, as well as with the Institut für Lebensmittel- und Umweltforschung e.V. – ILU (which was the second-best solution) concerning the production of dyes. In both cases, the parties expressed a willingness to engage in business discussions aimed at refining and valorizing the proposed technologies in terms of their suitability for apple biomass and assessing the economic efficiency of the proposed solutions.

At the same time, REFAL decided to undertake actions aimed at increasing the knowledge of the entire management team and the company's co-owners (12 local farmers) regarding biotechnological processes, as well as improving the varietal selection of apples produced to better match potential applications in biotechnological processes. These actions include:

(1) collaboration with the Institute of Horticulture, within which mutual study visits were organized: REFAL representatives visited the Institute to explore demo-scale fruit processing solutions and gain insight into a wide range of processing technologies and potential market products that can be derived from apples, produced at a demonstrative scale in the Institute's laboratories. In turn, representatives of the Institute of Horticulture visited REFAL to learn about the full scope of apple production, including storage, sorting, packaging and transportation technologies, both for the Polish market and for distant markets such as Egypt.

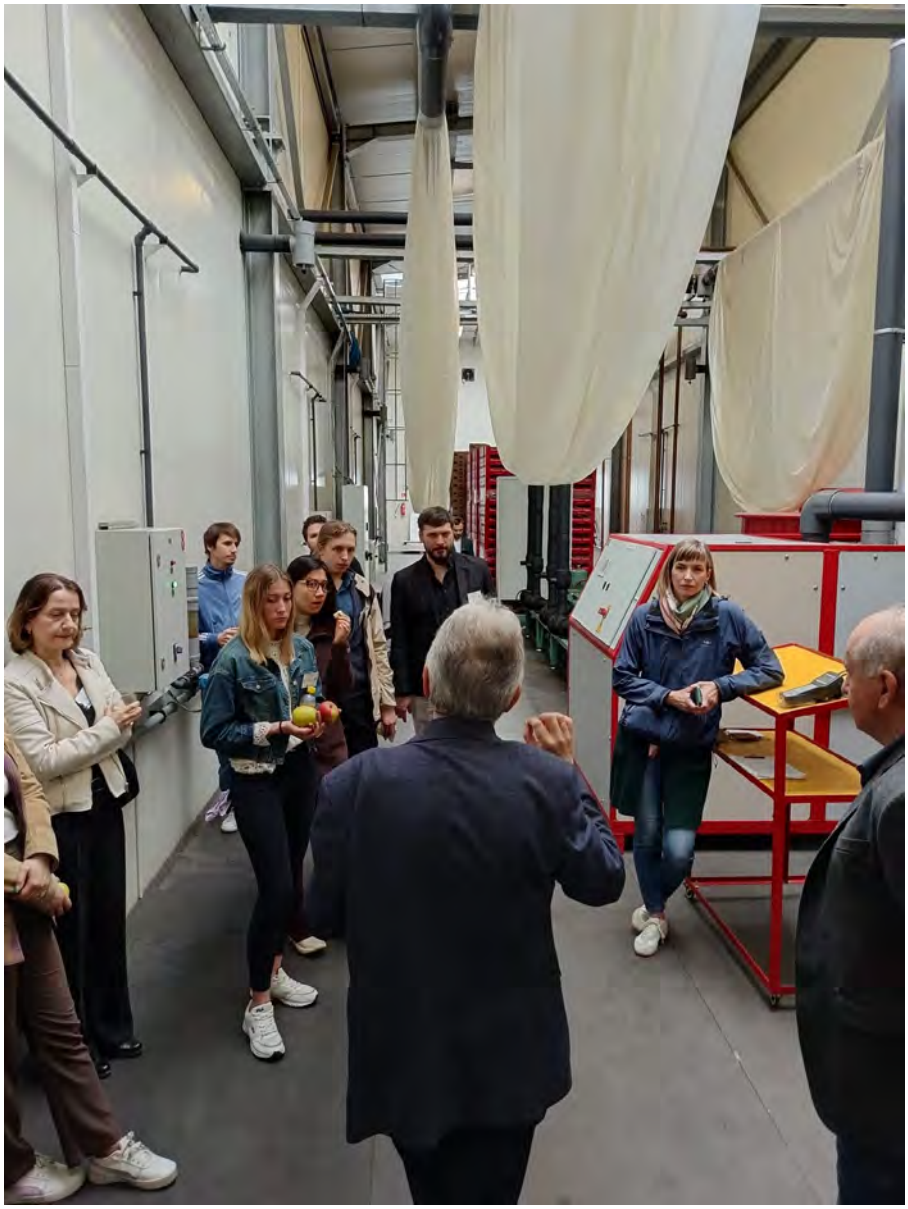
(2) collaboration with Lodz University of Technology, specifically with the International Centre for Research on Innovative Bio-based Materials (ICRI-BioM), located in the Lodz Bionanopark and established in cooperation with the Max Planck Institute for Polymer Research (MPI-P) in Mainz, Germany. As part of this collaboration, a lecture on the latest biotechnological advancements was held at REFAL in June 2025, delivered by Professor Stanisław Bielecki.

As a result of the discussions held with Food4Future and ILU, it was concluded that the technological solutions presented during the Hackathon are currently at a Technology Readiness Level (TRL) no higher than TRL 4. Further research and development efforts are required to advance them to TRL 6–7, including testing all aspects related to process automation, technological optimization and initial staff training. Currently, in both cases, in collaboration with the Pro Civis Foundation and the economic consultancy firm EPRD, work is underway to define a Research and Implementation Agenda. This agenda

will serve as the foundation for preparing application proposals for national programs in Poland or for the Horizon Europe program.

Based on the information presented during the Hackathon and further consultations with the solution providers, it was determined that there is strong market demand for both analyzed final products: succinic acid (Food4Future) and dyes (ILU). These products can be effectively produced using non-standard apples and biomass generated as a by-product in nearby juice and apple purée processing facilities located close to REFAL. What requires detailed research and development, optimization and thorough economic analysis are aspects related to economic efficiency and economies of scale, to define the boundary conditions for achieving competitive production compared to existing solutions.

Consequently, it was agreed that making final business decisions regarding the implementation of the investment will require further research, development and pre-implementation work to reduce potential risks, including those related to raw materials, technical and technological aspects, staffing, market conditions and the overall profitability of the project.



Picture 3. The hackathon participants visiting REFAL facilities (Photographer Jean-Pierre Kisielewski)

Conclusions

The management of REFAL emphasizes that participation in the Hackathon organized within the Bioboosters project has significantly influenced the attitude of both the company's Board and its co-owners regarding the importance of engaging in initiatives that can bring new development ideas and foster the exchange of knowledge and experience. The Hackathon method was recognized as a highly effective method for discovering new potential scientific and business partners, as well as original technological solutions with market relevance that can support the company's future growth.

Refal Hackathon	
Challenge	Maximizing the value of apple biomass
Target groups	Individuals, companies, SMEs, startups, scientific and research entities, academic/student entities
Organiser	Foundation of Education and Social Dialogue "PRO CIVIS", Świętokrzyskie Region, Poland
Mentors	REFAL (Poland), Estonian University of Life Sciences (Estonia), Jerzy Haber Institute of Catalysis and Surface Chemistry (Poland), Jamk University of Applied Sciences (Finland), Foundation of Education and Social Dialogue "PRO CIVIS" (Poland), Vidzeme Planning Region (Latvia), Center for the Promotion and Support of Agricultural Entrepreneurship in Sandomierz
Hackathon days	April 24–25, 2025, Sandomierz, Poland
Applicants	17 applications from Poland (9), Finland (2), Finland+Netherlands (1), Germany (2), Sweden (1) and Estonia (2)
Selected teams	6 teams Poland (4), Finland + Netherlands (1) and Germany (1)
Winner	Food4Future/Dar Ogrodu, Valorizing apple pomace through biotransformation into succinic acid and fully biodegradable biopolymers, such as polyhydroxyalkanoates (PHA) and polybutylene succinate (Bio-PBS).
Impact	REFAL initiated discussions with the winner on implementing the solution. While technically feasible, the economic viability of this process requires further research into efficiency, economies of scale, and overall profitability.
UN Sustainable Development Goals	

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This publication offers an overview of the impact of the BioBoosters Hackathon for boosting the circular transition of bioeconomy sectors in the Baltic Sea Region. The publication explores nine innovation journeys of leading bioeconomy companies that shared their challenges at the BioBoosters Hackathon organized in autumn 2024 and spring 2025. The impact stories highlight the impact of open innovation and inter-regional co-operation. The lessons learned from the hackathons boosted by the international innovation community are recounted and the conclusion is clear – BioBoosters Hackathon is making an impact! Hackathons are often a wild ride for the organizer but in the end, we are proud to share the results. Hope you will enjoy the journey with us.

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