

# A CATALYST FOR CHANGE

—  
ANNUAL REPORT 2023

LUXEMBOURG  
INSTITUTE OF SCIENCE  
AND TECHNOLOGY

LIST



# EXCELLENCE FOR IMPACT

LIST.lu



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## A CATALYST FOR CHANGE

“Progress is impossible without change, and those who cannot change their minds cannot change anything” (George Bernard Shaw). At the Luxembourg Institute of Science and Technology (LIST), we definitely want to progress and embrace the future. The Luxembourg, European and global scene is clearly changing and fast-moving. Think of the advent of artificial intelligence, the war in Ukraine, the climate crisis and energy crisis, ... Companies and governments need to adapt. That is why LIST, as one of the major players in research and innovation in Luxembourg is adjusting and, through its research and knowledge transfer activities, is supporting its private and institutional partners to gear up for the winds of change that are gathering pace.

To begin with, we support our partners by introducing technologies that are more respectful of the planet and suitable for tomorrow's world with less energy and water consumption, recycling of materials, life cycle analyses, ethical artificial intelligence, ... This is what our +700 employees are working on in the fields of information and communication technologies, environmental technologies, biotechnologies, advanced materials, and space resources. This unique combination provides the synergies that are essential to build a new economy and sustainable society.

In 2023, the outcomes of a number of our research partnerships, such as those ongoing with start-ups FourPoint and Wide (Women in Digital Empowerment), or those to come with Green Power Storage Solutions and Webasto, were presented at our Tech Day in June 2023 to an audience of 350 people. During the event, we also officially signed the second phase of our partnership with Goodyear, which includes strategic research programmes covering the period 2024-2029. Many other significant collaborations forged during the year are presented in the following pages.

To better answer our partners' needs and meet the demands of the industry, our institute installed a number of specific pilot plants. In the Greentech Innovation Centre, researchers can work at higher levels of technological maturity in the fields of biorefinery, water treatment and biogas production. LIST also set up an 18-metre-long physical vapour deposition (PVD) pilot line in its Hautcharage laboratories and opened new facilities for the intelligent management of energy networks. And the newly created Composite platform was showcased at the first Industry Day organised by the Sustainable Composite Materials and Manufacturing Innovation Centre.

We continued to use our expertise to monitor the presence of SARS-CoV-2 coronavirus in wastewater, by extending our analyses to Luxembourg airport. LIST also signed a collaboration agreement with the Ministry of Health and was selected to contribute to the country's defence efforts.

Ten years after its creation, the spin-off Open Assessment Technologies S.A. has been acquired by the Japanese company Uchida Yoko Co. LTD, enabling LIST to generate an additional revenue of €5.6 million from the sale of its shares.

Scientific excellence remains at the heart of our ambitions, as demonstrated by the two new PEARL projects supported by the Luxembourg National Research Fund (FNR). One will provide the world's first low-code online intelligent open source platform, and the other aims to improve the performance of quantum computers. LIST has a total of 137 national competitive projects, 65 international competitive projects, 150 collaborative projects and 50 large-scale service contracts in progress in 2023. 147 scientific articles are in top 10% journals, and 28 theses were successfully defended. These are only a few examples that show how LIST was successful in 2023.

In a few months, LIST will be ten years old, and the future looks bright for our young institute. We work on how we should change for making LIST stronger and enabling it to face the future with even more confidence. This project, named "Unity", will be implemented starting in 2024. It is based on three pillars: an adapted organisational chart with a career development plan for every LIST employee based on a collaborative value creating approach between units, an inclusive exercise on the mission and vision of LIST and an efficient IT infrastructure with new tools and proper attention for the introduction of AI in all aspects of LIST's activities. Sylvie Weyland has strengthened the Executive Committee and was appointed Director of Human Resources ad interim by the Board on 22 September.

This report reflects the unwavering commitment of our entire staff to excellence and their determination to constantly push back the boundaries of knowledge and innovation. We would like to take this opportunity to thank them warmly. Their remarkable achievements, supported by the new Minister for Research and Higher Education, Mrs Stéphanie Obertin, whom we had the pleasure to already welcome in our facilities, will undoubtedly let them play their role of a catalyst for change.

We hope you will enjoy reading this annual report, which is also intended to be more interactive. Please feel free to scan the QR codes that you will find throughout the pages to get more information.

Eva KREMER  
Chair of the Board of Directors

Dirk FRANSAER  
CEO ad interim





# 2023 IN RETROSPECT







## HUMAN RESOURCES



**710**

employees



**34 %**

women



**120**

new  
recruits



**60**

nationalities



**79,5 %**

researchers  
or innovation  
experts



**93**

PhD students  
based at LIST

## SCIENCE AND TRANSFER



**33**

Patents  
filed



**24**

Paid  
licences



**8**

spin-offs  
(existing for 3  
years or more)



**147**

scientific articles  
in top 10%  
journals



**28**

doctoral theses  
successfully  
defended



## R&D PROJECTS IN PROGRESS



### RESEARCH CONTRACT TYPES

- Competitive projects are research projects that have successfully undergone an international scientific evaluation following a call for projects under national or international programmes.
- Collaborative projects are research projects involving effective collaboration between at least two independent parties seeking a common goal based on a division of labour. The two parties jointly define the scope of the project, contribute to its execution, and share its risks and results.
- Projects falling under public utility missions entrusted to LIST and European Space Agency (ESA) projects, as well as those co-funded by foundations, have been classed as collaborative projects.



# 137

National  
competitive  
projects



# 65

European  
competitive  
projects



# 150

Collaborative  
projects  
and similar

EUR

# 6,42%

of income  
from services

Σ

# 402

RDI projects and  
contracts in total

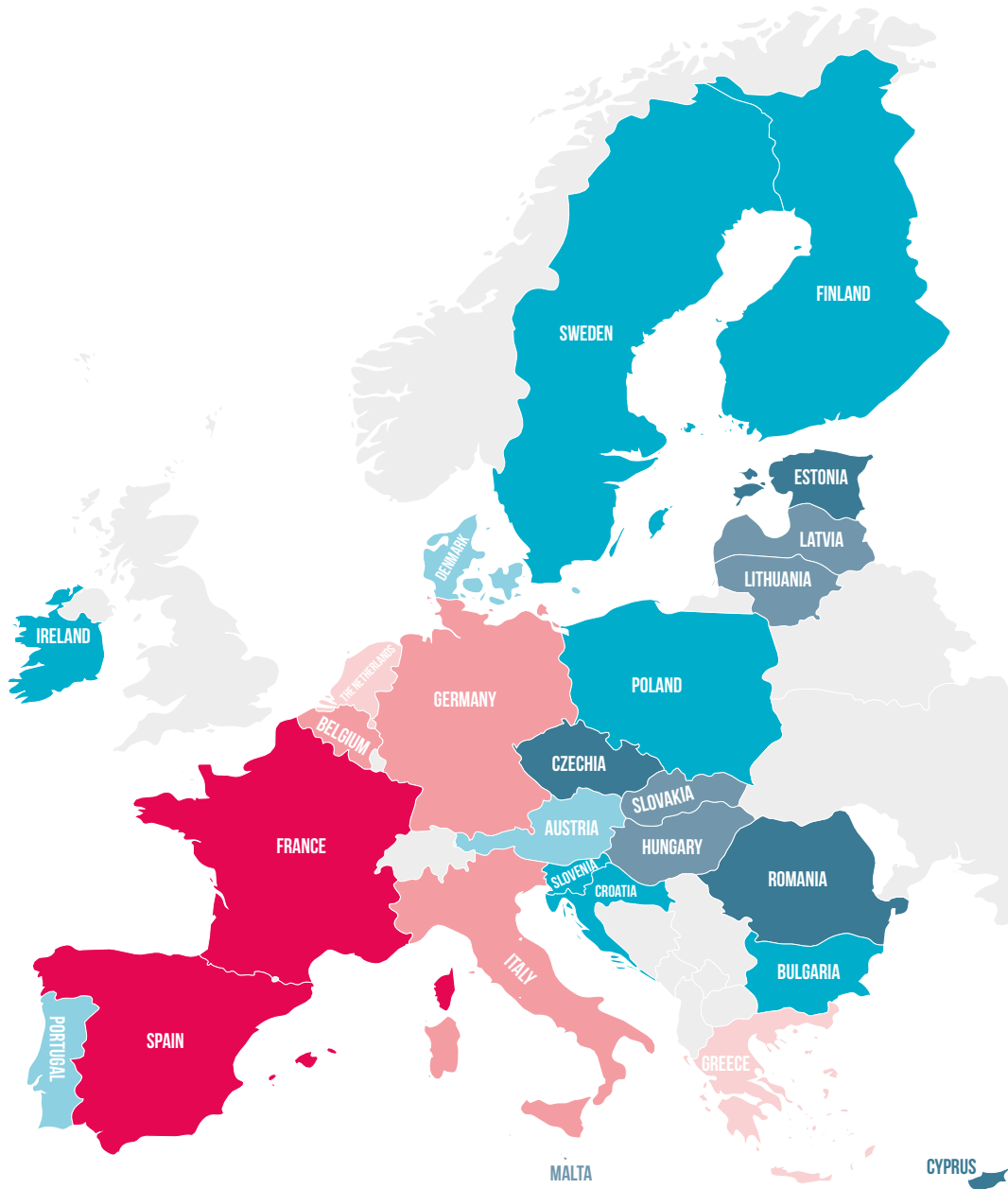
# KEY FIGURES 2023

As of 31.12.2023

## INTERNATIONAL COLLABORATIONS

### NUMBER OF CONTRACTS IN PROGRESS PER COUNTRY

#### EUROPEAN UNION (EU)



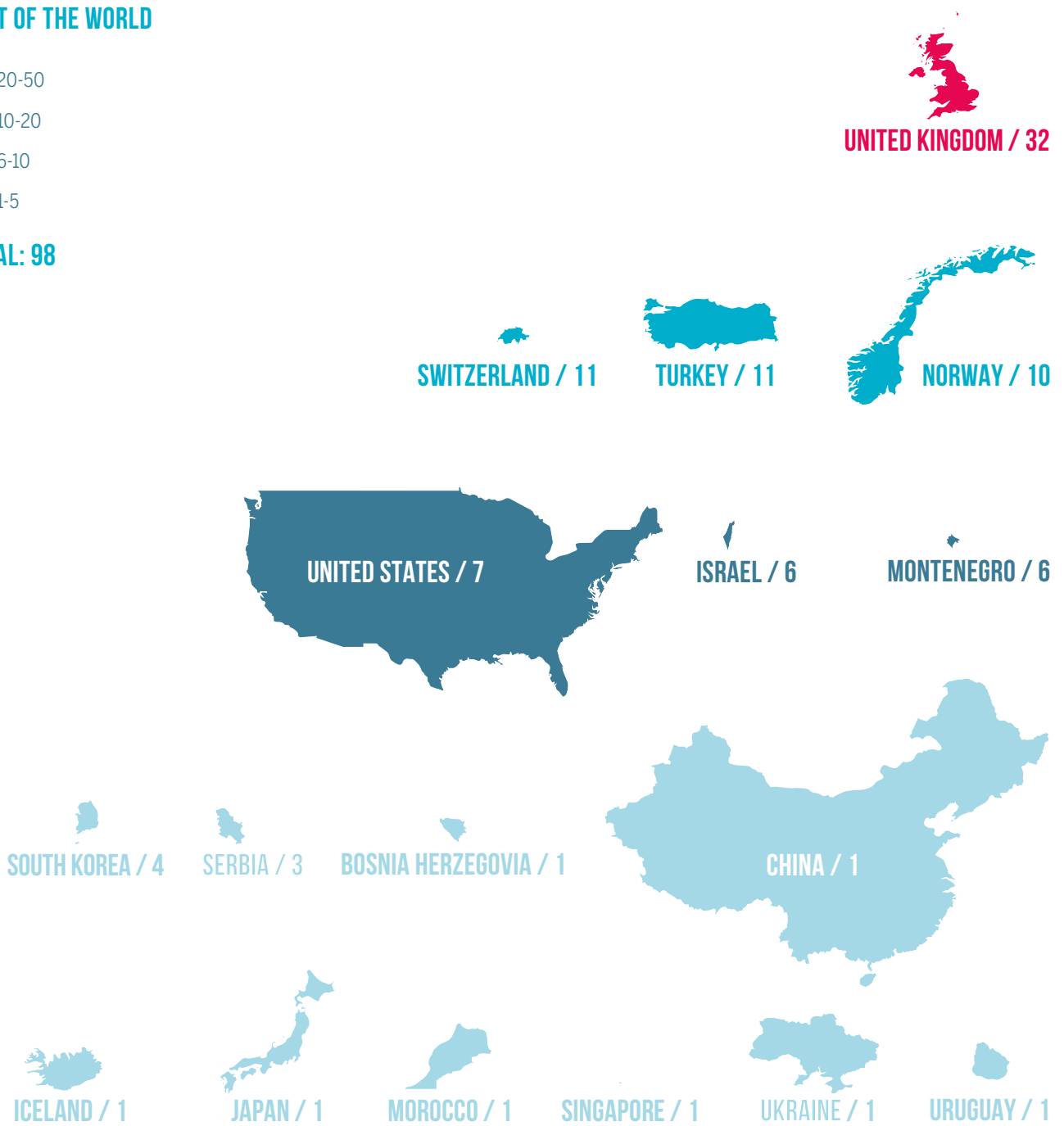
100-150	France	132
	Spain	101
80-100	Germany	95
	Belgium	90
	Italy	86
50-80	Greece	52
	The Netherlands	51
20-50	Portugal	34
	Austria	28
	Denmark	25
10-20	Finland	19
	Slovenia	19
	Ireland	13
	Poland	12
	Bulgaria	12
	Croatia	11
	Sweden	10
6-10	Estonia	9
	Romania	9
	Cyprus	8
	Czechia	7
1-5	Hungary	5
	Latvia	4
	Lithuania	3
	Malta	2
	Slovakia	2

**TOTAL: 839**

### REST OF THE WORLD

- 20-50
- 10-20
- 6-10
- 1-5

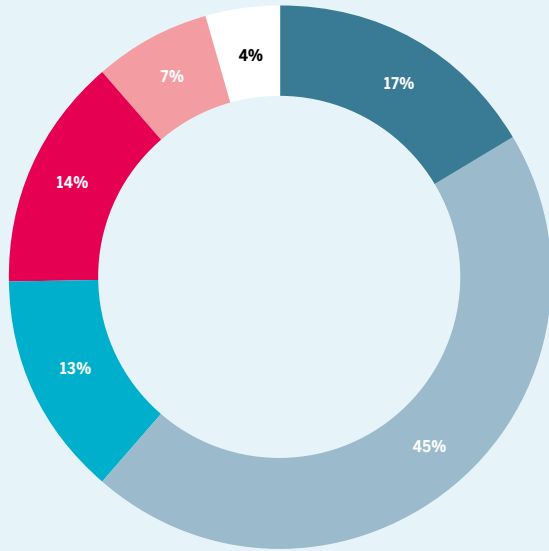
TOTAL: 98



# KEY FIGURES 2023

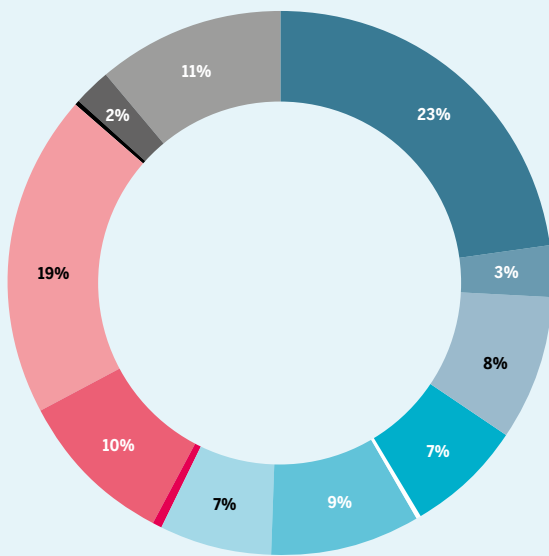
As of 31.12.2023

## BREAKDOWN OF PARTNERSHIPS IN PROGRESS IN 2023 BY TYPE OF PARTNER



Universities	155
Companies	421
Research centres	126
Public institutions	129
Foundations and associations	65
Other	41
<b>TOTAL</b>	<b>937</b>

## BREAKDOWN OF PARTNERSHIPS IN PROGRESS IN 2023 BY SECTOR

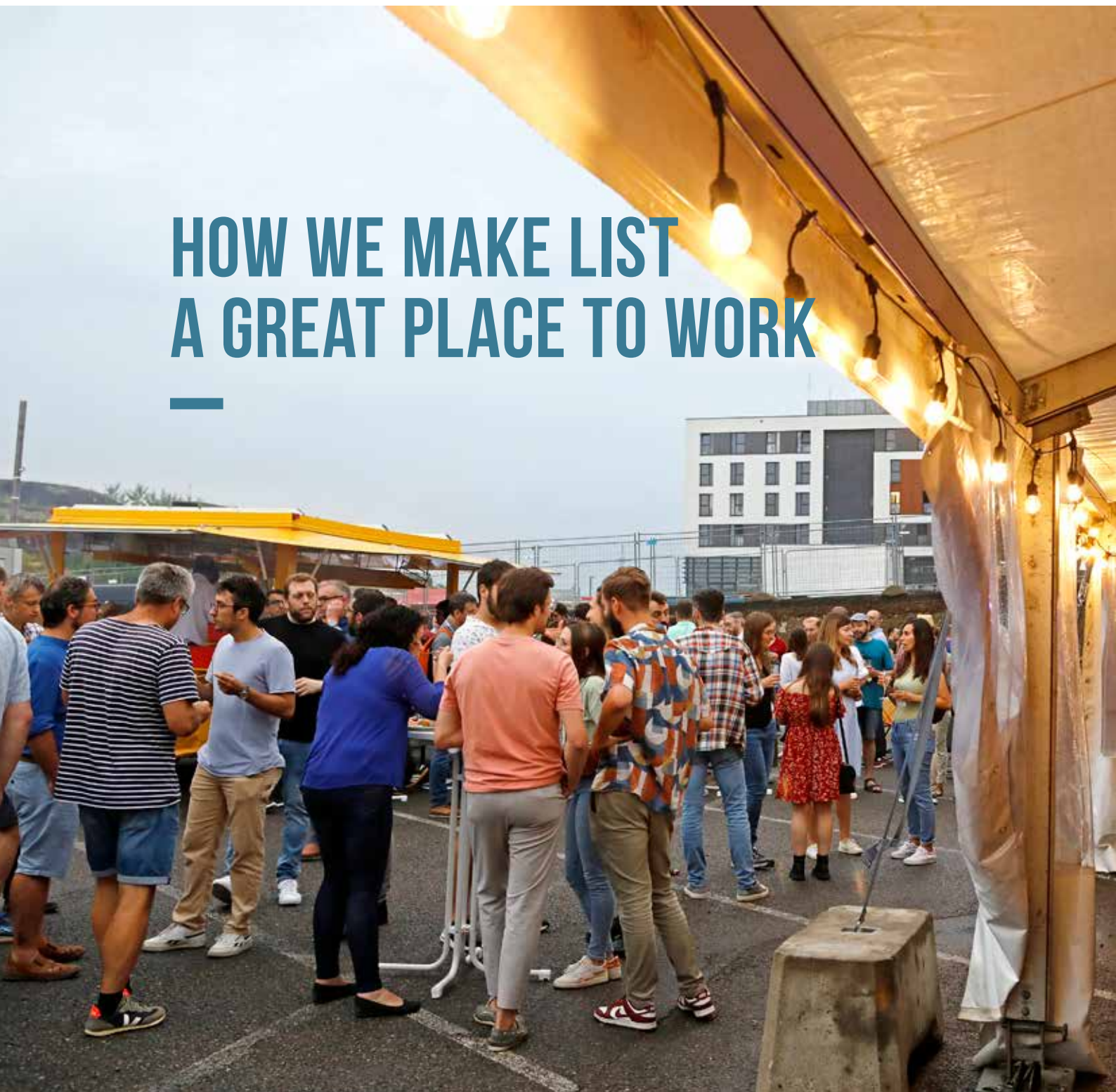


Agro and natural resources	110
Automotive/aeronautical	15
Biotech / Cleantech	40
Construction	34
Education technology	1
Energy	43
Health and medical technology	32
Domestic security	2
ICT	46
Industry	92
Logistics	1
Mobility	11
Space	52
<b>TOTAL</b>	<b>479</b>



# HOW WE MAKE LIST A GREAT PLACE TO WORK

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### EMBRACING AN INTERNATIONAL AND INCLUSIVE CULTURE

With more than 110 recruitments slated for 2023, LIST was determined to attract top talents by making the most of its diverse workforce of +700 individuals hailing from 60 different countries. Recognizing this diversity as one of its greatest assets, the institute is dedicated to fostering an international and inclusive culture. This commitment was exemplified in 2023 through various initiatives, including workshops highlighting the power of diversity and inclusion at work, commemorations of International Women's Day, European Diversity Month, and the International Day of People with Disabilities, as well as active participation in the March for Equality.

LIST's approach extended beyond diversity and inclusion in terms of gender or ethnicity, embracing differences in the broadest sense. Concrete actions, such as improving accessibility across LIST buildings and promoting inclusive language in internal communications, underscored the institute's dedication to creating an environment free from discrimination and harassment.



### STRIKING A BALANCE BETWEEN WORK AND PERSONAL LIFE

For years, LIST has been recognizing the importance of enabling its employees to achieve a harmonious blend of professional and personal life. In addition to the longstanding flexitime system, the institute introduced in 2023 a groundbreaking initiative offering up to 100 days of teleworking for employees living in Luxembourg. Furthermore, the Learning & Development department provided extensive training opportunities, totalling almost 11,000 hours in 2023, to support the continuous growth and development of its workforce.



## PRIORITIZING WELL-BEING AT WORK

Ensuring a healthy and safe working environment is essential for LIST. In line with this commitment, the institute established a comprehensive policy addressing harassment and violence in the workplace. This policy reaffirms LIST's dedication to safeguarding its employees from all forms of harassment and violence, fostering awareness, and encouraging the entire LIST community to actively contribute to creating a respectful and supportive work environment. By implementing preventive measures and mechanisms to address such issues, LIST underscores its pledge to uphold inclusivity and tolerance.



## PROMOTING SUSTAINABLE MOBILITY

In its efforts towards sustainability, LIST introduced two innovative applications to support greener travel options for its employees. Klaxit, supported by the Ministry of Mobility and Public Works, encourages eco-responsible commuting by facilitating carpooling among employees. Meanwhile, MUV - Mobility Urban Values promotes alternative modes of transportation through engaging competitions, encouraging the use of public transport and car-sharing. The success of these initiatives was further highlighted by the summer competition, which led to the planting of 30 trees in Luxembourg through a donation from LIST to the natur&environment foundation.

# HOW WE CONTRIBUTE TO ADVANCE SCIENCE AND INNOVATION

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**NATURAL RESOURCES & AGRICULTURAL MANAGEMENT**



**ENVIRONMENTAL HEALTH**



**SPACE**



**INDUSTRY 5.0**



**SMART & LOW CARBON TRANSPORTATION**



**CIRCULAR ECONOMY**



**RENEWABLE ENERGY**







# NATURAL RESOURCES & AGRICULTURAL MANAGEMENT

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Natural resource management and agriculture face a pressing challenge as resources become scarcer and farming practices need to adapt more sustainably. As populations grow and urbanization expands, demands on water, land, and energy escalate, placing strain on ecosystems and exacerbating environmental degradation. Concurrently, climate change is intensifying, disrupting traditional agricultural models and increasing the vulnerability of food systems. Addressing these challenges requires a comprehensive approach that prioritizes sustainable resource management practices. Embracing innovative technologies and agroecological approaches can enhance resilience, improve productivity, and mitigate environmental impacts, ensuring the long-term viability of agricultural systems while safeguarding natural resources for future generations.



## DEVELOPING INNOVATIVE BIOMETHANATION TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE

Ferme du Faascht, nestled in the Greater Region, epitomizes agricultural innovation and sustainability, thanks to the Luxembourg Institute of Science and Technology (LIST). Inaugurating its horticultural greenhouse and biomethanization site in August 2023, LIST researchers have been pivotal in developing a revolutionary process—biological methanation—to convert biogas carbon dioxide into biomethane. This innovation, patented by LIST, facilitates the storage and flexibilisation of green electricity, addressing the intermittent nature of renewable energy production. By injecting electrically produced biomethane into the natural gas network, Ferme du Faascht advances renewable energy storage, equivalent to several months of EU electricity consumption. As part of the e-MC2 project, supported by Luxembourg National Research Fund (FNR), LIST researchers explored digestate fractionation and refining techniques, yielding valuable products like compost and formulated fertilisers. This collaboration represents a leap towards circular and sustainable agriculture, embodying LIST's commitment to technological advancement and environmental stewardship. Through the JUMP funding programme, LIST continues its research, aiming to enhance biomethane production from renewable electricity.

**“This innovative storage model opens up new prospects for integrating and optimising renewable energies in the energy mix, thereby strengthening the transition to a low-carbon economy while guaranteeing the reliability of the energy supply”.**

Sébastien LEMAIGRE,  
Engineer, Environmental Research & Innovation department



IN THE LAB :  
<https://youtu.be/RtZtM-OHJJYM?feature=shared>



## EXPLORING FUNGUS RESISTANT GRAPEVINE CULTIVARS

LIST researchers at the Institut Viti-Vinicole are studying fungus-resistant grapevine varieties known as PIWI cultivars, which reduce the need for chemical treatments in vineyards. These cultivars, resistant to major fungal diseases, offer a sustainable solution for grape growers, minimizing pesticide usage and promoting climate resilience. Additionally, they enhance biodiversity in vineyards by reducing chemical inputs, fostering a more balanced ecosystem. LIST's expertise in viticulture aims to overcome market barriers and promote the adoption of PIWI cultivars, contributing to climate mitigation in agriculture.



IN THE LAB : <https://youtu.be/-NOJUL4MleQ>



Daniel MOLITOR, Marco BEYER & Kristina HEILEMANN



<https://pubs.acs.org/doi/full/10.1021/acsnm.2c05384>

## UNVEILING NANOPARTICLES SET TO REDEFINE AGRITECH

LIST researchers collaborated with SiSaf Ltd on a study titled «Nanoporous Quercetin-Loaded Silicon-Stabilized Hybrid Lipid Nanoparticles Alleviate Salt Stress in Tomato Plants.» Funded by FNR's BRIDGES project Sapphyre, the research explored the effectiveness of SiSaf's silicon-based hybrid lipid nanoparticles in delivering quercetin, an antioxidant, to plants. This innovative approach aims to protect plants from stress, with promising results observed in tomato plants. The nanoparticles, biocompatible and non-toxic, dissolve over time, releasing their cargo and silicic acid without harming the plant. This technology could revolutionize agricultural practices, offering a sustainable solution for crop protection and growth.



## HIGHLIGHTING ALARMING DECLINE IN EUROPEAN GRASSLAND BUTTERFLY NUMBER

A report co-authored by LIST researchers reveals a concerning decline in the number of grassland butterflies across Europe. The European Grassland Butterfly Indicator, compiled by Butterfly Conservation Europe, highlights a 36% decrease in butterfly abundance since 1990. LIST has been instrumental in coordinating butterfly monitoring programs in Luxembourg, involving citizen participation to collect standardized data. Factors contributing to this decline include intensified farming, land abandonment, and climate change-induced heatwaves and droughts. However, there is optimism as the indicator is set to be integrated into the EU's forthcoming Nature Restoration Law, signalling a commitment to reversing the trend and restoring balance to ecosystems.



<https://assets.vlinderstichting.nl/docs/290cb16a-e90f-4c5b-a7df-9b954d511cfa.pdf>



<https://www.nature.com/articles/s41561-023-01300-5>

## PREDICTING MEGAFLOODS

A study, published in *nature geoscience* and led by LIST, analyzed historical flood data across Europe, revealing that mega floods haven't changed significantly over time. By examining over 8,000 gauging stations spanning two centuries, the research proposes an international approach to predict floods by categorizing rivers based on shared characteristics. This method, using data from similar basins, could anticipate disasters like the 2021 Rhine basin flood. LIST's researchers emphasized the need for cross-border cooperation to enhance flood prevention, urging a shift from national to continental risk assessments. Future plans involve using accumulated knowledge to project river responses to climate change in Luxembourg and delving into natural archives for millennia-spanning insights. LIST's approach aims for informed decisions in infrastructure protection amidst evolving environmental challenges.



# ENVIRONMENTAL HEALTH

Climate change, urbanization, chemical pollution, and disruptions to ecosystems, including biodiversity loss, profoundly impact human health and well-being. Creating healthier environments has the potential to alleviate nearly a quarter of the global disease burden. The COVID-19 pandemic underscores the intricate interplay between human health and our planet. Ensuring clean air, a stable climate, as well as safe water and sanitation are essential for promoting good health. Despite strides made in mitigating environmental health risks, persistent traditional public health issues continue to challenge health equity. Research plays a pivotal role in addressing the current and future challenges that are often complex and interconnected by nature.





## FIGHTING CYANOBACTERIAL BLOOMS THANKS TO CITIZEN PARTICIPATION

Cyanobacteria blooms, a.k.a. 'blue-green algae', pose health risks and threaten aquatic ecosystems. With blooms becoming more frequent globally, understanding and monitoring them is paramount.

The Luxembourg Water Management Authority and LIST launched the «Bloomin'Algae» app, empowering citizens to report cyanobacteria blooms, vital for preserving water quality and ecosystem health. The app allows users to report bloom sightings with photos and GPS coordinates, contributing to an interactive map, thus helping to understand and monitor this environmental threat.

**“The proliferation of cyanobacteria in Luxembourg waters not only poses a health risk to bathers, domestic animals and livestock, but also undermines the environmental health of the aquatic ecosystem. In order to gain a better understanding, more field data is needed. To this end, the Bloomin'Algae application allows citizens to submit photos and the precise location of blue-green algae or suspected blue-green algae in just a few clicks.”**

Jean-Baptiste BURNET,  
Research & Technology Associate, Environmental Research & Innovation department



[www.cyanowatch.lu/](http://www.cyanowatch.lu/)





## TRACKING COVID VARIANTS AT LUXEMBOURG AIRPORT

LIST monitored wastewater at Luxembourg Airport to detect possible SARS-CoV-2 variants amid rising Covid cases in China. Samples were collected weekly and analyzed for viral variants and mutations. The first report, reassuringly, showed no new variants detected. Through the Coronastep project, LIST tracks coronavirus presence in wastewater, offering near-real-time data to inform government decisions alongside clinical tests.

Since the beginning of the pandemic and until 31 December 2023, LIST has published 174 reports.



[www.list.lu/en/covid-19/coronastep/](http://www.list.lu/en/covid-19/coronastep/)



[www.thelancet.com/journals/lanonc/article/PIIS1470-2045\(22\)00655-6/abstract](http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(22)00655-6/abstract)

## EXPOSING RISKS OF BRAIN CANCER FROM COMPUTED TOMOGRAPHY SCANS

LIST experts contributed to an International Agency for Research on Cancer-led study assessing brain cancer risks from computed tomography scans. Their software collected metadata from 70 European hospitals, improving dose estimates for individual organs. The study, published in The Lancet Oncology, found a significant risk, highlighting the importance of minimizing computed tomography radiation doses. This study, part of the European EPI-CT cohort, involved 658,752 patients from nine countries, making it the largest international study on computed tomography-related cancer risks in young patients.

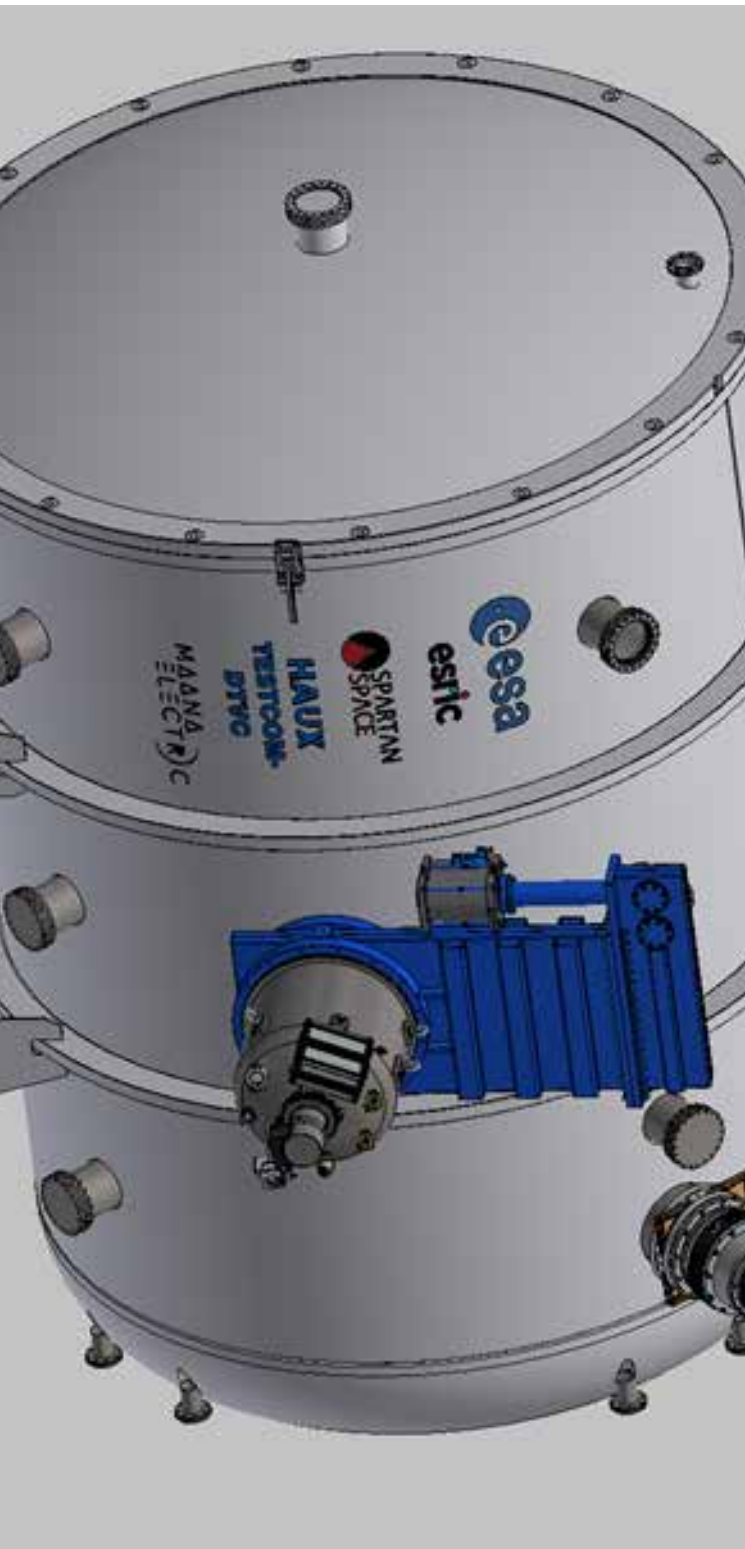


# SPACE

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When we learn about what lies beyond Earth, it gives us context for understanding our own planet. Studying the other worlds of our solar system and beyond makes it clear that Earth is a precious oasis for life.

The challenges of space exploration have generated new scientific and technological knowledge of intrinsic value to humanity, providing a better understanding of our universe and the solar system in which we live. Knowledge, combined with ingenuity, provides solutions and useful products and services for people around the world. The knowledge gained through space exploration has also opened up new perspectives on our individual and collective place in the Universe.



## PIONEERING LUNAR SURFACE TESTING TECHNOLOGY

The European Space Agency (ESA) initiated a collaboration with Spartan Space, Haux Life Support, Maana Electric, and the European Space Resources Innovation Centre (ESRIC) at LIST to develop a unique Dusty Thermal Vacuum Chamber (DTVC) capable of simulating lunar surface conditions for testing subsystem components. Scheduled for completion by 2025 at ESRIC/LIST premises in Luxembourg, this chamber will simulate lunar surface conditions, including high vacuum, extreme temperatures, and lunar dust presence, essential for testing subsystem components. The DTVC aims to enhance equipment reliability for future lunar missions, crucial for ensuring mission success amidst the challenges posed by lunar dust.

**“In the coming decades of lunar surface missions, the implementation of a DTVC will be a vital endeavour towards qualifying and accepting components crucial to the success of lunar missions.”**

Kathryn HADLER,  
Director, European Space Resources Innovation Centre (ESRIC)



[www.esric.lu/dtvc](http://www.esric.lu/dtvc)



## DRIVING THE LUNAR ECONOMY FORWARD THROUGH COLLABORATION AND INNOVATION

The fifth edition of Space Resources Week united global leaders from space agencies, research institutes, and industries. Organized by the European Space Resources Innovation Centre (ESRIC) together with the Luxembourg Space Agency (LSA), European Space Agency (ESA), and the Luxembourg Institute of Science & Technology (LIST), the event showcased cutting-edge technologies, fostered collaborations, and highlighted the burgeoning space resources ecosystem. Key moments included the signing of a partnership with KIGAM, the ESA-ESRIC Space Resources Challenge, and insights from startups driving commercialization efforts. With over 1,250 attendees, the event marked significant strides towards realizing the Lunar Economy.



Marek ROZEHNAL (Lightigo), Kathryn HADLER & Pavel POŘÍZKA (Lightigo)

## CATALYZING GLOBAL SPACE VENTURES FROM LUXEMBOURG

The ESRIC Start-up Support Programme entered its third edition, attracting innovative ventures worldwide. Over three months, these startups underwent tailored mentoring to validate technical concepts and align with market opportunities. Luxembourg's commitment to space development shone as it hosted ventures like Moliri Space (Estonia), Open Moon (Spain), Orbital Mining Corp. (USA), SolSys Mining (Norway), and We Space (Israel). With a vision to lead in space resources, ESRIC contributed to foster a dynamic ecosystem, supported by diverse startups aiming to advance the new-space economy.

## ADVANCING SPACE APPLICATIONS

LIST partnered with EARTHLAB Luxembourg to enhance Geo-Information-based applications through innovative solutions. The collaboration aims to promote research, foster joint projects, and demonstrate innovative technologies. This partnership aligns with LIST's ambition to lead in integrated space applications, merging Earth observation and telecommunications. Together, they aim to bring innovative space-based solutions to market.



Marco CHINI, Dirk FRANSAER, Thomas FRIEDERICH (Earthlab) & Lucien HOFFMANN



## UNLEASHING THE POWER OF REMOTE SENSING

LIST's remote sensing solutions are changing the face of environmental and humanitarian support worldwide. From generating global flood maps with HASARD® to combatting illegal fishing and oil spills using radar satellites, LIST's tools offer unparalleled accuracy and versatility. They monitor soil moisture, detect diseases in vineyards and forests, and assess urban damage in disaster areas like Mariupol. With applications ranging from environmental monitoring to disaster response, LIST's innovations are transforming the landscape of remote sensing technology.

## DEVELOPING A RISK MAPPING SYSTEM TO ADDRESS CLIMATE CHANGE RISKS

LIST and Spuerkeess joined forces to pioneer climate risk mapping, prioritizing societal well-being over profit. The collaboration aims to build a climate change assessment database and develop flood hazard maps for the Alzette river floodplain. Spuerkeess will convert these into flood risk maps for clients, enabling proactive risk management.



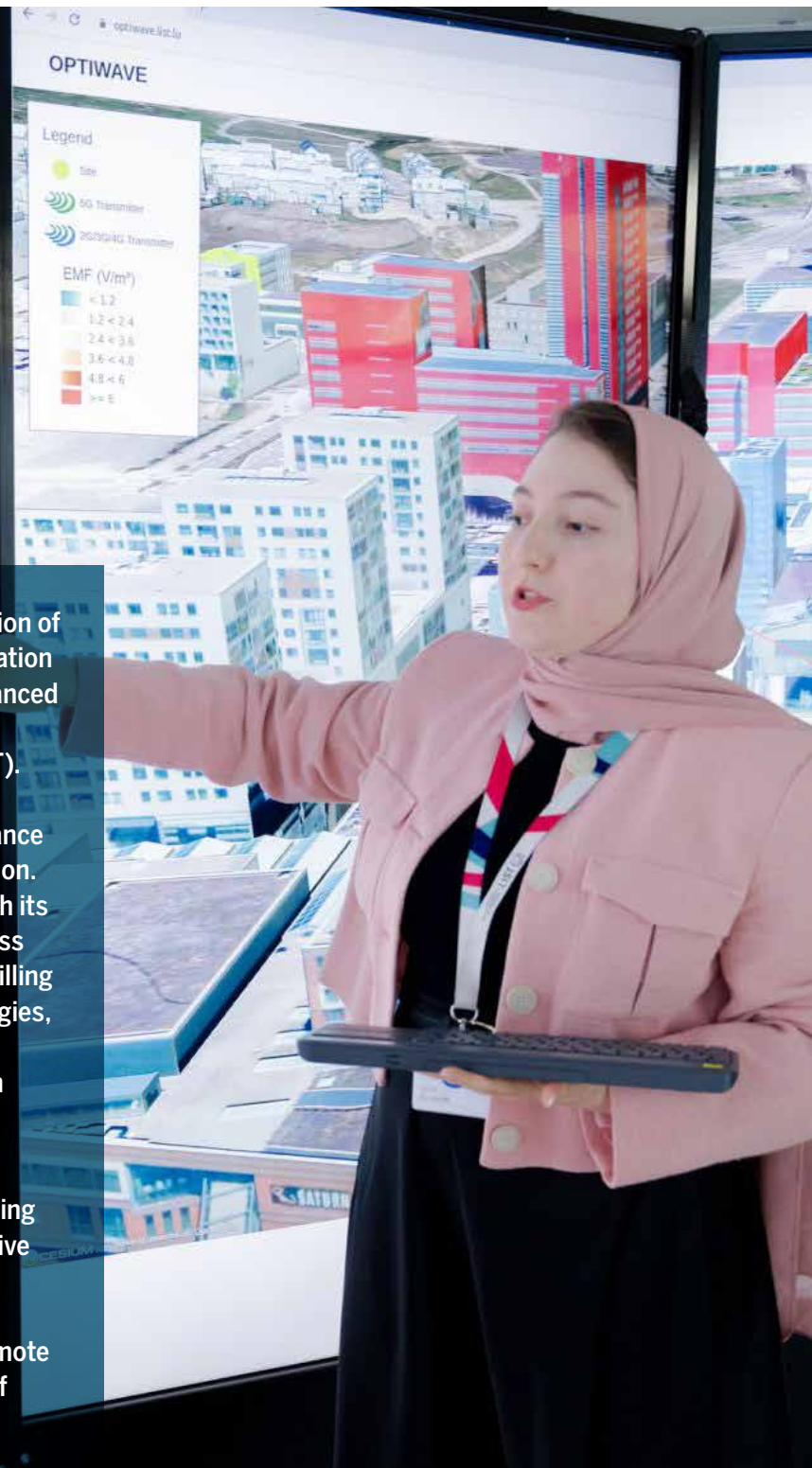
Françoise THOMA (Spuerkeess) & Rudi BELLI (Spuerkeess)



## INDUSTRY 5.0

Industry 5.0 represents the next evolution of manufacturing, emphasizing the integration of human-centric approaches with advanced technologies like artificial intelligence, robotics, and the Internet of Things (IoT). Priorities are put on the collaboration between humans and machines to enhance productivity, flexibility, and customization. However, this paradigm shift comes with its challenges, including the need to address concerns about job displacement, upskilling the workforce to adapt to new technologies, ensuring data security and privacy, and fostering interdisciplinary collaboration among researchers, engineers, policymakers, and other stakeholders.

Research plays a crucial role in addressing these challenges by developing innovative solutions, designing human-machine interfaces that prioritize safety and usability, and shaping policies that promote responsible and sustainable adoption of technologies.







## TRANSFORMING EUROPEAN CITIES WITH AI AND ROBOTICS EXPERTISE

CitCom.ai, funded by the EU with a budget of €19 million over 60 months, aims to bridge AI, data, and robotics innovations with real-world challenges, particularly those concerning the Green Deal. The project emphasizes testing and experimenting in cities to address climate adaptation and mitigation. CitCom.ai integrates expertise across Europe to propel advancements in AI and robotics. As one of the 33 partners, LIST operates one of the TEFs (testing and experimentation facilities) in electromobility.

Within the Luxembourg TEF, we propose several data, AI, and Digital Twin-related services related to support industrial partners to design, implement, prototype, and experiment with data-driven solutions to support the electromobility transition. Since September 2023 we have hosted five pilot experiments, including a Digital Twin toolbox for EV charging and solar generation in urban environments, a Vehicle-Integrated Photovoltaic (ViPV), an in-lab EV charger assessment service, an optimization tool for EV charging location, and a fleet emission tracker. We collaborate in the TEF with industrial partners, cities and communities aiming to contribute data, expertise and AI innovations for testing.

**“CitCom.ai brings together the strongest parties in the field within the EU and covers 11 EU countries from the outset. As part of this consortium, LIST will be able to demonstrate its expertise in AI testing and experimentation, helping companies to develop AI-based applications in the field of electromobility.”**

Francesco FERRERO,  
Director, IT for Innovative Services department



<https://citcom.ai>

## DEVELOPING THE WORLD'S FIRST OPEN SOURCE INTELLIGENT LOW-CODE PLATFORM

Jordi Cabot, leading LIST's Software Engineering RDI unit, received the PEARL Chair from the Luxembourg National Research Fund (FNR) to spearhead the BESSER (BETter Smart Software faster) project in collaboration with the Interdisciplinary Centre for Security, Reliability and Trust (SnT) at the University of Luxembourg. BESSER aims to pioneer the world's first open source intelligent low-code platform. With €3 million funding, it targets to streamline software development for professionals and amateurs alike, catering to the escalating demands of society, industry, and public administration. By integrating AI technologies and offering user-friendly interfaces, it enables even non-technical individuals to contribute to software development.

The timing couldn't be more opportune. Low-code platforms, forecast to dominate the market, offer a promising solution to expedite application development. BESSER aligns perfectly with Luxembourg's strategic goals, promising to enhance competitiveness and innovation in software development.



## NAVIGATING THE EU AI ACT: A PATH TO ETHICAL AI FUTURE

The European Union's groundbreaking AI Act sets the stage for ethical Artificial Intelligence development. Within this framework, LIST led efforts to ensure compliance, emphasizing transparency, accountability, and human oversight. The Act categorizes AI systems by risk, imposing strict standards for high-risk systems and transparency obligations. With a focus on human-centric and trustworthy AI, LIST's dedicated initiatives aimed to mitigate bias and enhance transparency, fostering ethical and inclusive technologies.

Just as with GDPR, LIST was actively involved in raising awareness and providing tools to comply with this upcoming regulation, reaffirming its commitment to supporting Luxembourg's AI landscape.



## REDEFINING STAGE TECHNOLOGY

Supported in part by the Ministry of the Economy's RDI law, LIST teamed up with Waagner and Biro Stage Systems to introduce autonomous, flexible, connected carriages to the stage, fundamentally altering the landscape of stagecraft. These marvels of engineering will be adapting seamlessly to spaces of all sizes, and unlocking limitless creative possibilities for directors and set designers.

Fueling this transformation are cutting-edge mechanics, electronics, and sensor technology, orchestrated to enable real-time communication and coordination among the carriages. Moreover, energy efficiency and sustainability are paramount concerns, with the carriages being equipped with state-of-the-art energy solutions. Safety and precision stand as cornerstones of this project. Advanced lock systems and AI-driven algorithms ensure stable setups and millimeter-precise movements, while robust security measures safeguard against unauthorized access. Complementing the mechanical marvels are advanced user interfaces featuring Augmented Reality/Virtual Reality capabilities, alongside digital twins for planning and coordination.



## LEADING €4M HORIZON EUROPE PROJECT FOR NEXT-GEN 6G NETWORKS

LIST spearheaded the 6G-TWIN project funded by the Smart Networks and Services Joint Undertaking (SNS JU) under the Horizon Europe programme under Horizon Europe.

European 6G strategies emphasize AI-driven management for complex networks, necessitating sustainable, adaptable architectures. The project aims to deliver change in wireless communication, focusing on AI-native management systems, sustainable networks, and Network Digital Twinning (NDT). With 11 partners, including universities, SMEs, and industrial entities, the project will develop demonstrators for real-world applications, contributing to the theoretical and practical advancement of 6G technologies.

With a €4 million budget over three years, the project epitomizes the EU's dedication to shaping wireless communication's future.



TECH ADVANTAGE Podcast : <https://shows.acast.com/661d0f-cfaed7bb0016f5d03b/episodes/661d0fd7f50b7900170b2f3a>







## EXPLORING LUXEMVERSE: BRIDGING REALITIES FOR SUSTAINABLE URBAN PLANNING

Amid the buzz surrounding the «metaverse» concept, researchers at LIST, led by Rod McCall, delved into creating «Luxemverse» - a blend of virtual and augmented reality representing Belval. Their mission: to understand and harness the potential of this digital twin.

Through Luxemverse, users can manipulate the environment, adding trees, energy-generating areas, and more, while monitoring real-time environmental impacts. Augmented reality, powered by HoloLens2, allows for on-ground validation and modification of virtual elements.

Challenges persist, notably in real-time data exchange between virtual and real realms. Yet, Luxemverse holds promise for urban planners and policymakers. Future plans envision collaborative interactions and potential integration with broader metaverse concepts.

In essence, Luxemverse is a practical tool shaping the future of spatial planning and interaction.

## MOVING FORWARD WITH QUANTUM COMPUTING

Florian Kaiser, leading the Quantum Materials Team at LIST, delved into developing quantum materials crucial for Europe's quantum network. By pioneering silicon carbide-based repeaters, LIST joined the Quantum Internet Alliance, aiming to revolutionize secure communication. Joining this alliance, Luxembourg emerged as a hub for quantum technology, poised to redefine global computing standards.

Additionally, Kaiser received the FNR PEARL Chair for his project focused on enhancing the performance of quantum computers. The project, named AQuaTSiC, (Advanced Quantum Technologies with Silicon Carbide) aims to maximize the number of qubits by connecting multiple systems. Contrary to standard approaches, the project integrates two small-scale quantum computing units on a photonic chip, akin to the way processors work on modern computer chips. This innovative approach allows for efficient communication between quantum computing units.



Florian KAISER





# SMART & LOW CARBON TRANSPORTATION

Smart and low carbon transportation is essential in combating climate change and reducing environmental impact. As urbanization increases and populations grow, the demand for transportation also rises, exacerbating environmental challenges such as air pollution and greenhouse gas emissions. The sector faces pressing challenges such as outdated infrastructure, reliance on fossil fuels, and inefficient transportation systems.

Research and technology offer promising solutions to these issues. From providing semi-industrial equipment designed to bridge the gap between laboratory-scale operations and semi-industrial production to utilizing industrial players' fleet to gather data on solar resources across Luxembourg's road network, to cementing partnerships with major transportation players, research can unlock innovative, circular solutions to meet future transportation demands.





## A NEW PVD PILOT LINE DRIVING FORWARD INDUSTRY STANDARDS

LIST achieved a breakthrough in material coating technology with the inauguration of its Physical Vapor Deposition (PVD) pilot line. This 18-meter semi-industrial equipment addresses scalability challenges, autonomous manufacturing, and technology transfer, marking a significant advancement in coating technology. Designed to bridge the gap between laboratory-scale operations and semi-industrial production, LIST's PVD pilot line offers a versatile platform for scaling up processes and validating innovative manufacturing techniques. With its dual functionality catering to both R&D experiments and continuous coating deliveries, this pilot line sets a new standard in the industry, positioning LIST as a leader in materials research and technology development.

**“The process of innovation remains incomplete until it is successfully integrated by the industry onto the market. With its production line setup closely mimicking real-world coating processes, LIST's PVD pilot line addresses the challenge of demonstrating the scalability of laboratory-scale results onto the industry, sharing risks for potential industry partners and advancing innovations to a technology readiness level for market transfer.”**

Dr Damien LENOBLE,  
Director, Materials Research and Technology department





## TAPPING INTO SOLAR ENERGY FOR SUSTAINABLE TRANSPORT

Cactus Supermarkets and LIST joined forces in the Solar e-Pace project, integrating photovoltaic technology onto vehicles to reduce reliance on fossil fuels. LIST researchers utilized Cactus's fleet to gather data on solar resources across Luxembourg's road network, facilitating the development of tools for future solar energy use in transportation. This collaboration underscores Cactus's commitment to sustainability and LIST's dedication to innovative solutions for sustainable mobility, driving towards a greener future.



Lucien HOFFMANN, Marc HÖFFMANN (Cactus), Benoît MAJERUS (Cactus) & Liz NEPPER (Cactus)



Damien LENOBLE & Claude MAACK (Gradel)

## DRIVING SUSTAINABLE TRANSPORT SOLUTIONS

Euro-composites and Gradel joined LIST's Sustainable Composite Materials and Manufacturing Innovation Centre, marking a pivotal step towards sustainable transportation solutions. The initiative, supported by key European transport players, aims to develop lightweight, eco-friendly composite materials for zero-emission mobility. With a focus on aerospace and mobility markets, the partnership signalled a shift towards sustainable structures utilizing natural resources and waste materials. The collaboration underscores the urgent need to adopt low-carbon technologies in the transport sector, paving the way for innovative, circular solutions to meet future demands.



# CIRCULAR ECONOMY

The pressing need to transition to a circular economy stems from the unsustainable linear model of production and consumption currently in place, which results in excessive waste generation, resource depletion, and environmental degradation. Transitioning to a circular economy is crucial for addressing global challenges. Research plays pivotal roles in transforming waste into sustainable solutions, thereby mitigating the adverse effects of resource depletion and pollution.

Breakthroughs in material science enable the development of durable and easily recyclable materials, fostering a circular economy where products are reused, repaired, and recycled to their fullest potential. In this transformative process, life cycle assessment (LCA) emerges as a critical tool in understanding the environmental impact of products from cradle to grave



## RECOVERING, RECYCLING, REMANUFACTURING

The global shift towards a bioeconomy gains momentum as research in green chemistry and bio-based materials burgeons. At LIST, experts delved into innovative methods to harness waste materials for sustainable product development. Pioneering approaches included utilizing lignin and cellulose derivatives to reinforce polymers, and exploring vitrimers for recyclable composites. Collaborative efforts ensured interdisciplinary synergy, propelling forward impactful solutions. However, experts cautioned that sustainability demands holistic evaluation beyond mere bio-based utilization, emphasizing the importance of green chemistry principles in achieving truly eco-friendly outcomes.

**“Bio-based compounds can be engineered from natural resources. We can use seemingly unimportant materials to create functional products. Our focus is on the use of materials derived from wood, specifically lignin.”**

Jean-Sébastien THOMANN,  
Powder and Colloid Engineering Group Leader, Materials  
Research and Technology department





## EXPLORING LIFE CYCLE ASSESSMENT'S ROLE IN TACKLING TRIPLE PLANETARY CRISES

An article, published in Nature Reviews Earth & Environment, co-authored by experts including Enrico Benetto from LIST delved into the significance of Life Cycle Assessment (LCA) in addressing today's pressing environmental challenges. LCA offers a holistic view, evaluating products from creation to disposal, considering impacts on climate, biodiversity, and pollution. The article highlighted the need for standardized methods, especially in assessing large-scale systems like sustainable consumption. Combining LCA with other tools shows promise in guiding policy for a sustainable future, emphasizing the urgency of putting knowledge into action.



## EMBRACING THE TRANSFORMATIVE POWER OF BUILDING INFORMATION MODELLING

Through applied activities, outreach, and research projects, LIST drove innovation, aligning BIM with environmental imperatives. Focusing on BIM's role in climate change mitigation, LIST collaborated with industry and research platforms like ECTP, integrating AI and digital twins. At BIMLUX 2023, LIST showcased its Digital Deconstruction platform, enabling informed decision-making and achieving a remarkable 17% reuse rate at Ettlbruck station. LIST's efforts extended to Life Cycle Assessment (LCA), vital for carbon footprint reduction. In collaboration with partners, LIST advanced data interoperability and holistic sustainability approaches, exemplified by projects like SemanticLCA and LegoFit.



# RENEWABLE ENERGY

## SMART GRID

Transitioning to renewable energy not only helps to combat global warming by reducing carbon emissions but also promotes economic growth, job creation, and technological innovation.

One transformative aspect lies in the conversion of waste heat into valuable energy, a process that not only minimizes environmental impact but also maximizes resource utilization. Redefining conventional cooling methods not only reduces energy consumption but also diminishes reliance on refrigerants with high global warming potential. Additionally, advancements in hydrogen production utilizing new materials and methods offer a promising avenue for sustainable energy generation. Collectively, these advancements signify a profound shift towards more sustainable and efficient energy practices, essential for a greener and more resilient future.



## TRANSFORMING WASTE HEAT INTO VALUABLE ENERGY

LIST in collaboration with ArcelorMittal Foundation Luxembourg unveiled Heat2Power®, a tool designed to optimize waste heat recovery and convert it into valuable electrical energy. LIST had been working closely with ArcelorMittal's operational teams, centered around the concept of the «Forge,» to develop and test innovative solutions as part of ArcelorMittal's transition to circular and decarbonized steel production.

Through the Heat2Power project, LIST and ArcelorMittal joined forces on methods of process integration and mathematical optimization to maximize electricity and steam generation from waste heat. The tool utilizes specific technologies and a sophisticated optimization algorithm to identify the most efficient and economically viable solutions.

The software, soon to be deployed as Software as a Service (SaaS), provides an intuitive interface for users to input data regarding waste heat streams and relevant parameters. The algorithm then processes this data to provide users with an optimized system design, which can be further fine-tuned manually.

Heat2Power® represents a significant step towards a greener and more sustainable future for industrial processes, contributing to the decarbonization efforts of companies like ArcelorMittal. The partnership between LIST and ArcelorMittal highlights the importance of collaboration between research organizations and industry in driving innovation and addressing complex challenges.

**“What makes this project important is its complexity. In the basic model we are examining, there are approximately 600,000 variables that need to be quantified. The challenge lies in the fact that it is not feasible to manually calculate and determine the best solution by going through the entire list of solutions. To address this issue, we employed methods of process integration and mathematical programming. As such, we can effectively handle the complexity associated with the numerous variables with the goal being to design and select optimal values for all the variables involved.”**

Alexandre BERTRAND,  
Research & Technology Associate, Environmental Research & Innovation department



Dirk FRANSAER, Alexandre BERTRAND & Henri REDING (ArcelorMittal)



TECH ADVANTAGE Podcast : <https://shows.acast.com/661d0fc-faed7bb0016f5d03b/episodes/661d0fd7f50b7900170b2f35>



## REDEFINING CONVENTIONAL COOLING METHODS

Researchers at LIST have introduced a groundbreaking refrigeration technology set to transform conventional cooling methods that harm the environment. Their recent publication in *Science* showcases the potential of using the electrocaloric effect, where materials undergo reversible temperature changes in response to an electric field.

LIST pioneered the development of electrocaloric materials. Their innovative design utilizes multilayer capacitors within a fluid-filled pipe, termed a regenerator, to induce cooling effects through an electric field. This technology, unlike traditional refrigeration systems relying on vapour compression, offers a more energy-efficient and eco-friendly alternative, replacing compressors and harmful fluids.



<https://www.science.org/doi/10.1126/science.adi5477>



## PIONEERING THE FUTURE OF HYDROGEN WITH NEW MATERIALS

During Hydrogen Week, LIST showcased pioneering research in hydrogen production and material development. With its two projects, STONB and HEPHOTO, focusing on strontium titanate and sodium tantalate respectively, to enhance solar-driven water splitting for hydrogen production, Sybilla lab took centre stage. Through innovative processes, Sybilla Lab optimizes material properties, boosting solar photon absorption.

With funding from Luxembourg National Research Fund and collaboration with 3D-Oxides, these projects set new standards in hydrogen production. Sybilla Lab's capabilities, supported by the Sybilla 450 machine, enable scalable production of crucial photo-electrodes.



IN THE LAB :  
<https://youtu.be/frInssZ8OeE>

## INCREASING OUR FOOTPRINT IN THE LARGEST TECHNICAL PROFESSIONAL SOCIETY OF ELECTRICAL AND ELECTRONIC ENGINEERS IN BENELUX

Pedro Rodríguez took the helm as Chair of the IEEE Benelux IAS/PELS/PES Joint Chapter. With vast experience as Head of the Intelligent Clean Energy Systems unit and recognized as a Fellow of the IEEE, his appointment heralds a new era of collaboration in Belgium, the Netherlands, and Luxembourg.

The chapter, representing a significant cohort of over 3500 members, aims to bridge the gap between researchers, industry professionals, and students. Through various initiatives, including the upcoming IEEE Benelux IAS/PELS/PES Young Researchers Symposium, the focus remains on fostering interaction and knowledge exchange.

Pedro's leadership underscores the commitment to advancing industrial applications, power electronics, and electrical power engineering. With his guidance, the Chapter is poised to make significant strides in promoting innovation and excellence within the field.

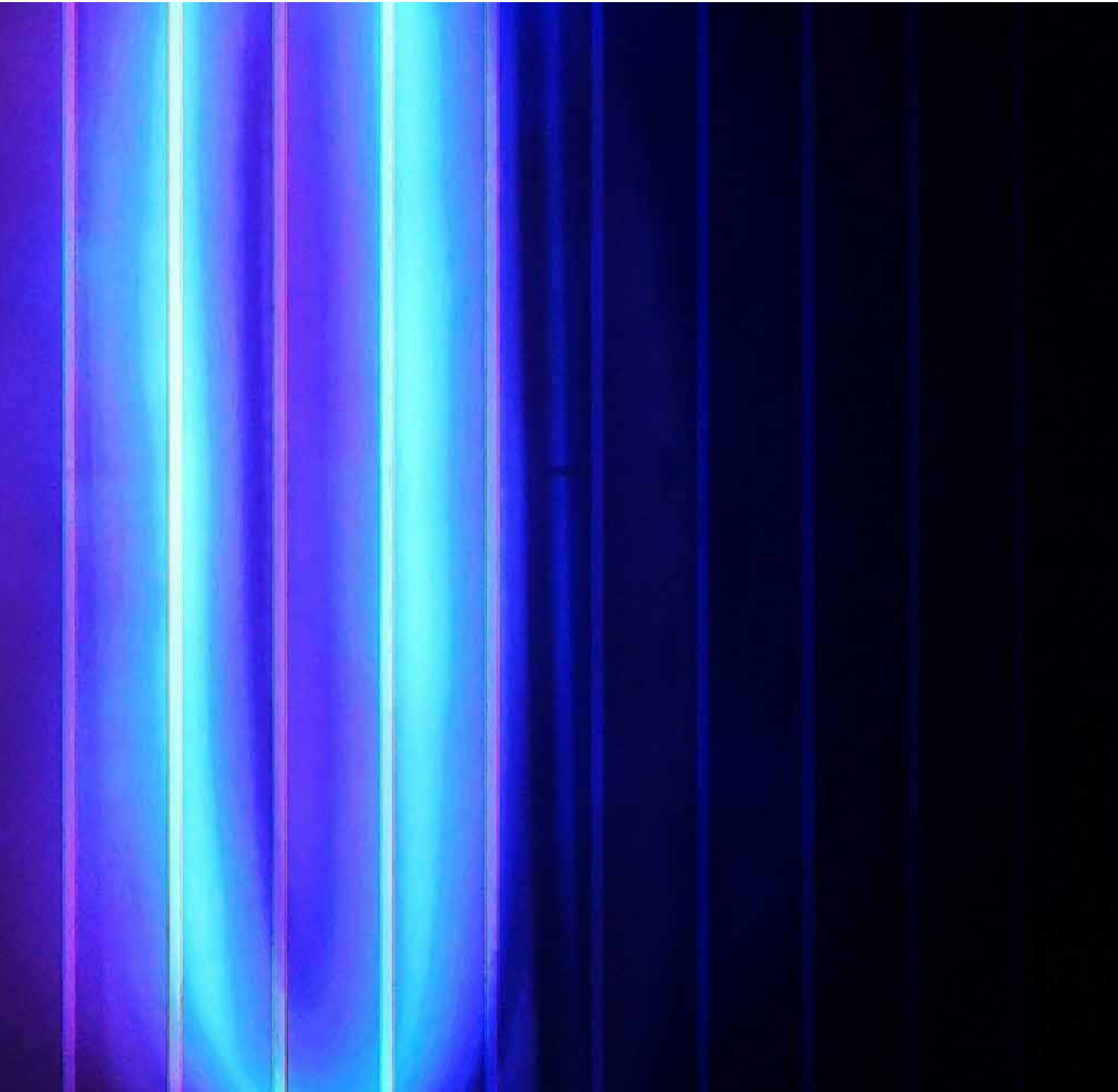


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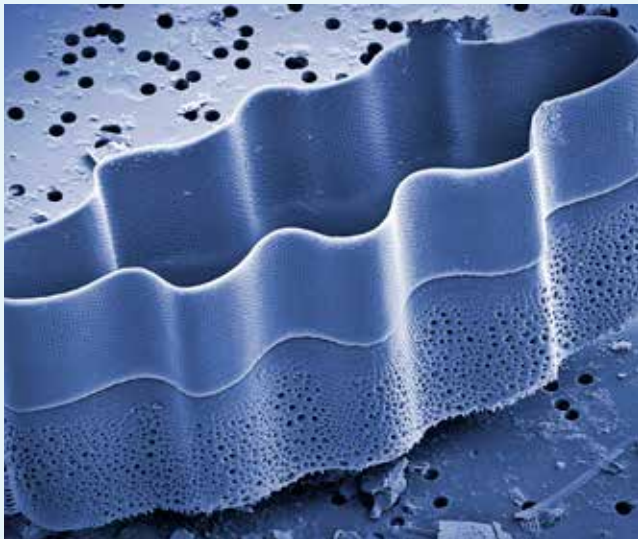
# HOW WE CREATE A DIALOGUE BETWEEN SCIENCE & SOCIETY

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LIST is committed to bridging science with society through diverse outreach activities. From showcasing research projects in letzScience to actively engaging with students through «Chercheurs à l'école,» LIST seeks to foster curiosity and dialogue in STEM fields. At the 2023 Science Festival, LIST's workshops unveiled innovative solutions, making science accessible and attractive to a wider audience. Moreover, the launch of 'TechAdvantage' podcast and 'In the Lab' video series underscores the Institute's dedication to driving progress and fostering dialogue in science and technology. With initiatives like Engineering Trainee Days and contributions to the Science Festival, LIST unlocks the wonders of science for all, sparking curiosity and inspiring future generations.



### BRIDGING SCIENCE AND SOCIETY

LIST actively contributed to the Luxembourg National Research Fund (FNR)'s initiatives aimed at presenting scientific projects to the general public. Featured in letzScience, three of LIST's research projects highlighted the institute's commitment to scientific outreach: (1) the Stomata project delved into plant-environment interactions; (2) the Plasma project explored plasma's applications in materials and healthcare; and (3) the Diatoms project unraveled diatoms' role in soil health assessment.

Additionally, LIST researchers participated in "Chercheurs à l'école" (Researchers go back to school), bridging the gap between researchers and students, fostering curiosity and dialogue. These engagements exemplify LIST's dedication to promoting STEM education and public engagement with science.

### UNLOCKING SCIENCE FOR ALL

At the 2023 Science Festival, LIST researchers demonstrated their commitment to making science more accessible by hosting workshops that showcased their innovative solutions. These workshops, including a Chatbot Show, Driving between the Physical and Virtual Worlds, AI and Astronomy, and another focusing on the intersection between humans, machines and the environment, provided engaging platforms for participants to interact with pioneering research. The Science Festival is an essential means of presenting and promoting science and research in Luxembourg, with particular emphasis on arousing the curiosity of young people and the general public.



## GOING BEHIND THE SCENES OF RESEARCH

LIST demonstrated its dedication to scientific outreach through the launch of two engaging series:

'TechAdvantage' offers deep dives into cutting-edge innovations spanning materials technology, sustainability, and IT. Featuring expert discussions and quick-bite episodes, it illuminates the pivotal role of technology in shaping our world.



'In the Lab' takes viewers behind the scenes, showcasing LIST's researchers and engineers in their element. From state-of-art equipment to market-oriented prototypes, this series highlights the institute's pivotal role in driving innovation for both public and private stakeholders.



## ENGAGING STUDENTS IN SCIENCE

LIST took proactive steps to engage with students and the public, showcasing its commitment to fostering interest in STEM fields.

Participating in the Engineering Trainee Days, LIST provided students with a unique opportunity to gain hands-on experience in the daily work of STEM professionals. Students immersed themselves in the professional, linguistic, and relational aspects of STEM careers.

Additionally, LIST contributed to the Science Festival, organized by the Musée national d'histoire naturelle Luxembourg and the Luxembourg National Research Fund (FNR). Through four dedicated booths, LIST researchers highlighted their diverse activities, bridging the gap between scientific research and public understanding. From exploring the interface between physical and virtual worlds to delving into the intersection of humanity, technology, and the environment, LIST offered engaging experiences that sparked curiosity and dialogue.





# HOW WE COLLABORATE WITH THE INDUSTRY AND PUBLIC STAKEHOLDERS

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**PROPELLING THE INNOVATION ROADMAPS OF INDUSTRIAL PARTNERS AND PUBLIC PLAYERS FORWARD**



**LAUNCHING THREE INNOVATION CENTRES FOR PRE-INDUSTRIAL SCALEUP**



## PROPELLING THE INNOVATION ROADMAPS OF INDUSTRIAL PARTNERS AND PUBLIC PLAYERS FORWARD

LIST serves as a vital nexus for fostering collaboration and innovation among industrial partners and public stakeholders. Through events such as the Tech Day, LIST highlights cutting-edge technologies and facilitates dialogue, focusing on the symbiotic relationship between people and technology. Collaborations and strategic partnerships with industry leaders such as Goodyear, Arkema, ArcelorMittal and Cactus as well as public institutions such as Spuerkeess, enable LIST to address industry challenges and advance innovation roadmaps. In addition, LIST's innovation centres, including the Innovation Centre for Sustainable Manufacturing and Composites, the Greentech Innovation Centre and the Digital Twin Innovation Centre, play a key role in advancing technology and promoting collaboration across different sectors, helping partners, private companies and public stakeholders to shape a sustainable and innovative future.



### NAVIGATING THE NEXUS OF HUMAN-TECH FUTURES

The 5<sup>th</sup> edition of the Tech Day showcased cutting-edge technologies and fostered dialogue with industry players. With over 350 participants, including 160 companies, the event emphasized the symbiotic relationship between humans and technology. Highlights included seven flagship technologies in the Tech Village, each delving into the intricate interactions between humans and machines, from environmental monitoring to healthtech advancements.

Tech Day also served as a platform for LIST to spotlight ongoing and potential partnerships, including collaborations with startups such as FourPoint and Wide (Women in Digital Empowerment), as well as ventures with Green Power Storage Solutions and Webasto.

Reflections echoed on its impactful journey since 2018, with over 40 demonstrators showcased, 99 speakers, and over 1,500 participants welcomed.



<https://www.list-techday.eu/>



## FOSTERING INNOVATION THANKS TO FAVORABLE COLLABORATIVE MODELS

LIST champions collaborative innovation across sectors, offering diverse partnership opportunities for businesses, universities, and public institutions. Through strategic collaborations like research contracts and joint research partnerships, LIST addresses specific industry challenges while fostering long-term innovation roadmaps.

In 2023, we totalled 150 collaborative projects, including the second phase of our partnership with Goodyear, spanning 2024-2029. The partnership encompasses six strategic research programs focusing on data science, tire sensing, tire recycling, sustainable materials, and structure-property relationships. Significant collaborations were also forged with Cactus and TICE in the field of photovoltaic energy use, Spuerkeess for the mapping of areas at risk from climate change, and Waagner-Biro for the design of autonomous connected wagons to move theatre sets. Moreover, LIST facilitated technology transfer through 24 paid licences, and expert consultations.



<https://paperjam.lu/article/cocreer-grandes-innovations-de>

Dirk FRANSAER

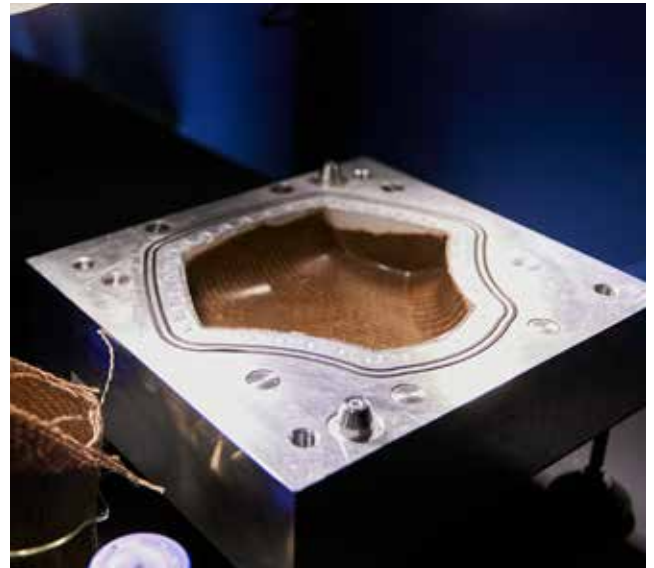
## LAUNCHING THREE INNOVATION CENTRES FOR PRE-INDUSTRIAL SCALEUP

The three Innovation Centres at LIST play pivotal roles in advancing technology and fostering collaboration across various sectors. The Sustainable Composite Materials & Manufacturing Innovation Centre focuses on developing lightweight, recyclable materials for transportation, with industry leaders and partners ensuring relevance and applicability. The Greentech Innovation Centre accelerates environmental technology development through interdisciplinary approaches, state-of-the-art facilities, and strategic collaborations. Meanwhile, the Digital Twin Innovation Centre pioneers transformative ecosystems by driving advancements in modeling, simulation, and data analytics across industries like Smart Cities and Clean Energy, ensuring flexibility and regulatory compliance. Through these initiatives, LIST supports partners, private companies, and public stakeholders in shaping a sustainable and innovative future.

### SHAPING THE FUTURE OF TRANSPORTATION AT THE SUSTAINABLE COMPOSITE MATERIALS & MANUFACTURING INNOVATION CENTRE

The Sustainable Composite Materials & Manufacturing (SCMM) Innovation Centre focuses on developing ultra-lightweight, recyclable materials for future transportation. With cutting-edge infrastructure, SCMM covers the entire composites value chain, facilitating rapid prototyping and testing. Members comprise industry leaders such as Arkema, Euro-Composites, and Gradel, while our partners include Luxinnovation, Airbus, Thales Alenia Space, and Toyota. The establishment of SCMM has been made possible through co-funding from the European Union, the Ministry of Higher Education and Research, and the Ministry of Economy.

In 2023, SCMM hosted its first Industry Day, attended by industry leaders and experts. The event celebrated significant milestones in composite materials innovation and the SCMM Innovation Centre's progress since its establishment a year ago. Highlights included keynote speeches from global industry figures, live demonstrations showcasing breakthroughs in composite materials, and the signing of a membership contract with Arkema, a leader in specialty materials.



[www.list.lu/en/institute/centres/sustainable-composite-materials-manufacturing-smmm-innovation-centre/](http://www.list.lu/en/institute/centres/sustainable-composite-materials-manufacturing-smmm-innovation-centre/)

## ACCELERATING THE DEVELOPMENT OF NEW ENVIRONMENTAL TECHNOLOGIES AT THE GREENTECH INNOVATION CENTRE

The Greentech Innovation Centre drives biotechnology developments. With over 60 experts, it fosters innovations in biotechnology, clean water, and environmental risk management. State-of-the-art facilities support scale-up processes, ensuring seamless transitions from lab prototypes to industrial production. Additionally, the centre pioneers waste water treatment hardware and biocatalysts for sustainable energy production. Leveraging partnerships and IP licensing, it accelerates technology adoption and fosters economic growth.

In 2023, the Greentech Innovation Centre inaugurated new facilities. With these advanced installations, the centre aims to elevate Technology Readiness Levels in biorefinery, water treatment, and biogas production. The infrastructure includes unique bioreactor platforms up to 300L capacity, enabling large-scale prototypes and partnerships with industry. Collaborations with key partners like IBLA, Biorock, and PM-International enhance LIST's capacity in environmental technology innovation.



[www.list.lu/en/institute/centres/greentech-innovation-centre/](http://www.list.lu/en/institute/centres/greentech-innovation-centre/)

## PUSHING THE LIMITS OF TECH INNOVATION AT THE DIGITAL TWIN INNOVATION CENTRE

The Digital Twin Innovation Centre provides an innovative approach to business operations across industries. Offering virtual replicas of physical entities, Digital Twins enable comprehensive analysis, monitoring, and predictive capabilities without impacting the original. The centre's vision extends the utility of Digital Twins across the entire value chain, from enhancing comprehension to decision support. The centre drives advancements in modeling, simulation, and data analytics, fostering transformative ecosystems. Through strategic deployment, partnership establishment, and support services, the Centre accelerates the adoption of Digital Twin technologies. Core technologies driving LIST's efforts include IoT, machine learning, cloud computing, and cybersecurity. The centre prioritizes open standards and interoperable solutions, ensuring flexibility and regulatory compliance for its partners.

In 2023, the Digital Twin Innovation Centre started developing a common toolkit for researchers to contribute data and models, aiming for seamless interaction among digital twin projects. This approach is to enhance efficiency, enabling faster demonstration of research results and potential data reuse and interoperability.



[www.list.lu/en/institute/centres/digital-twin-innovation-centre/](http://www.list.lu/en/institute/centres/digital-twin-innovation-centre/)



# WHY OUR RESEARCH EQUIPMENT STANDS OUT









## DESIGNING STATE-OF-THE ART LABORATORIES

LIST enhanced its laboratory spaces in Hautcharage and Belvaux. Hautcharage 2 boasts 2,000 m<sup>2</sup> of new laboratory space, creating an efficient and impressive research environment. Meanwhile, ESRIC completed three cutting-edge laboratory zones in Belvaux, equipped with state-of-the-art facilities for innovative research in space.

### 2,000 M<sup>2</sup> OF NEW LABORATORY SPACE IN HAUTCHARAGE 2

The ambitious project of transforming a former industrial hall into state-of-the-art laboratories has reached its successful conclusion at Hautcharage 2. With 2,000 m<sup>2</sup> of new laboratory space and 200 m<sup>2</sup> of office space, the facility was fully operational. The installation of the environmental department in the new extension was completed, and some laboratories were also operational. LIST has a new, efficient, and impressive research space.



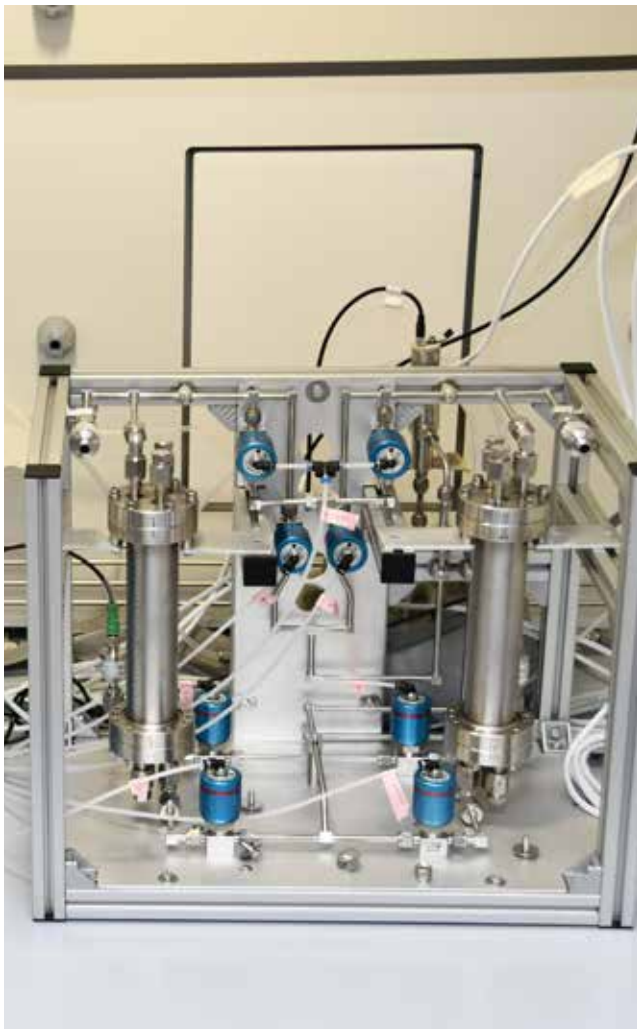
Among the new installations, the new facilities at the Greentech Innovation Centre include a platform of bioreactors with a capacity ranging from 1 litre to 300 litres that is unique in the Greater Region





## ESRIC'S THREE ZONES OF CUTTING-EDGE LABS IN BELVAUX

ESRIC completed three zones of its state-of-the-art laboratory facilities, located in Belvaux. These zones include Zone A, dedicated to sample preparation, ensuring meticulous handling and preparation of materials for experimentation. Zone B stands out for housing large reactors like the Alchemist and the ISRU Lab, set to facilitate innovative research in in-situ resource utilization, particularly focusing on molten salt reactors in the future. Finally, Zone C features cutting-edge equipment for gas purification through PURIST technology and precise analysis using advanced mass spectrometers. With these completed zones, ESRIC is poised to lead groundbreaking research across various scientific disciplines, further solidifying its reputation as a hub for cutting-edge scientific exploration and innovation.



## MAJOR UPGRADE AT MAISON DES MATÉRIAUX

A substantial project is underway at Maison des Matériaux, with preparations for the addition of seven new floors scheduled for completion in 2024. Spanning over 2,000 square meters of laboratory space and 680 square meters of office space, this expansion represents a significant investment in LIST's infrastructure. These state-of-the-art facilities will provide additional resources for LIST's teams engaged in materials research. Specifically, they will support advancements in characterization, chemistry, laser technology, and composite materials.



# HOW WE TRAIN THE FUTURE GENERATION OF SCIENTISTS

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FUELING FUTURE SCIENTIFIC INNOVATORS

DOCTORAL THESES DEFENDED







## FUELING FUTURE SCIENTIFIC INNOVATORS

LIST plays a pivotal role in shaping the next generation of scientists through its dedicated supervision of 93 PhD candidates. Through mentorship and guidance, LIST empowers these candidates to conduct groundbreaking research and develop their expertise in their respective fields. In 2023, the culmination of this effort was evident as 28 candidates successfully defended their theses, marking a significant milestone in their academic and professional journey.

Testifying to LIST's commitment to promoting a positive research culture, Pierre Verge was recognized as an outstanding mentor at the FNR Awards 2023. Since joining LIST in 2011, Pierre Verge has been dedicated to creating a healthy working environment, conducive to the sustainable development of fulfilled scientists. His recognition at the FNR Awards 2023 is an affirmation of the transformative impact of mentorship in the world of research.



“One aspect I genuinely cherish is being part of a group. Firstly, the research aligns perfectly with the vision I had when contemplating a PhD. The work we do resonates with the aspirations I held. Secondly, beyond the research, the group’s friendly atmosphere is something truly special. It creates an environment where one feels valued not just for their academic contributions but also for their individuality. This blend of meaningful research and a supportive community has made my PhD journey not only intellectually stimulating but emotionally fulfilling”,

Dr. Saba Tabean, whose PhD thesis focused on exploring correlative microscopy methodologies for enhanced imaging and analysis with Helium ion microscope.



“During my four years at LIST, I had the opportunity to meet and collaborate with scientists from diverse domains, ranging from material characterization to cell physiology. This experience allowed me to enhance my skills and knowledge through shared experiences in multi-disciplinary facets. Additionally, it was enriching to explore cultural diversity, facilitated by the wide array of nationalities represented at LIST”,

Dr. Thierry Hellebois, whose PhD thesis focused on the valorisation of plant-derived gums from alfalfa and flax seed gums as co-structurant biopolymer for the development of novel probiotic delivery systems based on cryogels.

“The research environment I’ve been working in has been very conducive to interdisciplinarity and collaboration. What I appreciated most was the independence I was given, while still benefiting from constant support when needed,”

Dr. Charlotte Stoffels, who developed a new methodology using high-resolution chemical imaging techniques allowing the localization of Perfluoroalkylated substances (PFAS) inside cells and tissues as part of her PhD thesis.



**ADJAOUD Antoine**

"Design and synthesis of new lignin-based benzoxazine vitrimers",  
University of Luxembourg, 15/09/2023

**AGCA Muhammed Akif**

"Trusted distributed AI for critical and autonomous systems",  
University of Luxembourg, 12/09/2023

**BAYRAM Alper**

"Hybrid LCA-ABM of dairy farming systems including nonlinear optimization under environmental, technical and economic constraints", University of Luxembourg, 26/04/2023

**BELLOMO Nicolas**

"Remote plasma chemical vapour deposition for gas diffusion layer and proton exchange membrane synthesis for fuel cells",  
University of Luxembourg, 11/01/2023

**BLAZQUEZ MARTINEZ Alfredo**

"Photoferroelectric effects in polycrystalline bismuth ferrite",  
University of Luxembourg, 12/09/2023

**BONANNO Enrico**

"Water flow and solute transport in the stream corridor: hyporheic flow directions, parameter identifiability and transient storage processes", Vienna University of Technology, 21/02/2023

**CRESSA Luca**

"Advanced analysis of battery materials via correlative charged particle characterisation techniques", University of Stuttgart, 05/12/2023

**DEY Benjamin**

"Growth and crystallisation of photocatalytic  $\text{TiO}_2$  on thermolabile substrates by pulsed electron cyclotron wave resonance PECVD",  
University of Luxembourg, 06/07/2023

**FERREIRA Marta**

"Deposition of nanocomposite coatings based on  $\text{Al}_2\text{O}_3$  and gold nanoparticles exhibiting surface plasmon resonance",  
University of Luxembourg, 29/11/2023

**FLORENT Perrine**

"Soil viral particles as tracers of surface water sources and flow paths", University of Luxembourg, 24/01/2023



**GNANASAMBANDAN Poorani**

“High performance transparent conducting materials for solar cells”, University of Luxembourg, 02/10/2023

**HELLEBOIS Thierry**

“Study of alfalfa and flaxseed gums as co-structurants in probiotic cryogel scaffolds”, University of Lorraine, 24/11/2023

**HILL Christina**

“Resonant Raman scattering and other new coupling phenomena in ferroelastic  $\text{BiVO}_4$ ”, University of Luxembourg, 03/07/2023

**KRIEGER Louis**

“New insights into plant hydraulics by pulling instead of pushing water through plant segments”, University of Luxembourg, 08/02/2023

**LAKE Niels**

“Towards high temporal and *in situ* estimations of suspended sediment sources”, University of Southampton, 03/03/2023

**LARREA GALLEGOS Gustavo Martin**

“On the sustainability assessment of complex systems - Understanding the effects of disruptions on the sustainability of supply networks”, University of Luxembourg, 15/12/2023

**MASHAYEKHI Fatemeh**

“Integration and interfacial engineering of strain sensors in additively manufactured polymeric structures”, University of Luxembourg, 05/07/2023

**MONTEMAGNO Alessandro**

“Investigating rare earth elements and water stable isotopes dynamics in forest ecosystem”, Wageningen University & Research, 06/11/2023

**MOUSSA Adnan**

“Water ages in the critical zone: hydrological travel times in streamflow and evapotranspiration”, University of Luxembourg, 19/09/2023

**MURILLO NAVARRO Diana Elisa**

“Theory and simulations of caloric effects in ferroelectric materials”, University of Luxembourg, 18/10/2023

**OSUEBI-IYKE Emmanuella**

“Costs and benefits of carbon investments into shoots and roots”, University of Luxembourg, 19/09/2023

**SEHGAL Dhruv**

“High frequency monitoring of suspended particulate matter”, Wageningen University & Research, 06/10/2023

**SONG Longfei**

“Processing of piezoelectric oxides films for surface haptics”, University of Luxembourg, 20/07/2023

**STOFFELS Charlotte**

“When mass spectrometry analysis bridges environmental toxicology”, University of Luxembourg, 20/11/2023

**TABEAN Saba**

“Exploring correlative microscopy methodologies for enhanced imaging and analysis with Helium ion microscope”, University of Luxembourg, 30/11/2023

**THAKUR Gitanjali**

“Investigating physical controls of vegetation-atmosphere interaction using ecosystem-scale measurements”, Karlsruhe Institute of Technology, 18/07/2023

**VAN HATEREN Theresa Catharina**

“Soil moisture droughts evaluated using Earth observation”, Wageningen University & Research, 22/11/2023

**VAN ZWEEL Karl Nicolaus**

“Observing unseen flowlines and their contribution to near stream endmembers in forested headwater catchments”, University of Luxembourg, 08/03/2023

# APPENDICES

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GOVERNANCE

BALANCE SHEET

PROFIT AND LOSS ACCOUNT

WATT

\$1.61

\$1.54

0

1

0





## BOARD OF DIRECTORS 2023



From left to right: Robert Kerger, Isabelle Kolber, Benoît Otjacques, Jean-Sébastien Thomann, Marie-Christine Mariani, Dirk Fransaer, Eva Kremer, Diane Wolter, Etienne Jacqué, Tom Battin, Letizia Lukas, Candi Carrera, Steve Kremer & Stéphane Jacquemart

### MEMBERS OF THE BOARD OF DIRECTORS

#### Eva Kremer

CEO of Société Nationale de Crédit et d'Investissement (Luxembourg), Chair

#### Etienne Jacqué

Corporate R&D Manager at CEBI International SA (Luxembourg), Vice-Chair

#### Tom Battin

Professor at the École Polytechnique Fédérale de Lausanne (Switzerland)

#### Candi Carrera

Owner, 36 Square Capital (Spain)

#### Isabelle Kolber

Head of Laboratory at SEBES (Syndicat des eaux d'Esch-sur-Sûre - Luxembourg)

#### Steve Kremer

Director of First Class Research at the Nancy National Institute for Research in Digital Science and Technology (INRIA - France)

#### Letizia Lukas

Coordinatrice de projets de digitalisation at Ministère de l'Éducation nationale, de l'Enfance et de la Jeunesse

#### Marie-Christine Mariani

CEO of MCM SARL (Luxembourg)

#### Diane Wolter

President of CBM Luxembourg Foundation

#### Stéphane Jacquemart

Chair of the Staff Delegation

#### Jean-Sébastien Thomann

Member of the Collaborative Council

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#### Dirk Fransaer

CEO ad interim

### GOVERNMENT COMMISSIONER

#### Robert Kerger

Advisor to the Ministry of Research and Higher Education

### SECRETARY

#### Benoît Otjacques

## EXECUTIVE MANAGEMENT



**Dirk Fransaer**  
CEO  
ad interim

## RDI DEPARTMENTS



**Prof. Dr Lucien Hoffmann**  
Director, Environmental Research and Innovation (ERIN)



**Dr Kathryn Hadler**  
Director, European Space Resources Innovation Centre (ESRIC)



**Francesco Ferrero**  
Director, IT for Innovative Services (ITIS)



**Dr Damien Lenoble**  
Director, Materials Research and Technology (MRT)

## HUMAN RESOURCES



**Sylvie Weyland**  
Human Resources Director ad interim

## FINANCE & ADMINISTRATION



**Dirk Fransaer**  
Administrative and Financial Director ad interim

## APPROVAL OF ACCOUNTS

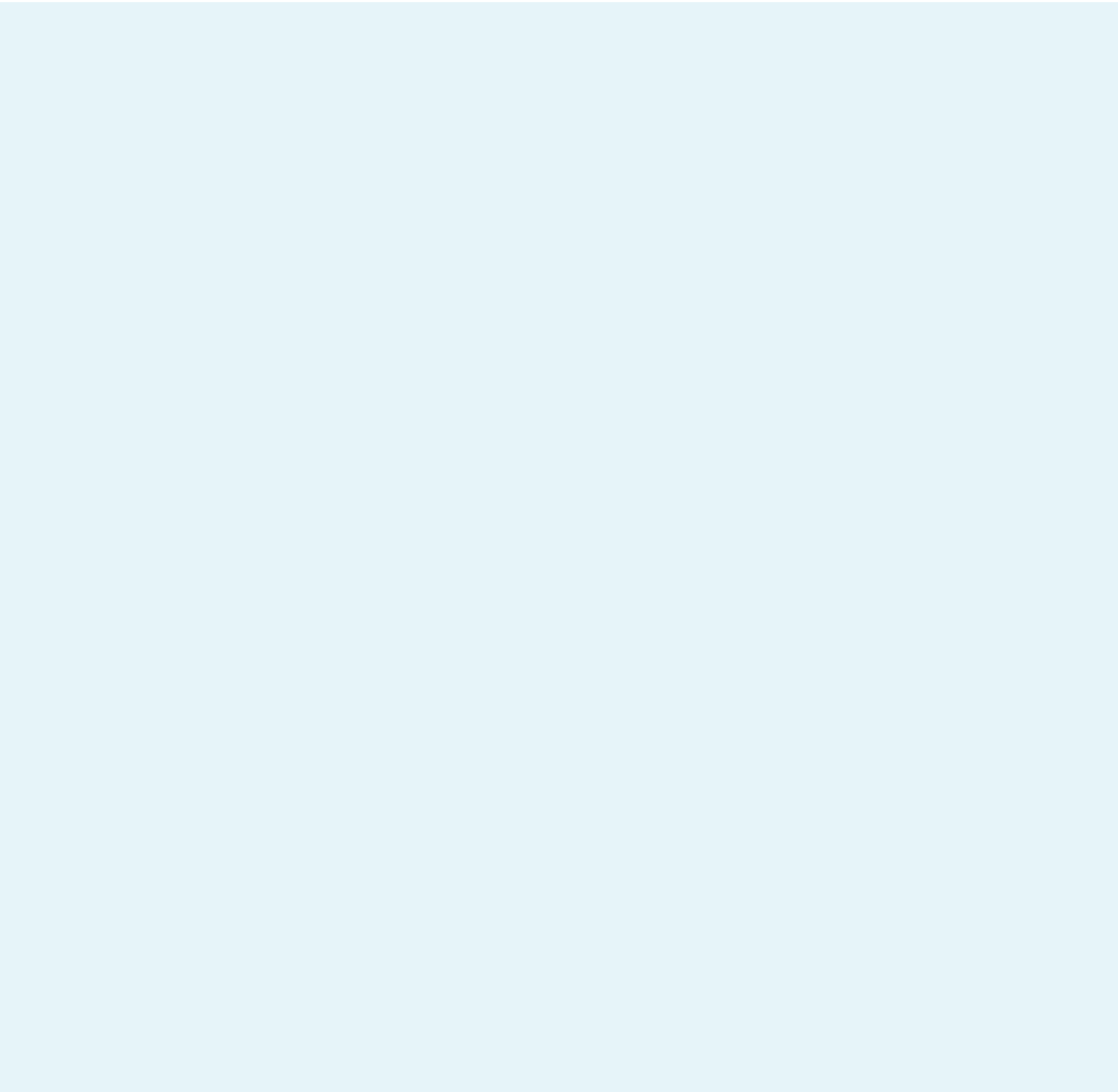
The accounts were audited by statutory auditors KPMG and approved by the Board of Directors during their meeting of 19 April 2024.

The full financial report is available at [www.list.lu](http://www.list.lu)

Assets (in euros)	2023	2022
<b>Fixed assets</b>		
<b>Intangible fixed assets</b>	<b>595.853,71</b>	<b>722.546,03</b>
Concessions, patents, licences, trademarks and similar rights and assets	595.853,71	722.546,03
<b>Tangible fixed assets</b>	<b>45.133.641,01</b>	<b>40.384.156,30</b>
Land and buildings	90.254,18	92.209,95
Plant and machinery	36.581.923,26	23.054.613,42
Other fixtures and fittings, tools and equipment	2.846.556,81	2.610.895,50
Payments on account and tangible assets under development	5.614.906,76	14.626.437,43
<b>Financial fixed assets</b>	<b>81.355,53</b>	<b>468.832,74</b>
Shares in affiliated undertakings	25.000,00	415.938,20
Amounts owed by affiliated undertakings	-	-
Securities held as fixed assets	56.355,53	52.894,54
<b>Total fixed assets</b>	<b>45.810.850,25</b>	<b>41.575.535,07</b>
<b>Current assets</b>	<b>114.046.863,21</b>	<b>101.906.104,90</b>
<b>Inventories</b>	<b>652.021,57</b>	<b>567.570,88</b>
Raw materials and consumables	652.021,57	567.570,88
<b>Receivables</b>	<b>38.073.736,85</b>	<b>32.208.997,94</b>
Receivables from the sale of goods and services	3.857.363,85	3.825.568,62
Other receivables	34.216.373,00	28.383.429,32
<b>Cash at bank and in hand</b>	<b>75.321.104,79</b>	<b>69.129.536,08</b>
<b>Total current assets</b>	<b>114.046.863,21</b>	<b>101.906.104,90</b>
<b>Accruals</b>	<b>2.881.385,52</b>	<b>2.185.990,99</b>
<b>Balance sheet total (assets)</b>	<b>162.739.098,98</b>	<b>145.667.630,96</b>
<b>Equity and liabilities (in euros)</b>	<b>2023</b>	<b>2022</b>
<b>Equity</b>	<b>98.257.721,15</b>	<b>95.469.279,78</b>
Capital contributions	37.518.673,70	37.518.673,70
Reserves	58.287.191,96	58.287.191,96
Profit or loss brought forward	- 336.585,88	-
Profit for the financial year	2.788.441,37	-336.585,88
<b>Provisions</b>	<b>2.876.985,00</b>	<b>180.000,00</b>
<b>Liabilities</b>	<b>57.422.074,72</b>	<b>43.753.136,69</b>
Payments received on account for orders where not separately deducted from inventories	36.355.089,32	28.595.040,55
Trade creditors	5.467.367,87	7.788.186,99
Other liabilities	15.599.617,53	7.369.909,15
Tax liabilities	7.766,08	23.559,22
Social security liabilities	3.268.720,10	1.848.555,47
Other liabilities	12.323.131,35	5.497.794,46
<b>Accruals</b>	<b>4.182.318,11</b>	<b>6.265.214,49</b>
<b>Balance sheet total (equity &amp; liabilities)</b>	<b>162.739.098,98</b>	<b>145.667.630,96</b>



	2023	2022
Net turnover	6.804.248,55	6.797.698,87
Other operating income	90.343.051,76	81.140.226,56
Raw materials and consumables, and other external expenses	-22.436.479,25	-19.925.540,73
Raw materials and consumables	-8.596.375,17	-6.511.280,82
Other external expenses	-13.840.104,08	-13.414.259,91
Staff costs	-64.308.790,53	-57.933.144,64
Salaries and wages	-57.114.780,42	-51.203.727,06
Social security expenses	-7.078.832,78	-6.595.026,16
covering pensions	-4.432.096,11	-4.004.195,16
other social security expenses	-2.646.736,67	-2.590.831,00
Other staff costs	-115.177,33	-134.391,42
Value adjustments	-7.826.996,92	-7.419.742,73
on formation expenses, and intangible and tangible fixed assets	-7.734.903,42	-7.373.577,73
on current assets	-92.093,50	-46.165,00
Other operating expenses	-6.163.432,57	-2.962.295,39
Income from participating interests	4.802.328,70	-
Other interest and financial income	1.587.587,77	51.249,77
derived from affiliated undertakings	-	-
other interest and financial income	1.587.587,77	51.249,77
Value adjustments in respect of financial fixed assets and in respect of transferable securities held as current assets	-	-
Interest and other financial expenses	-13.076,14	-85.037,59
concerning affiliated undertakings	-	-
other interest and financial expenses	-13.076,14	-85.037,59
Profit after corporate income tax	2.788.441,37	-336.585,88
<b>Profit for the financial year</b>	<b>2.788.441,37</b>	<b>-336.585,88</b>



## IMPRESSUM

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Luxembourg Institute of Science and Technology

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