



MAX IV AND THE INDUSTRY

2022

MAX IV

MAX IV funders



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A world-class tool for industrial research

In 2021, MAX IV launched its first internal strategy dedicated to industry, and began outlining the steps towards a stronger industry presence at the facility aiming towards the year 2030.

The primary goal is to ensure that the industry can effectively utilise the capabilities of MAX IV in its research and development.

The industry strategy is built on four central pillars. By 2030, we aim to:

1. Broaden the industry user base.
2. Increase the industrial use of MAX IV.
3. Develop MAX IV to support industrial needs.
4. Employ a collaborative approach to industry engagement.

The MAX IV Industrial Relations Office works closely with industry partners and the surrounding ecosystem of actors to achieve these strategic goals.

MAX IV offers a wide range of techniques and capabilities catering to various research topics within materials science. To establish strong connections, we have adopted an industry sector approach, targeting the ten most important industry sectors in the Nordics.

What you are reading now is the first report on the progress and activities related to industry engagement at MAX IV. In 2022 MAX IV was very much a facility in full operation, with the last of the

16 fully funded beamlines coming online. It was also a year marked by fruitful collaborations and meetups, with industrial partnerships being very popular.

MAX IV truly enables Swedish and international industries to make a real impact.

Magnus Larsson

Head of Industrial Relations, MAX IV





Linnéa Björn, Chalmers University of Technology, at the desk in the ForMAX beamline control room assisting Tetra Pak in the first-ever industry experiment at ForMAX in November, 2022.



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To lead the green transition, we need the best tools and expertise. During 2022 we started to define the practical conditions needed for the industry and MAX IV to jointly create business value from leading research.

Magnus Fredriksson, Program Manager, Alfa Laval

INDUSTRY USER

Working with Alfa Laval to design new collaboration processes between MAX IV and the industry

MAX IV and the global engineering company Alfa Laval have a close collaboration, both in terms of research and developing new ways for the industry to benefit from MAX IV. The common goal is to shape and improve the way MAX IV and industry can collaborate to enable the green transition through technological development and advanced expertise.

During 2022, the MAX IV Industrial Relations Office continued collaborating with Alfa Laval through its full-time team member dedicated to strengthening synchrotron-based R&D activities within the technology and manufacturing industry.

Productive workshops and discussions were organised with Swedish companies and trade associations, facilitating knowledge transfer and mapping current and emerging industrial research needs. These activities contributed to a closer

dialogue with the industry in general and the technology and manufacturing industry sector in particular.

Together, MAX IV and Alfa Laval identified capabilities and expertise at MAX IV that are relevant to the industry and could be packaged, combined, or developed in new ways. These valuable insights will guide the further development of MAX IV's offers and processes with the industry.

Alfa Laval is also involved in the project DEVPEEM which aims to develop better tools for simulating realistic conditions during experiments at MAX IV. The project primarily focuses on mimicking industrial manufacturing processes through temperature control. It is a collaboration between Alfa Laval, MAX IV, SWERIM, Gränges, Seco Tools, and Lund University, funded by Vinnova.



Elin Persson Jutemar, Tetra Pak, with her colleagues and the research team from Chalmers University of Technology and Paul Scherrer Institute.

INDUSTRY USER

Tetra Pak commenced ground-breaking sustainable packaging research at ForMAX

In November 2022, global food packaging and processing company Tetra Pak performed the first-ever industry experiment at the newest beamline ForMAX.

The experiment focused on exploring more durable and recyclable materials for paper-based straws to replace single-use plastic straws. It successfully rendered high-resolution data that will be used as input to the computational material simulations in Tetra Pak's virtual modelling tools for product development.

ForMAX beamline is the result of the forest and packaging industries joining forces with academia and the Knut and Alice Wallenberg Foundation.

The opening of the beamline in the autumn of 2022, as well as the first industry experiment performed by Tetra Pak, made national and international headlines in the media through jointly coordinated press campaigns.

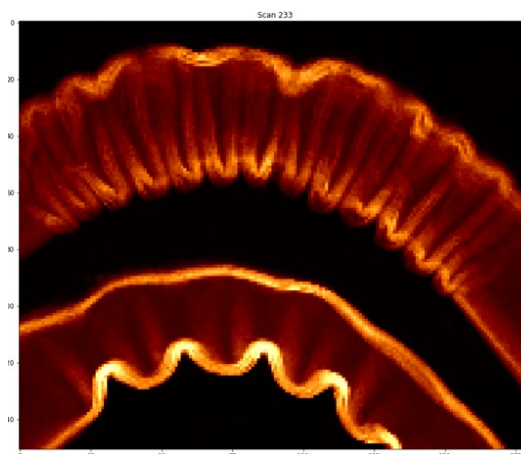


Figure 1. SAXS imaging map from ForMAX showing two types of corrugated paper straws. Each pixel represents data from a separate measurement. The colours correspond to the intensity and orientation of the X-ray scattering pattern.



Statistics

MAX IV and the industry – 2022 in numbers

TOTAL INDUSTRIAL USE

Most industrial research at MAX IV was conducted in collaboration with academia

MAX IV caters to users from both academia and industry. In 2022 most industry users accessed MAX IV through the open access program in collaboration with an academic partner or institute. This way, they had access to both the capabilities at MAX IV and to their collaboration partner's material-specific expertise, and they often got help with research data analysis as well.

In 2022, the number of collaborative research projects between industry and academia at MAX IV was record high. The combination of academic curiosity and know-how and industrial expertise and ambition for innovative solutions generated a wide array of scientific experiments with strong industrial impacts.

Out of the 5678 total industry-connected hours of use at MAX IV in 2022, 12% were for proprietary research, where companies paid for access and the possibility to keep their results confidential. 88% took place through collaborative, peer-reviewed

open-access projects, where the results were to be published, contributing to the dissemination of research findings that benefit society at large.

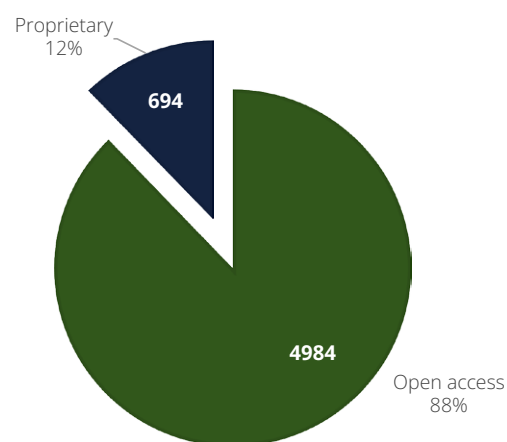


Figure 2. No. of industry-connected hours used at MAX IV in 2022 divided by type of access.

INDUSTRY SECTORS

Drug discovery and metals engineering were the primary industry sectors using MAX IV

In looking at what types of companies conducted research at MAX IV, we see that almost a third of the industrial use-time was connected to the drug discovery sector. The research primarily consisted of Macromolecular X-ray Crystallography at the BioMAX beamline, with both large and small companies such as AstraZeneca, SARomics Biostructures, and Sprint Bioscience represented as users.

The drug discovery sector has an advantage in having established a standardised measurement method that facilitates the optimisation of data collection at large-scale research infrastructures. Furthermore, the recently installed all-in-one fragment screening facility FragMAX contributed to increased utilisation of MAX IV by this sector.

A quarter of the usage by industry was connected to the metallic materials and metals engineering

sector, the second biggest user group in terms of beamtime. Several market-leading Swedish metals and engineering companies collaborated with MAX IV on R&D projects.

Emerging user groups

Two emerging industry user groups were the battery and health and life science sectors. Currently, these sectors primarily use synchrotron research methods to understand specific challenges within their value chains. These sectors have also been prioritised target groups by the MAX IV Industrial Relations Office and are expected to continue to grow as users in the coming years.

Another target group has been the food sector, where strong initiatives, such as the Northern Lights on Food platform, have paved the way for a growing user base.

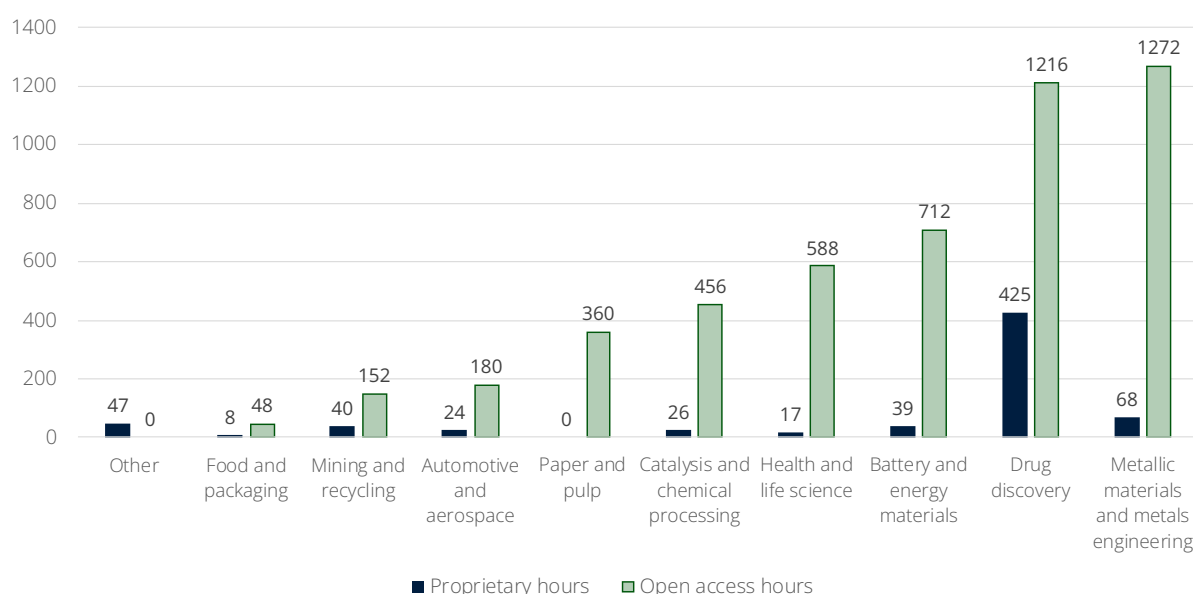


Figure 3. No. of industry-connected hours used at MAX IV in 2022 by type of access and per industry sector. The "Other" category includes the use of support labs by user groups that do not clearly belong to any of the other categories.



29%

*of the industry-connected
hours used at MAX IV in 2022
were affiliated with the drug
discovery industry sector.*

INDUSTRY SECTORS

Engaging the health and life science industry sector through joint initiatives

To increase awareness about MAX IV's capabilities, the Industrial Relations Office's outreach activities focused on community building and knowledge sharing within the health and life science sector.

Part of the outreach was done through the project InfraLife (Infra Access for Life Science Sweden), a collaboration between MAX IV, ESS, and SciLifeLab funded by the Swedish Research Council. One of the two InfraLife coordinators representing the Southern node is located at MAX IV.

Educational and networking events

In August, InfraLife organised a successful two-week course in integrative structural biology and how to use the research techniques available at MAX IV, ESS, and SciLifeLab.

The course was open to scientists and researchers from academia, health care, and industry and took place in Lund, Gothenburg, and Stockholm. The course was deemed valuable by both scientists and researchers. Now, the

ambition is to make it a recurring event through national collaboration.

The Industrial Relations Office also participated in the conference Nordic Life Science Days in Malmö in September 2022, which offered an important opportunity for industry to meet with life science researchers and scientists and to discuss how large-scale research infrastructures can be useful in their industrial R&D projects.

A new route into MAX IV for life science SMEs

Finding a collaboration partner for research at MAX IV is not always a straightforward process. To connect the industry with valuable networks and resources, MAX IV joined forces with ESS, Science Village Scandinavia, RISE, SWERIM, and Lund University to establish the digital platform MAXESS Industry Arena (www.maxess.se) already in 2020, with funding from Region Skåne.

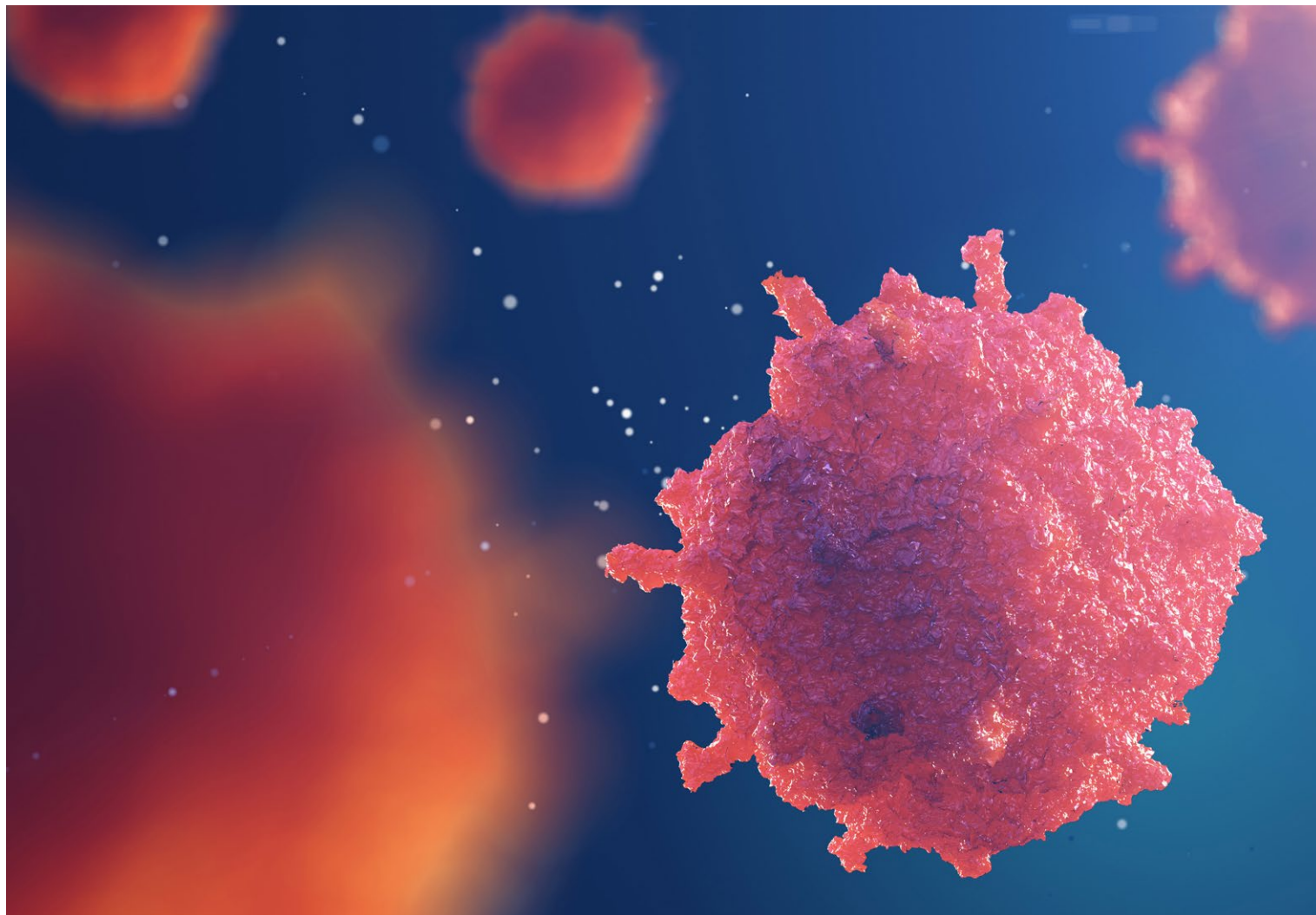
Throughout 2022, MAX IV collaborated with the life science incubator SmiLe in Lund to increase the



Participants in the integrative structural biology course organised by MAX IV, ESS, and SciLifeLab through InfraLife.



InfraLife at the Nordic Life Science Days 2022 with Elin Jonsson, Tobias Krojer, Cat Halthur, and Magnus Larsson from MAX IV.



use of research infrastructures by life science SMEs by making resources more visible and accessible via MAXESS Industry Arena.

The collaborative project, "MAXESS: SMEs to LSRI", was funded by Region Skåne and the European Union through The Swedish Agency for Economic and Regional Growth.

By the end of 2022, the project had generated new life science SME users from SmiLe who conducted pilot experiments at MAX IV.

One such experiment was the contract development and manufacturing organisation Magle Chemoswed, which used X-ray Powder Diffraction at DanMAX beamline to measure the amount of polymorphs in tablets.

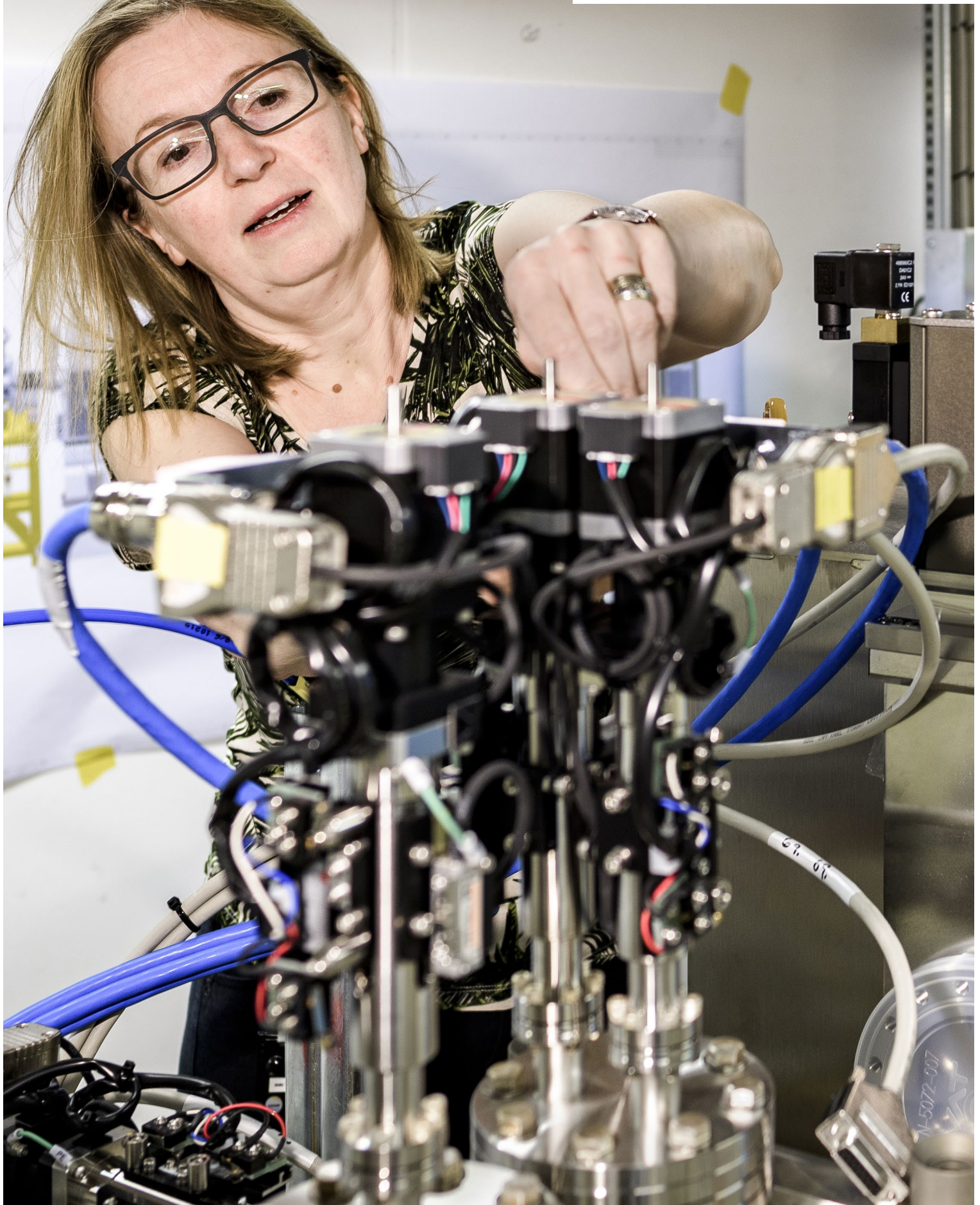
Another example was the company Truly Labs, which is planning a pharmacological study of lung fibrosis biomarkers using NanoMAX.

Overall, the collaboration established a more robust route for life science companies into MAX IV and ESS.



Martin Lindsjö, Principal Scientist at Magle Chemoswed, preparing the samples in the DanMAX sample preparation lab.

Ann Terry, CoSAXS Beamline Scientist and Group Manager for Diffraction and Scattering, at the CoSAXS beamline.



INDUSTRY-CONNECTED PROPOSALS

CoSAXS and Balder beamlines received the highest number of industry-connected proposals

Of the 764 proposals submitted to MAX IV through the 2022 spring and fall open access mode cycles, 119 included a declared link to industry, meaning roughly one in six had a connection to industry. The average acceptance rate for these proposals was 51%.

Regarding the division between the beamlines, CoSAXS and Balder received the highest number of industry-connected proposals. However, it is worth noting that ForMAX did not open for experiments until the end of 2022.

CoSAXS saw its main demand from the health and life science sector looking to perform Small-Angle

X-ray Scattering (SAXS) experiments. The beamline also catered to other industry sectors, such as packaging. One example was Tetra Pak and MAX IV using SAXS at CoSAXS to study polymer morphology in packaging materials, with the aim to understand how the polymer properties affect the material's ability to contain certain food products.

Balder beamline hosted several battery research projects studying battery material properties using research techniques such as X-ray Absorption Spectroscopy (XAS).

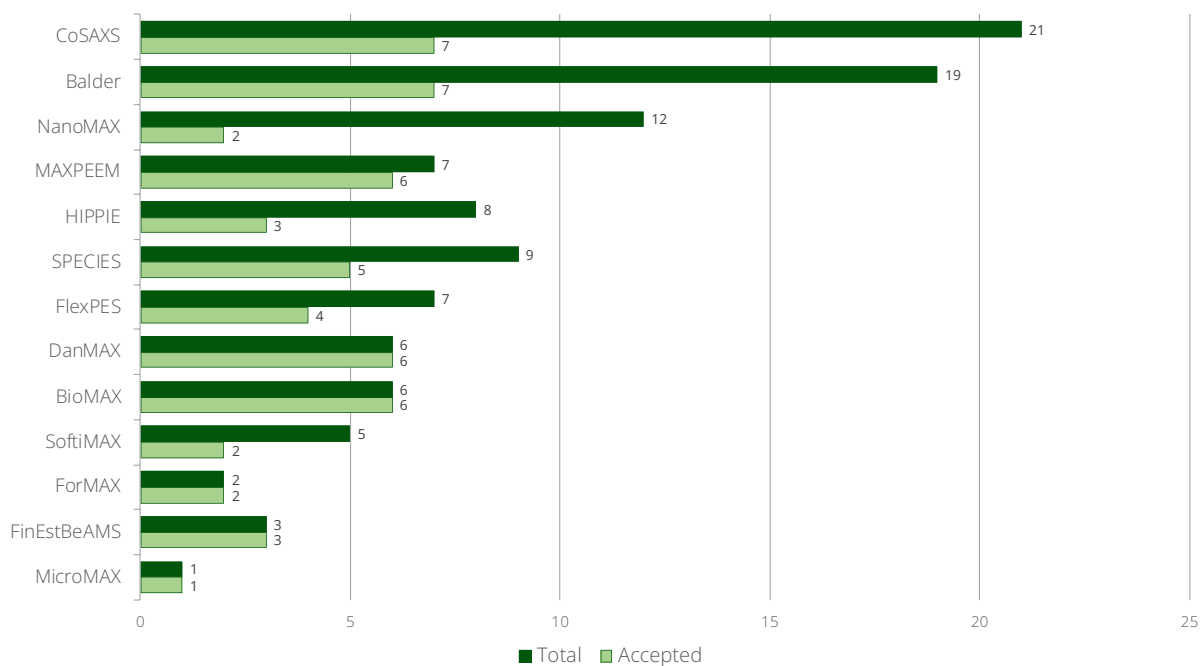


Figure 4. No. of proposals with an industry connection per beamline in 2022. Proposals put on reserve lists and proposals for training and education are not included. Five out of six open-access proposals to BioMAX were 'BAG' proposals containing several research projects.



PROPRIETARY USERS

Macromolecular X-ray Crystallography and Vinnova-funded pilot projects drove increased proprietary use

The proprietary users that pay for faster, confidential access to MAX IV are a growing user group. Between 2021 and 2022 this group grew by 22%, from 27 to 33 user groups.

The proprietary hours sold to industry, including beamtime and access to the support labs, increased by 20%, from 559 hours in 2021 to 694 hours in 2022 distributed over 104 separate experiment sessions.

The main platform attracting proprietary users to MAX IV was the Macromolecular X-ray Crystallography infrastructure. We also saw great value in the opportunity of providing proprietary users access to MAX IV through industrial pilot projects funded

by Vinnova. About one third (33%) of all proprietary hours in 2022 were through these pilot projects.

Increased industry-dedicated staffing

The increased proprietary use is also the result of community-building efforts via different sector-specific platforms.

Such platforms include MetalBeams for the metal industry sector, Nothern Lights on Food for the food sector, and Treesearch which brings together the paper and pulp sector.

Co-creation and participation in these communities during 2022 established an important

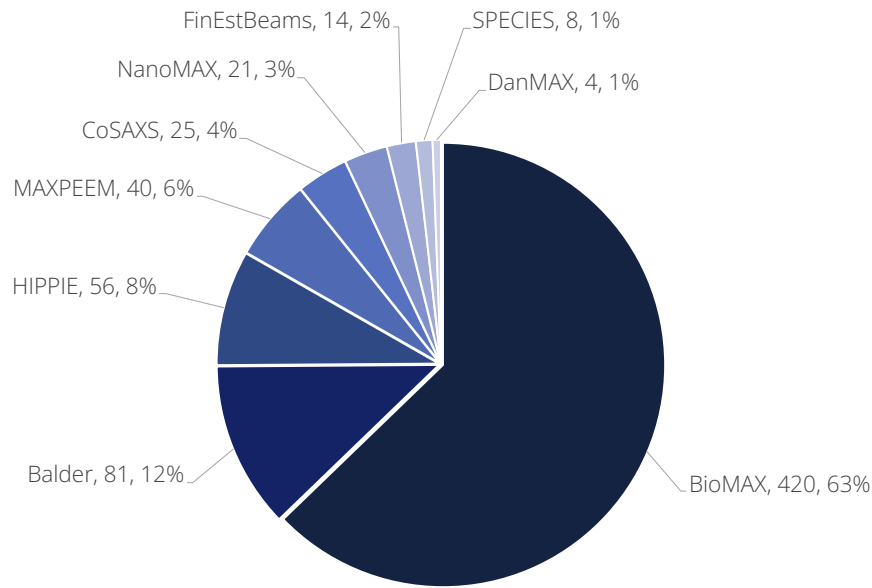


Figure 5. No. of proprietary beamtime hours used per beamline in 2022.

touchpoint between MAX IV and the member companies and organisations.

With funding from the Swedish Research Council, MAX IV collaborated with RISE and SWERIM on strengthening the Swedish institutes in supporting industrial use of large-scale research infrastructures. The collaborative project started four years ago, and when it ended in 2022, it had

led to the implementation of new capabilities and resources, including nine new employees at RISE and SWERIM dedicated to assisting companies in using MAX IV.

These efforts also contributed to the increased number of industry users in 2022, both through open access and proprietary access.

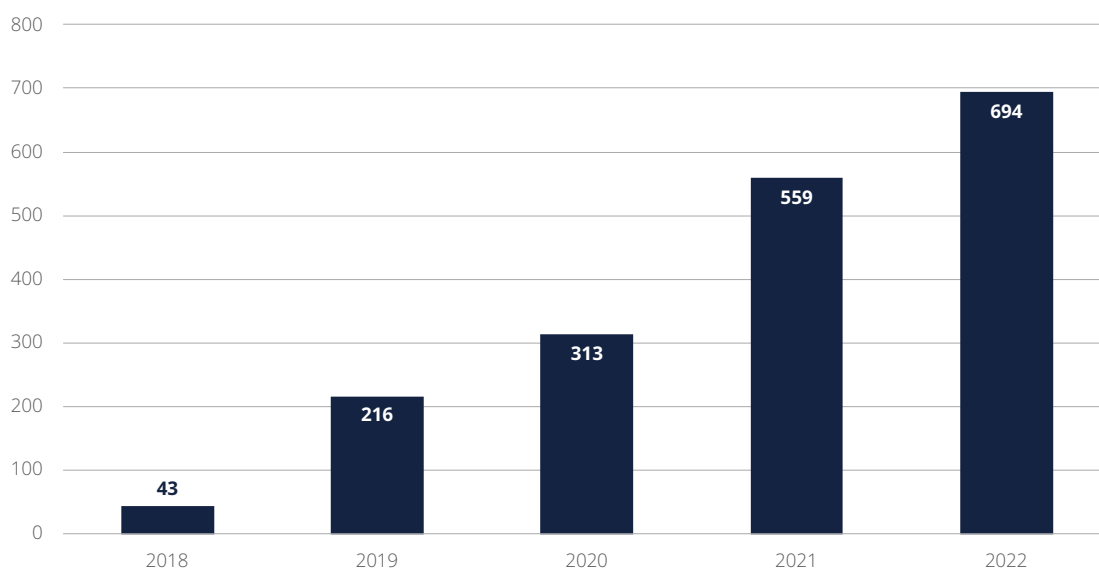


Figure 6. No. of proprietary hours sold to the industry over the past five years.



SUSTAINABILITY RESEARCH

More research projects focused on sustainability

As the industry is facing increased sustainability requirements and net-zero climate targets, business models and supplier needs throughout the entire industrial value chain are changing.

This has created an increased need of understanding new material systems on all levels, resulting in a growing use of MAX IV.

In 2022, there was a growing interest from the battery industry sector to study the ageing effects of charging cycles, and test new raw materials for increased battery recyclability.

The possibility to examine battery materials and cells under realistic conditions and across multiple length scales using synchrotron light is essential for the battery sector.

There were also several research projects within sustainable energy materials, such as more energy-efficient solar cells and environmentally friendly biostimulants, conducted at Balder beamline.

New EU legislation has also accelerated industrial research on optimal and safe secondary use of waste and industrial side streams for a circular economy.

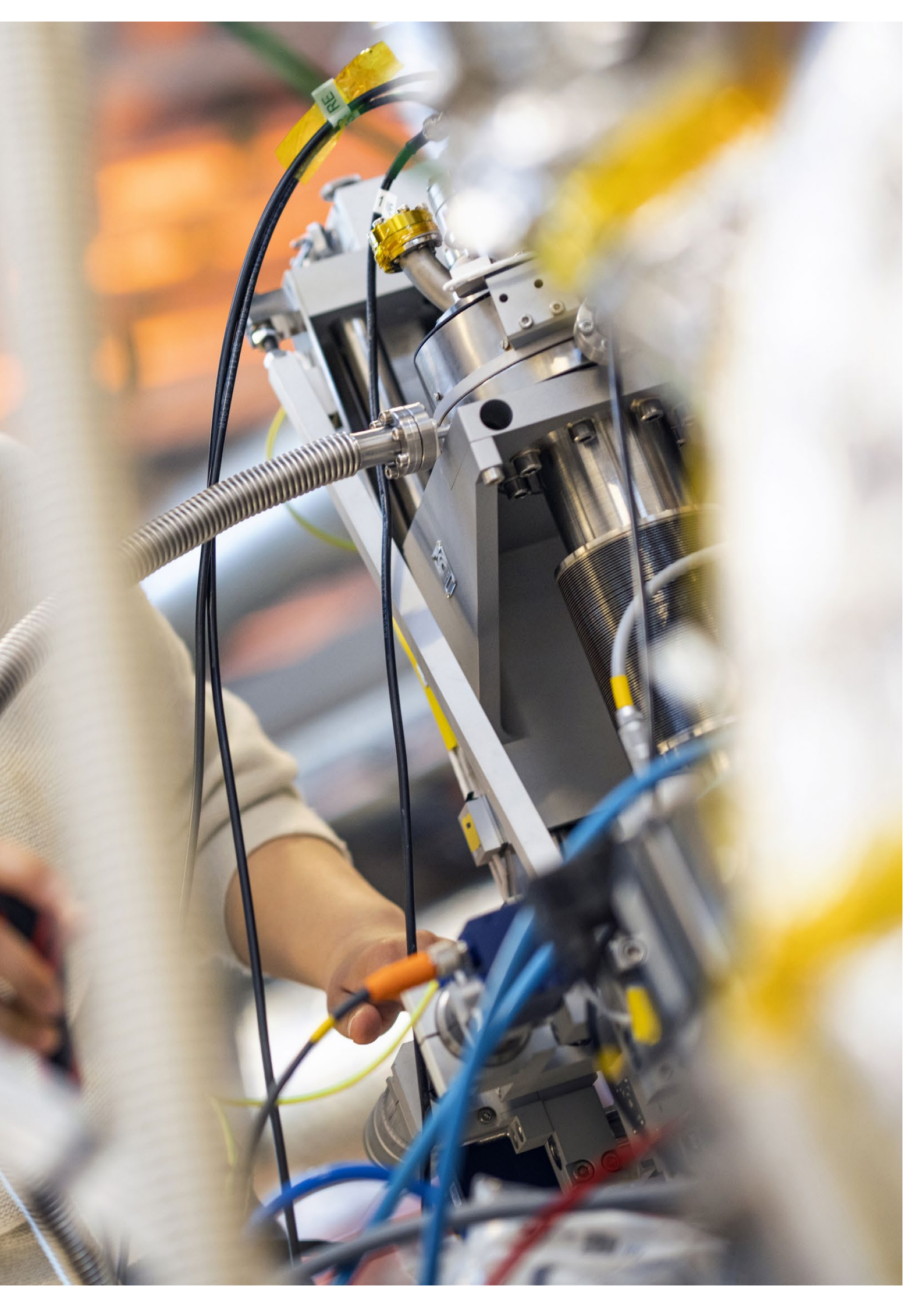
A Swedish subsidiary of the Norwegian waste handling organisation NOAH teamed up with Fortum and RISE to conduct research at MAX IV with funding from Vinnova. Using X-ray Absorption Near-Edge Spectroscopy (XANES) at Balder beamline, the team determined the chemical forms of trace metals in the ashes of burnt waste from energy recycling.

The experimental data can be used as a basis for classifying the toxicity of the ashes, which determines whether it could be reused for new purposes instead of having to be treated as hazardous waste and deposited in landfills.

This could make a big difference both for the industry, nature, and the economy.

The development of methods for measuring compositions of heavy metals and trace elements, even at very low sample concentrations, is one of the emerging research technologies at MAX IV that are accelerated by the industry. The findings from such research could be used to design new circular processes, enabling the green transition at a wider scale.





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