LATVIAN ACADEMY OF SCIENCES

YEARBOOK 2023

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The Latvian Academy of Sciences expresses gratitude to the Boris and Inara Teterev Foundation and Mrs. Inara Tetereva personally for her significant contribution in publishing the Yearbook of the Latvian Academy of Sciences

ZINĀTNE

Publisher ***Zinātne* Ltd**
Registration No. 40003576967

Printed at *ADverts*

ISBN 978-9934-599-45-3

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SCIENTIARUM
LATVIENSIS

IVARS KALVIŅŠ
PRESIDENT OF THE LATVIAN ACADEMY OF SCIENCES

THE LATVIAN ACADEMY OF SCIENCES – A CATALYST FOR NATIONAL GROWTH

The Latvian Academy of Sciences (LAS), as did the entire democratic world, spent 2022 reacting to the situation of a bloody and brutal war waged by Russia in Ukraine; under these circumstances, the question has arisen of whether democracy can defend itself against attempts by an aggressor state to take away part of the territory of Ukraine by military force and subject it to Russian domination; additionally, whether democracy might take advantage of the joint efforts of Western countries to construct a safer and better world by developing cooperation in economics and trade, as well as in the fields of science and culture. Given the attitude of Russian and Belarusian scientists towards the invasion of Ukraine launched by their governments, the LAS decided to cease all cooperation with scientists from these countries, and to intensify cooperation with Ukraine, supporting its researchers with funds donated by members of the LAS. A number of individual position statements have been published and the LAS has co-signed the relevant messages issued by international Academies of Sciences; thus, we have publicly expressed, and we will continue to express our unwavering support for the heroic struggle of the Ukrainian people against the invaders and their allies, urging the governments of Latvia, and other countries, immediately to provide all necessary military and other support to the people and armed forces of Ukraine so that they can drive the invaders from Ukrainian territory and stop the genocide launched by Russia against the people of Ukraine. We are convinced that the fate of Western democracy and the future of Latvia and other countries in the Baltic region is now being decided in Ukraine. Therefore, any delay in supplying arms to Ukraine is unacceptable. More than once in the past, Russia has attacked its peaceful neighbours with military force, and only defeat on the battlefield in Ukraine can deter Russia from further pursuing its imperial ambitions.

War in the heart of Europe has had a devastating impact on the global economy, disrupting supply chains built up over decades, forcing a radical change not only in the choice of sources of energy, but also in the transition of Latvian and other Western economies to rely upon alternative sources for energy. This, of course, also impacted the involvement of the LAS in shaping national energy independence policy and promoting a green transformation. The

LAS has identified research into the production and application of alternative energy carriers as one of its development directions, establishing at the LAS the Centre of Excellence and Innovation in Smart Hydrogen Energy Science. The aim of the Centre is to coordinate the efforts of scientists and entrepreneurs in the field of hydrogen extraction and use technologies in Latvia, as well as to take part in international cooperation projects in this field.

We are pleased to be able to report that the 2022 LAS competition for the best scientific achievements in Latvia also includes among the winners a group of researchers from Riga Technical University led by Andris Šutka, Full Member of the LAS, which has developed a membrane-free technology for hydrogen extraction via electrolysis of water, paving the way for significantly cheaper industrial hydrogen extraction in smart energy applications. The development of thermochromic coatings, which allow control of the infrared transmittance of window panes, can also contribute to the green transformation in energy saving. These coatings have been developed by researchers at the Institute of Solid State Physics of the University of Latvia under the leadership of Juris Purāns, Full Member of the Latvian Academy of Sciences.

Continuing its ongoing drive to move science and economic policy towards the priority development of smart energy, the LAS has chosen sustainable energy as the main theme of the 18th Baltic Intellectual Cooperation Conference. The conference, organised by the LAS, will take place from 20 to 21 April in Riga at the LAS high-rise building and will be attended by scientists from Poland, Finland, Sweden, and other countries, in addition to representatives of the Latvian, Lithuanian, and Estonian academies of sciences. The said conference is expected to address current energy policy issues in the areas of energy extraction, storage, transmission, and use, offering recommendations to national governments on how best and most efficiently to achieve energy independence from Russia, as well as how to develop more environmentally friendly technologies for obtaining cheap energy. Senior EU energy officials and also representatives of the Latvian energy industry have confirmed their participation in this meeting. This conference is a logical continuation of work carried out by the LAS within the framework of cooperation projects with the Latvian National Committee of the World Energy Council, and with Latvenergo, including the selection of candidates for the 2022 LAS and Latvenergo Energy Award.

We are proud of the contribution of the Latvian Academy of Sciences to Higher Education and Science in Latvia, through cooperation with scientific institutions that are a part of higher education, as well as with national research institutes. Together, we have jointly ensured that Latvian higher education, science and innovation are receiving the attention of politicians and the executive branch, and we expect a significant increase in public support for this field of endeavour. One of the goals of the development strategy of the LAS is to create an innovation support platform, or "Silicon Valley", on the basis of the LAS. As a first step in this direction, the Latvian Government has handed over to the LAS the high-rise building in which it presently resides, allowing us to plan major changes of this building, transforming it into a Palace of Science, Research and Innovation, where institutions related to applied research and science management would be concentrated, and a base would be developed for science popularisation, to interest school youth in choosing to study at universities and become scientists. We hope to gain government support to transform the LAS high-rise building to be a part of the innovation ecosystem, i.e. a platform where scientists may meet innovative entrepreneurs and where the infrastructure needed for innovation is located, including an artificial intelligence centre, design offices, testing laboratories for innovative products, and certification centres.

The LAS is and will continue to be a meeting place for the most distinguished members of the intellectual elite of Latvia. Last year, five newly elected full members and six foreign members joined our family. Our hopes for the future lie with the new generation of scientists, 14 of whose most distinguished researchers were elected as corresponding members of the LAS. We are also pleased with the additional new honorary members.

The Latvian science, notwithstanding pandemics and war and economic difficulties, continues to expand in STEM fields, as well as in the humanities and social sciences. New and outstanding achieve-

ments in medicine, pharmacy, biotechnology, biology, IT, physics, technical sciences, social sciences, and humanities, as well as in other fields, give confidence that the LAS, together with its partners in higher education and other scientific institutions, will be able to ensure that education and science become the backbone of Latvia's growth and the basis for Latvia to become an equal player in the international science and education ecosystem. In order to achieve this, the LAS actively takes part in the work of international science cooperation institutions – ALLEA, EASAC, ISC, etc.

Together we are a force changing the world for the better!

Translated by **Eduards Bruno Deksnis**

BAIBA MOĻŅIKA
SECRETARY GENERAL, LATVIAN NATIONAL COMMISSION FOR UNESCO

UNESCO FOR SCIENCE AND PEACE

Since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed.
Preamble to the Constitution of UNESCO

Never before this belief, which is enshrined in the constituting document of the UN Educational, Scientific and Cultural Organisation (UNESCO), has been as important as it is now. Education, science, and culture know neither geographical nor cultural boundaries and contribute to building global peace by bridging disagreements and conflicts and showing us answers and solutions.

UNESCO focuses on implementing the 17 Sustainable Development Goals adopted by the United Nations in 2015. Aiming at reducing poverty and ensuring sustainable development of the world, these goals serve the interests of all countries across the globe and can only be reached if working together. At the same time, part of these goals largely describes also the national-level challenges and concerns, and are covered by national development planning documents as these are issues keeping the people's minds busy nowadays.

Science plays a significant role in promoting balanced and sustainable growth of the society and in studying the challenges of the modern world. Science, technologies, and innovations will be those affecting the further development of humanity, as they are key to solving modern environmental issues, like water and terrestrial resource management, and preventing risks related to climate change and catastrophes. Science must look for solutions allowing for the maintaining of biodiversity and effective use of resources, both at the same time.

The pool of resources available for the research and scientific development is limited, and this applies to all – financial means, infrastructure, and human resources. It is therefore critical to identify those research topics that are most urgent to solve in order to ensure they receive the necessary resources. Apart from scientific achievements and research results, balanced development also requires international cooperation, exchange of knowledge and engagement of the intellectual resources of the community. The resulting scientific, technological and innovation development can then have a positive impact on the environmental, economic, and social aspects.

The modern world shows an increasing need for more active interdisciplinary collaboration in research. The rapid development of science and technologies has raised the issue of ethical principles, addressing of which requires close cooperation of all branches of science.

One of the functions of UNESCO is drafting of regulatory standards providing for framework and helping member states to develop their policies for education, science and culture. In autumn 2021, UNESCO

adopted two major policy planning documents – Recommendation on the Ethics of Artificial Intelligence and Recommendation on Open Science.

The Recommendation on the Ethics of Artificial Intelligence is the first global agreement on setting ethical standards for AI, and was developed by an international group of experts that also included a representative from Latvia. The purpose of this Recommendation is to ensure that AI systems work for the benefit of humanity, people, society, environment, and ecosystems, and to prevent their potential harm.

The Recommendation on Open Science sets the principles of open science, resulting in more available scientific information, data and results and making their use more reliable. Involvement of Latvian experts in drafting the Recommendation together with the Latvian Open Science Strategy 2021–2027, which was adopted this year, proves our potential in building cooperation between scientists, policy makers and the society and in fostering the openness of the research process.

The positive impact of science and innovations on sustainable development relies not only on the results of the research activity but also on the cooperation of various organisations. Thus, in order to achieve good results, it is necessary to develop successful partnerships with international and national institutions, scientific and research institutions, the private sector and the society.

One of examples of such successful cooperation is the L'Oréal-UNESCO international programme *For Women in Science*. This programme was started in Latvia in 2005, and after the joining of Estonia and Lithuania in 2017 it has become an important and traditional annual event in the Baltic science. Research undertaken by the winners of the programme – the young scientists working in the fields of life sciences and environmental science and the branches of physical, formal, technological and engineering science – introduce us to specific scientific discoveries that are gradually becoming part of our everyday thus improving our standard of living. Such initiatives and programmes also help us pay attention to science and promotes our awareness about the research processes.

This cooperation of L'OREAL, the Latvian, Lithuanian, and Estonian Academies of Science, and the National Commissions for UNESCO is an excellent example of how joint action gives way to ever-present awareness of and interest about the activities and achievements in science and ensures regular and sustainable support to and belief in scientists and researchers and the overall scientific development.

VALÉRY GAUCHERAND
CEO AT L'ORÉAL POLAND&BALTIC, L'OREAL

THE WORLD NEEDS SCIENCE, AND SCIENCE NEEDS WOMEN

Humanity is facing huge challenges. Science is part of the solution. Contributing to making women scientist visible and supporting them to reduce inequalities in the world of research is the objective of the For Women in Science programme. Today, in the world of science, having a talent is sometimes still not enough for women to fully express their potential and be recognised for their true value. Too many historical obstacles – cultural, academic, or institutional – affect their choices, impact their careers, and minimise their contribution. Yet despite the constraints, there are many women who strive to be at the forefront of fundamental, often vital, contributions. For Women in Science Young Talent laureates are demonstrating that scientific progress will not be made without them, and we must lose no time in recognising and promoting science and them. Especially at current times when amid multi-layered and compounding crises, the progress towards gender parity, as Global Gender Gap Report 2022 by the World Economic Forum states, is stalling. In this context, accelerating parity must be a core part of the public and private agenda. Collective, coordinated, and comprehensive action is needed to create sustained improvements.

L´Oréal Foundation and UNESCO have been leading it for nearly 25 years. Our programme was a pioneer in 1998. It made focus on equality between men and women long before gender equality issue was in the news. Today I am convinced its role goes far beyond that. The For Women in Science programme does justice to the greatest women researchers of our times – we make them known to a large number of people because the voices of women scientists are too often silenced. We give them a platform because some territories remain closed to equality. As a proof, globally in nearly 110 countries close to 4000 profiles have been highlighted and supported. We will continue to deliver this cause, with the exemplary and precious support of the Latvian Academy of Sciences and National Commission for UNESCO. Our partnership has been a key factor for success

during all these years. We share the same values and drive to succeed, and we are thankful and honoured to continue these commitments in the future.

I started to work in Poland Baltic region beginning of 2022 and with admiration I have learned how much has been done, how strong the programme L´Oréal-UNESCO For Women in Science Young Talents (FWIS) Programme stands here. I have been proud to hear about the programme history and development in Latvia where since its start as early as in 2005 already thanks to great initiative of the programme patroness in Latvia, Vaira Vīķe-Freiberga, academician, PhD, President of the Republic of Latvia (1999–2007). In Latvia already 54 talented scientists have been awarded and we can see examples of strong scientific career – many of our young talents have become members of academies of sciences, professors, leading researchers, and opinion leaders. We can see that the programme is giving more confidence, recognition, and possibilities to women scientists. And they have become strong supervisors and mentors themselves to young scholars and students.

I would like to express my gratitude to our programme jury – Latvian Science Academy Members – for their efforts and expertise in analysing and evaluating the applications submitted by our candidates. With continuous strong leadership of the President of the Academy, academician Ivars Kalviņš, earlier dedication by academician Ojārs Spārītis, and thanks to strong Jury and programme foundation developed by the late academician Jānis Stradiņš, we are confident that For Women in Science support is well targeted in Latvia.

I would like to say a special thank you to the Program Honorary Patroness Academician Dr. Vaira Vīķe-Freiberga. Because of her great initiative 18 years ago, we are in Latvia together supporting our talented scientists and learning their successes.

I hope that the story of our talents will travel to schools and universities to inform and inspire and help making choice. The world needs science, and science needs women.

ILZE TRAPENCIERE, HEAD, INTERNATIONAL DEPT., LATVIAN ACADEMY OF SCIENCES

MODRIS GREITĀNS, PHD, INTERNATIONAL SECRETARY, LATVIAN ACADEMY OF SCIENCES

BAIBA RIVŽA, PHD, GENERAL SECRETARY, LATVIAN ACADEMY OF SCIENCES

ANDRIS ŠTERNBERGS, PHD, VICE-PRESIDENT, LATVIAN ACADEMY OF SCIENCES

Various aspects of energy will be discussed: fossil energy – natural gas, oil; renewables – hydro, geothermal, photovoltaics – solar, hybrid tandem solar cells, fuel cells, wind, waves, piezo, tribo, bioenergy, biofuel, CO_2 conversion; thermoelectric, thin film batteries for medical implants; nuclear – nuclear power plants, modular reactors, fusion, etc.

There will be a plenary session, three sections, and a meeting of the Presidents of the participating academies of sciences. The sessions are:

Energy harvesting and sources;

Energy storage, transmission and secure energy supply;

Efficient and sustainable energy use.

In total, nine or more hours of lectures and discussions – accessible to general public – are expected to be delivered by the top researchers in the Baltics, Finland, and Hamburg Academy of Sciences.

PROGRAMME OF THE 18TH BALTIC CONFERENCE ON INTELLECTUAL COOPERATION

20 April 2023, Introduction, welcome			
by the Presidents of the participating Academies of Sciences, I. Kalviņš, J. Banys, T. Soomere, M. Gyllenberg, E. Kreuzer, Executive Vice-president, European Commission V. Dombrovskis (TBC), ministerial representatives from Latvia			
20 April, Plenary session			
WILLIAM GILLETT	EASAC	Director of Energy Programme	Science-based advice on policies to reduce greenhouse gas emissions from the EU energy sector to net zero by 2050
PETER LUND	FI	Professor, Aalto University	Deep decarbonisation of energy systems through advanced systems solutions
JAREK KURNITSKI	EE	Tenured Full Professor, Tallinn University of Technology, Aalto University, Adjunct Professor	Towards zero-emission building stock
ALGIRDAS KALIATKA	LT	Chief Research Associate, Lithuanian Energy Institute	Research in Lithuanian Energy Institute for the Energy Sector Development
ANDRIS PIEBALGS	LV	Professor, European University, ex-Commissioner of Energy	Are pipelines and ships an 'either or' infrastructure decision for Europe's hydrogen economy?
DISCUSSION			

THE 18TH BALTIC CONFERENCE ON INTELLECTUAL COOPERATION "ENERGY FOR THE FUTURE SOCIETY"

20–21 APRIL 2023, LATVIAN ACADEMY OF SCIENCES

20 April, Session No. 1			
GEDIMINAS STANKŪNAS	LT	Chief Research Associate, Lithuanian Energy Institute	How close are we to obtaining nuclear fusion's "limitless" energy?
MAARJA GROSSBERG-KUUSK	EE	Tenured Full Professor, Tallinn University of Technology, School of Engineering, Department of Materials and Environmental Technology, Estonian Young Academy of Sciences, President	Development of next generation photovoltaic technologies in Estonia
ANDRIS ŠTERNBERGS	LV	Institute of Solid State Physics, University of Latvia	Challenging scientific issues for sustainable future energetics risen by the energy crisis

21 April, Session No. 2			
DETLEF SCHULZ	DE	Prof. Dr. ing. habil. Helmut Schmidt University, Department of Electrical Power Systems	Hydrogen for the Northern German Energy System – diversity of challenges and interdisciplinary assessment
ANNA MUTULE	LV	*Dr. sc. ing.*, Professor, Head of Smart Grid Research Centre, Institute of Physical Energetics	The evolution towards smart grids: drivers and potential impacts
ANDRIS ŠUTKA	LV	Riga Technical University	Innovative amphoteric decoupled water electrolysis – a simple concept to split water and produce H2 with high efficiency in a cheap and safe way
ENN LUST	EE	Professor of Physical Chemistry, University of Tartu	Development of hydrogen and fuel cell technologies in Estonia

21 April, Session No. 3			
MIKAEL COLLAN	FI	VATT Institute for Economic Research	The Finnish price of electricity transfer dilemma – pricing driven by the regulation model
VIDAS LEKAVIČIUS	LT	Chief Research Associate Lithuanian Energy Institute	Energy poverty in the Baltic States
MODRIS GREITĀNS	LV	Managing Director, Institute of Electronics and Computer Sciences	Energy efficiency: artifical versus human intelligence
RALFAS LUKOŠEVIČIUS	LT	Director of LtD. Addeco	Development of the biomethane sector in Lithuania
DMITRI VINNIKOV	EE	Research Professor, Tallinn University of Technology, Riga Technical University, Visiting Professor, Estonian Academy of Sciences, Member	

SHORT HISTORY OF THE BALTIC CONFERENCES ON INTELLECTUAL COOPERATION

The tradition of holding the Baltic Conferences on Intellectual Cooperation dates back to the 1920s and afterwards. Conferences were organised by the Institute of Intellectual Cooperation (Paris) at the League of Nations. Estonia, Latvia, Lithuania, and Finland, regularly participated at the Conferences, and occasionally also Sweden and Denmark attended. During the1930s, six Conferences on Intellectual Cooperation were held.

The first conference took place in 1935 in Kaunas, Lithuania, then in 1936 – Tartu, in 1937 – Helsinki, in 1938 – Riga, and in 1939 in Kaunas. The last pre-war conference was convened in Tallinn on 15–17 June 1940, in conjunction with the Baltic Week. However, the deliberations were interrupted by the USSR aggression against the Baltic States.

Almost 60 years later, the pre-war tradition was continued – the seventh Baltic Conference on Intellectual Co-operation was organised in Riga in 1999, convened by the Latvian Academy of Sciences. History and the future prospects of mutual cooperation of the Baltic states was discussed, with particular focus on the protection of intellectual values and science. Since then, 11 conferences have been organised by the Baltic and Finnish partner academies on various topics. Conferences always offer a forum for science policy discussion.

MORE ABOUT THE BALTIC INTELLECTUAL COOPERATION CONFERENCES

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SCIENCE NEEDS PEACE

NATO, EU, AND BALTICS DEFENCE PRIORITIES ON THE BACKGROUND OF THE LONG-TERM CONFLICT BETWEEN RUSSIA AND UKRAINE

RAIMONDS BERGMANIS
Member of the 14th Saeima, chairman of Defence, Internal Affairs and Corruption Prevention Committee

24 February 2014 was the forerunner of the brutal invasion of the Russian army in Ukraine that eight years later, on 24 February 2022, split the Western world into two fronts, creating the greatest security crisis in the European continent since the end of the Second World War.

For almost a decade, the West, including Europe and even the Baltic, were not brave enough to recognise the seriousness of Russia's geopolitical interests already observed throughout all this time. Now comes a time when we are forced to improve the focus of our security and defence. Recently identified risks and threats have been changed back to cold war when military threats are back on top.

Now the unwavering unity of the partners in helping Ukraine has been observed. Meanwhile, the North Atlantic Treaty Organization (NATO) and European Union (EU) member states are strengthening their military capabilities, increasing budget costs secured for defence and discussing if Article 5 of the Treaty once shall become reality.

The security perspective of the Baltic and Europe in the conditions of the Ukrainian war, which also directly affects the security situation of Latvia, can be evaluated in the context of the position and active action of Allies, of our strategic partners NATO. It is essential to be aware that the Alliance will focus on what it does best – providing 360-degree protection of its members from WWD, conventional and hybrid attacks, requiring Allies to deal with several crises simultaneously [1]. Collective approach is a way to provide coordinated military planning and capability development. Hence, very serious attention to home tasks must be paid in each country.

Considering the abovementioned, this article will analyse a few aspects directly affecting the Baltic and European defence situation – politics and finance. The author notes that the mentioned ones should be considered as one of basic.

POLITICS

NATO Parliamentary Assembly points out the fact that not only military aspects are at the core of defence. The strategic concept states that defence can only be effective if backed up by robust societal resilience. Recently, in Madrid summit (2022) NATO strongly states that we stand together in unity and solidarity and reaffirm the enduring transatlantic bond between our nations. Our commitment to the Washington Treaty, including Article 5, is iron-clad [2]. Covering extra-large geographic area in North Europe, membership of Sweden and Finland in NATO would signify increase of defence conditions in the Baltic Sea region, and the Baltic States. In 2023, the approaching elections in Turkey would play a significant role in the process of enlarging the number of NATO allies. Nevertheless, there is still hope that at the end of the day Turkey would show confident support to Western values including the peace and democracy and through its activities will improve the strength of NATO.

Strengthening EU–NATO cooperation, in July 2018 the President of the European Council, the Presi-

dent of the European Commission, and the NATO Secretary General signed new Joint Declaration improving the NATO–EU strategic partnership.

The Declaration from 2018 states that the NATO and the European Union are strengthening cooperation in a range of areas, including military mobility, counter-terrorism, resilience to chemical, biological, radiological and nuclear-related risks, and promoting the women, peace, and security agenda [3]. Today the type of risks and weapons to be considered have been changed.

Empowering EU member states to speak in the language of power, through Strategic Compass for Security and Defence, Member States agree on a common strategic vision for the EU's role in security and defence and commit to a set of concrete and wide-ranging objectives to achieve these goals in the coming 5–10 years [4]. The document strengthens our security and defence. Being ambitious, but achievable with sustained political commitment, the Compass provides the **strategic perspective** and details the tools and initiatives required to ensure more rapid, decisive, and robust EU action.

The Security and Defence Committee of the Baltic Parliamentary Assembly, chaired by Latvia, has set as one of the priorities strengthening of the Baltic cooperation in border control and in civil protection [5]. Parliamentarians admit that the Baltic sates need to support Ukraine in joining the EU on a fast track, think about a Marshall Plan for Ukraine, and strategically discuss Russia after the war. It also became increasingly evident that the Baltic states need to be very active in explaining to other Western countries how they could support Ukraine better [6]. The Baltic states are in a unified security policy framework, which requires to fulfil relevant obligations from the other side and carry out home tasks with the highest responsibility.

Terrorism threatens the stability of many countries and continues to challenge national security systems worldwide. Interdependence remains important but it is increasingly conflictual and soft power weaponised: vaccines, data, and technology standards are all instruments of political competition. [7]. The war in Ukraine proved that military actions involving conventional weapons back the threats. The situation requires an even more careful and systematised approach of the member states reviewing the priorities and budget expenditures in favour of defence.

Following the 4th industrial revolution and technological development, the Western society considered threats accordingly. However, in fact we see brutal conventional war against Ukraine and its civilians where scenes in battlefield might look like those of the Second World War. War is always war, but it is disappointing to see that the progress of civilization and knowledge gained in the past 100 years have not been considered. Accordingly, the lessons, even the negative ones, have not been learned. Intelligence must speak in the language of primitivism to be understood.

FINANCE

Allies significantly increase expenditures for defence and international society joins sanctions against Russia and Belorussia with the aim to **weaken Russia's economic base**, depriving it of critical technologies and markets and significantly curtailing its ability to wage war [8].

Already in 2006, NATO Defence Ministers agreed to commit a minimum of 2% of their Gross Domestic Product (GDP) to defence spending to continue to ensure the Alliance's military readiness [9]. The members of the NATO pledged in 2014 to increase their defence spending to 2 percent of their gross domestic products by 2024 [10]. Since then, the part of annual GDP allocated for defence by allies has increased significantly. (Fig. 1)

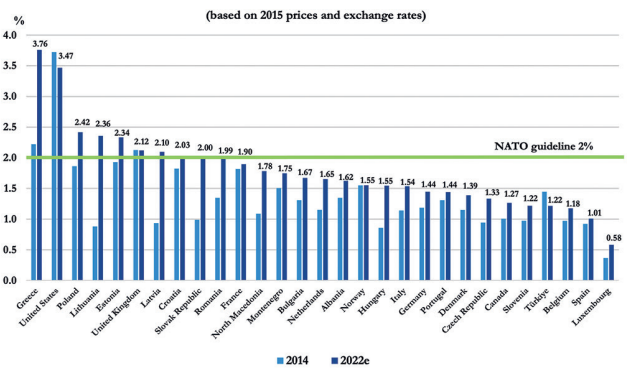

Fig. 1. Defence expenditure as a share of GDP (%) (based on 2015 prices and exchange rates) [11]
Note: Figures for 2021 and 2022 are estimates

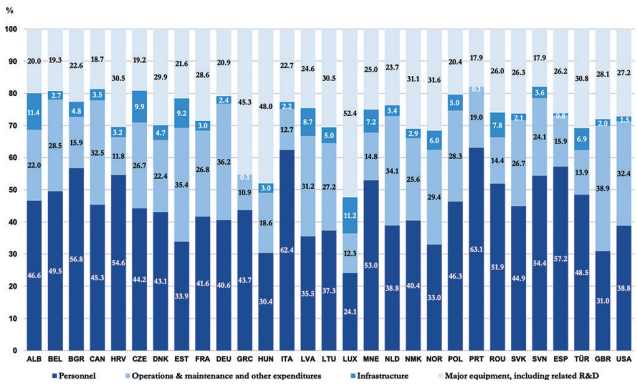

Fig. 2. Main categories of defence expenditure (%) (percentage of total defence expenditure), 2022 [11]

Raimonds Bergmanis and NATO Secretary General Mr Jens Stoltenberg

Only nine out of all NATO allies have achieved the planned in 2022: Greece (3.76%), USA (3.47%), Poland (2.42%), Lithuania (2.36%), Estonia (2.34%), United Kingdom (2.12%) Latvia (2.1%), Croatia (2.03%), and Slovakia (2.00%) [11].

NATO Parliamentary Assembly states that all European Allies need to step up and ensure the allocation of adequate resources both for the upgraded presence in Central and Eastern Europe and for the new Force Model [11].

Considering the differences in absolute numbers of GDP of member states and their different defence policies, in general, the amount of defence spending has increased significantly since 2014 with a rapidly growing trend. It still leaves space for the countries to develop their own defence priorities based on the international situation. For instance, mandatory military services, prioritising the aims of infrastructure modernisation or human resources.

Differences are observed in proportion that allies spend for needs for personnel, maintenance, infrastructure, and equipment. (Fig. 2)

The structure of defence budget expenditures of the Baltic States in 2022 (forecast) is similar for personnel expenditures for Latvia, Lithuania, and Estonia, spending 35.5%, 37.3%, and 33.9%, respectively, while for infrastructure they are 8.7%, 5.0%, and 9.2%, respectively, while 24.6%, 30.5%, and 21.6% are expected for the purchase of equipment, respectively.

CONCLUSION

Defence of states largely depends on the defence strategies adopted by alliances, which means the impact of globalisation processes also in this field. Security is expensive, but it is impossible to save on it. Despite that the priorities of expenditures of the allies may vary, the main aims shall strongly focus on peace and defence.

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STRENGTH OF LATVIA FOR THE LONG-TERM DEVELOPMENT

BAIBA RIVŽA
Dr. habil. oec., Latvia University of Life Sciences and Technologies, Full Member of the Latvian Academy of Sciences
ANDRA ZVIRBULE
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Nowadays national economies have numerous challenges, and long-term development should focus on sustainability. The sustainability of Latvia and the potential solutions in the fields which scientists from the Latvian Academy of Sciences and Latvia University of Life Sciences and Technologies (LBTU) worked on: the knowledge economy; digitalisation of small and medium enterprises; employment; the bioeconomy and the circular economy as elements of a green economy; education and digital competences. Several approaches are applied to design national strategies, in which sustainability is mainly focused on systematically balancing the interaction between environmental and social aspects. Boundary conditions for development shift from an unsustainable to a sustainable vision (assuming that sustainability is driven by innovation, participation and cooperation). A map of the interaction between ecological and societal processes could be created by summarising the different scenarios and definitions of concepts. (Fig. 1)

As shown in Figure 1, socio-economic development is focused on social equality and includes important trends in human well-being. At the same time, environmental and climate change are more important for the development and implementation of global sustainability strategies. The mapping outlines several ways of advancing the discourse on the sustainability strategy. Besides, the approach applied in this case does not consider aspects and views related to an unsustainable approach to dealing with environmental or socio-economic problems. The map shows three widely accepted views on the changes needed in political and economic entities and human-nature relationships to achieve sustainable development, and how to achieve this in current entities.
In our research the main purpose of the analysis was: to determine the readiness of Latvia and the most important priority for sustainable development, which was digital transformation; value orientation of the society; sustainability of education; the Green Deal (incl. the bioeconomy, the circular

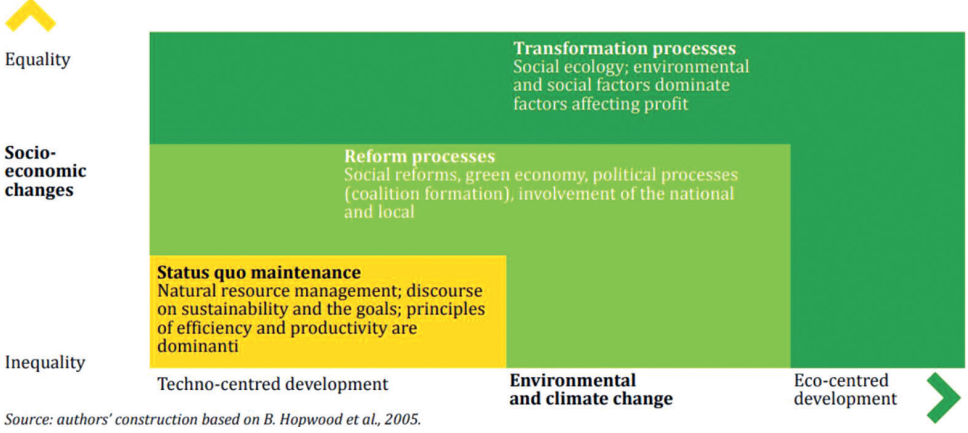


Fig. 1
Interaction between the environment, climate change and societal processes

economy); economic restructuring. For the research, we use an Analytic Hierarchy Process (AHP) and the Analytical Network Process (ANP) method to examine the experts' opinions and the interaction with other external factors that could affect the identified priorities (Fig. 2).

After summarising expert opinions to determine the most important development priority in relation to the main goal – the readiness of Latvia for and the most appropriate priority of sustainable development, it could be concluded that, according to the experts, the most important priority was economic restructuring (average rating 0.31) and the sustainability of education (average rating 0.28) (Fig. 3). The other alternatives – digital transformation (average rating 0.18) and the value orientation of the society (average rating 0.14) – were also relatively highly rated, and there was a relatively high level of expert consensus on the two alternatives, as the variance was less than 10%.

Arranging the average ratings by all the experts in relation to the main goal in a hierarchy allows for an overall arrangement of both the factors and potential scenarios. The key factors influencing the achievement of the main goal – the readiness of Latvia for and the most appropriate priority of sustainable development – were labour market involvement in the build-up of digital skills and an increase in the role of lifelong learning, whereas the least important factor was the impact of climate change adaptation on regional development. Such a result basically confirms previous research findings both in the context of digitalisation and in the field of lifelong learning and societal development. However, this does not mean that the other factors are irrelevant, especially if they are rated, for example, in a different context and based on other, more complex research studies. The ratings by the experts revealed that achieving the main goal – the readiness of Latvia for and the most appropriate

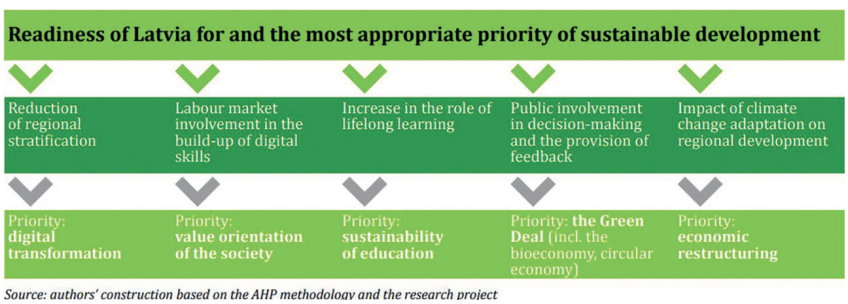


Fig. 2
Hierarchy for the goal set: the readiness of Latvia for and the most appropriate priority of sustainable development, depending on the factors and alternatives

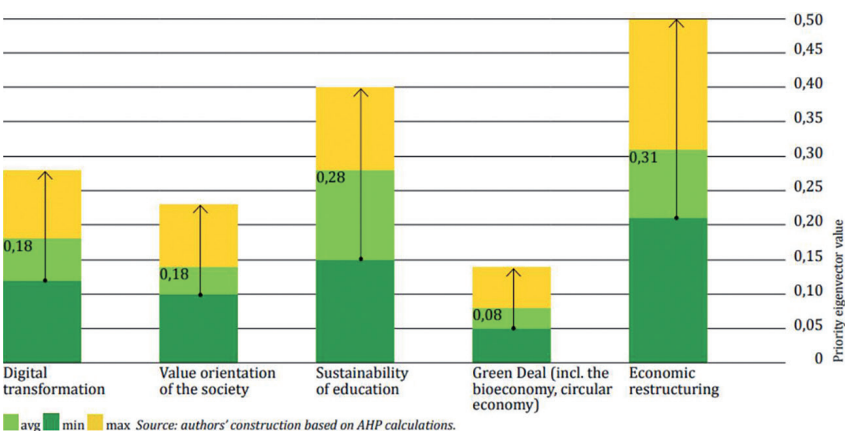


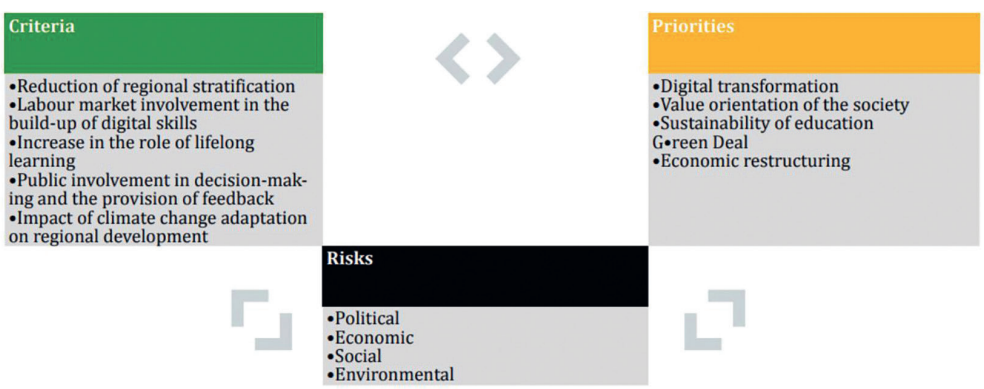
Fig. 3
Expert ratings of all the potential priorities regarding the main goal, including minimum and maximum priority eigenvector values

Discussion at the Latgale Congress on the possibilities of the knowledge economy in the Latgale region

priority of sustainable development – requires economic restructuring and the sustainability of education. Economic restructuring and the sustainability of education as potential priorities aimed at achieving the main goal – the readiness of Latvia for and the most appropriate priority of sustainable development – were rated higher by the experts, whereas the lowest rating was given to the Green Deal.

The calculations performed using the AHP method showed that higher ratings were given to the following criteria: public involvement in decision-making and the provision of feedback, increase in the role of lifelong learning and reduction of regional stratification. The lowest rating was given to the criterion of the impact of climate change adaptation on regional development. The ANP analysis revealed that the ratings of the sustainability of education and economic restructuring were high, whereas the Green Deal was rated low (Fig. 4). A comparison of the results with those obtained by the AHP methods revealed that there was no significant difference, and the ratings of priorities due to the different opinions of the experts changed only slightly. The ANP analysis identified political and economic risks that could significantly influence the identified priorities of sustainable development in the future. This is indicated by the current significant increase in energy prices and problems with the implementation of Green Deal initiatives.

From our results of the study, several recommendations for state and regional development are provided. All research results and achievements within the project Challenges for the Latvian State and Society and the Solutions in International Context (Interframe-LV), implemented under the guidance of the Latvian Academy of Sciences (LAS), under the national research programme Latvian Heritage and Future Challenges for the Sustainability of the State (2018–2022), are summarised in the monograph. The collective scientific monograph has been produced by an inter-institutional and interdisciplinary team of researchers. The leading institution of the project was the Latvian Academy of Sciences (LAS), while its partners were the University of Latvia (LU), Latvia University of Life Sciences and Technologies (LBTU) and Rīga Stradiņš University (RSU) which involved researchers from other research institutions, mostly regional – Ventspils University of Applied Sciences, Vidzeme University of Applied Sciences, Rēzekne Academy of Technology, Liepāja University.



Source: authors' construction based on the ANP methodology.

Fig. 4
ANP scheme including all groups of criteria, priorities and external factors or risks

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PARADOXICAL DISCOURSE OF THE ETHICS OF WAR

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The ethics of war can be seen as an oxymoron, i.e. a juxtaposition of two incompatible concepts. An oxymoron, as we know, is useful in rhetoric and in the creation of poetic texts. What about the use of two incompatible concepts in the context of social reality? Is it possible to talk about morally harsh military conflicts involving killing, destruction, and violence? Why pay attention to the ethics of war, while understanding that war – be it the war in Afghanistan, in Iraq, or the brutal attack by Russia on Ukraine – cannot be explained or stopped by ethical means?

Despite the apparent incompatibility of the concepts of war and ethics, it must be acknowledged that a discourse does exist on the ethics of war. The numerous studies on the ethics of war in contemporary political science, philosophy, theology, published in the *Journal on Military Ethics*, refer to countless works of literature, film, and art create and sustain a living discourse on the permissibility, or the condemnation of brute force and violence, exposing the misery and injustice of military intervention, protesting against it, and, at the same time, justifying the noble and just moral right to resist aggression by any means, including military means. The moral evaluation of war is further exacerbated by the reality of wars experienced in the 21st century, including the most recent conflict, Russian military aggression against Ukraine that began on 24 February 2022. The terrible reality of the bloody invasion by Russia, which was and continues to be widely communicated to the world to an unprecedented extent by means of modern communication technologies, revealing human suffering, vulnerability, misery of refugees, destruction and death calls for a legal, political, and ethical assessment. The reality of war has revealed unprecedented courage, heroism, resilience, compassion and solidarity, which remind us of our humanity and supports our resistance to barbarism in the name of justice.

The task and purpose of ethics is to recognise evil, aggression, barbarism, and brutal chaos, in order to distinguish between what is reasonable and fruitful, so as to circumscribe the extent of what is evil. The essence of ethics comprises two parts: the visionary part, the ideal-forming part, and the regulatory part. Since antiquity, the notion of the absolute has been developed and the concept historically been refined with recourse to the philosophy created by Plato (429–347 BC). That what is good co-exists alongside what is true and beautiful is included in this philosophy. The absolute is not fully attainable, but there is a fundamental moral transformation along the way. For centuries, ethics has constructed and spoken of the project of an ideal life – a full and just life imbued with solidarity. The ethics of Aristotle (384–322 BC) affirms the role of virtue in building a rational and happy life. The ethics proposed by Immanuel Kant (1724–1804) developed the categorical imperative, with the demand to act in such a way that the motive for action can at the same time also serve as a general principle. In addition to the ideal, practical normative rules have been developed which today have in turn taken on a regulatory function of moral development, supervision, and control. These are part of the maintenance of social order by reconciling particular interests (of individuals, states, and communities) with the desires and needs of others.

Questions about the role of ethics in assessing war, with a view to reducing brutality and prolonging peace, are regularly met with both sceptical and affirmative responses. On the one hand, the truth enunciated by the ancient historian Thucydides,

truth about the unconditional dominance of the more powerful over the less powerful is still current today. The clash of power and forces is vividly revealed in Aesop's (c. 620–564 BC) fable of the meeting of a hungry wolf and an innocent lamb by a river, which ends with the powerless one, the lamb, being condemned at breakfast. Political and military reality dictate scepticism. On the other hand, there is a long-standing separate assessment of the justice of military conflict, demanding that the parties involved be held accountable for starting a war, and for the crimes and abuses of waging war. Nowadays, military conflict is assessed and regulated in accordance with the legal obligations of international relations and UN documents. Moral standards play an important role in shaping public attitudes and sentiments. Ethics is seen as a kind of contract, adopted as a result of the historical experience of the coexistence between states and between people, and its discourse – visionary and normative – is applied to the ideology and reality of war.

In 1945, immediately after the end of the Second World War, emotional contemplation of the evils and devastation of war began with the demand and hope – never again. The need for a new civilisation that would prevent the evils of total destruction in the future was raised and discussed. The Nobel Prize-winning poet and publicist Thomas Stearns Eliot (1888–1965), questioning the deleterious effect on the new civilisation of the unpredictability of events, offered the definition of culture "in a period of unparalleled destructiveness" [1, p. 11], where culture would take on the role of *an emotional stimulant* [1, p. 12]. One can also use the metaphor of a moral catalyst, ferment, or, following Poruks, a Latvian intellectual poet, be a kind of social yeast, without which no event can mature. Ethics, as an essential part of culture, would perform the function of a stimulus, a social ferment, a catalyst. After the Second World War, it was necessary to restore a sense of the value of individuals and their life, set out in documents on human dignity and human rights: the Charter of the United Nations Organisation (1945), the Universal Declaration of Human Rights (1948), and other international and nationally adopted documents on human rights. The hope and demand for human dignity was normatively enshrined by combining moral and legal norms in a single, universal declaration of human rights, justifying the continued inviolability of the right to life and fundamental freedoms.

A building in Borodyanka (a suburb of Kyiv) after the attack of Russian warplanes to the residential area
Photo by Kurt Sauter (Switzerland)

The horrific experience of vulnerability, of genocide experience endured during the Second World War, is captured in the Ethics of Otherness by the Lithuanian-born French philosopher Emmanuel Levinas. Ethics were formulated that should apply to everyone, asking them not to hurt others and to be responsible for their own actions by refraining from violence.

The ethics of war can be seen as an important stimulus or enzyme that sharpens the sense of justice, engages in action and at the same time makes a clear distinction between the morality, immorality, and amorality of war. By means of rational argumentation and emotional experience, war ethics participates in the evaluation of military conflict.

The transformative presence of ethics, or in its basic elements, is expressed in three ways: **first, in the assessment of the intentions and causes of war (*jus ad bellum*); second, in the demand for morality (*jus in bello*) in the conduct of warfare; and third, in how the end of a war comes about (terminal) and its aftermath (*jus post bellum*).**

JUS AD BELLUM

Recognising that **ethics influences attitudes towards war** and the parties involved, ethics focuses primarily on the justness/unjustness of war. What constitutes a just and unjust war? The views of Augustine (354–430) and Thomas Aquinas (1225–1274) that hold that violence for self-preservation is permissible and just, both to punish an aggressor for an unjust invasion and to restore peace, are still quoted today to define boundaries. Pacifist sentiment does not recognise violence of any kind. Today, there is sometimes an avoidance of the boundaries of just/unjust war: can war be recognised as legitimate and ethical if "should we engage in practice that kills in any given case"? [2, p. 21]. War may be hard to justify in the abstract, but in any given case an unjust attack is not hard to distinguish from just resistance in defence of the sovereignty of one's state by military means. The ideology of the attackers conceals and masks the real intentions and causes of the war, which in turn form the basis of information warfare. Paradoxically, the military aggressor justifies an external invasion precisely on moral grounds – liberation, prevention of human rights violations, self-defence or a misleadingly imagined self-defence? The impermissible violence of war against another state is prepared long before the invasion, as the fascism of Hitler and the Russian war in Ukraine today both show. T. S. Eliot presciently warned of Russian imperialism in 1948, "so that we might expect, so long as the Russian Empire holds together, to find the increasing assertion of the dominant Muscovite culture, with subordinate races surviving, not as peoples each with its own cultural pattern, but as inferior castes" [1, p. 95]. His warning came true. At the same time he expressed the hope, which turned out to be an illusion, that perhaps "the Russians have been the first modern people to practice the political direction of culture consciously, and to attack at every point the culture of any people whom they wish to dominate" [1, p. 95].

JUS IN BELLO

The regulatory role of the ethics of war is manifested in direct supervision of the conduct of war and the requirement to humanise and reduce the violent character of armed force. Ethics includes the categorical, albeit difficult to implement, requirement to protect civilian life, historical and cultural monuments and nature. The debate in the ethics of modern warfare is triggered by high-tech military technology with its precision in targeting, which supposedly allows the mitigation of neutral non-combatant casualties. The war in Ukraine proves that the ethics of war does not depend on advanced military technology, but on the ideology of warriors, on the responsibility to preserve humanity and culture even in war. The equipment itself does not protect hospitals, schools, museums and people, but, on the contrary, helps to precisely undermine infrastructure when there is total disregard for legal norms and ethics. The presence of digital technologies today increases the parallel role of information warfare. Informational mendacity, deception, unjust and unjustified incitement, justification of war crimes are subject to ethical evaluation.

Military ethics is embedded in the education and training of soldiers as preparation for life-threatening warfare. Peer de Vries links the ethics of military practice with the ethics of virtues, naming and promoting virtues such as courage, patriotism, heroism [3]. However, in war, the glory, rewards, and satisfaction of killing the enemy are, for many combatants, individually linked to guilt over the death of another human being, with severe psychological consequences. The inexorable opposition between the two roles of soldier and man is sometimes inescapable in many cases, including those involving the destruction of the enemy.

The ethics of war is shaped by many irresolvable contradictions and paradoxes, including the fact that alongside destruction, violence and suffering, war stimulates compassion, a readiness to help and save, to sacrifice and to unite in common resistance.

In Latvian folklore, there is a quatrain of folk songs that calls for pity for the war horse, because the dead soldier is mourned by his mother, but "who cries for the war mare". It is a sensibility of the highest order, whose presence reminds us of the humanity of categorically distancing and preventing war.

JUS POST BELLUM

Finally, the discourse of war ethics includes an attitude towards how war is ended. Termination theory focuses on the moral characteristics of the parties to a conflict, such as trust or distrust of one another, on which depend the duration of peace negotiations, the possibility of compromise and a fair agreement at the end. Equal in importance to the concept of a just war is the notion of a just peace, without which any treaty may be short-lived and unstable. A just peace does not only refer to cessation of violence, but develops further the requirement to agree on proportionality, reparations, guilt and punishments, "through relationships and interactions (mutual cooperation, deliberation, compromise, respect, truth" [4, p. 20]. The need to achieve a just and fair peace may prolong negotiations, but it facilitates reconciliation and contributes to the future sustainability of peace. The discourse of apology, forgiveness, admission of guilt and reparation is a complex and difficult process that is recognised as part of the end of modern wars and of sustainable peace. The ethics of the aftermath of a war also includes the post-traumatism of soldiers, where many ex-combatants are psychologically unable to overcome the horrors of war and come to terms with the aforementioned internal conflict between the duty to kill and the sanctity of another human life, leading to Post Traumatic Stress Disorder. Although the morality of action differs radically between war and peace, the legal destruction of an enemy often triggers traumatic experiences in later life [5].

CONCLUSION

The brutal reality of the Ukrainian war reveals the acute need for the 21st century to return to the ethics of war. The ethical discourse of war has been rationally deployed in academic research. However, more than research, the dilemmas and paradoxes of war ethics are revealed by the nation's traditional culture, literature, art, both with the eerie chaos of Pablo Picasso's Guernica (1937) and with Erich Maria Remarque's *All Quiet on the Western Front* (1928) and countless other masterpieces of literature, music, cinema. They evoke at once the deepest condemnation of war, together with a righteous admiration for the strength of the defence of one's country, devotion, proud yearning for freedom and the deepest compassion for the victims of war. The heroic experience of Ukraine in defending its land testifies that war may unite. The discourse of war ethics consists of condemnation and protest of inhumanity, defence of the fragility of life, and admiration for those "who know how to stand up for their freedom and independence to the end" [6, p. 370].
War ethics, like culture, plays the role of a guardian of humanity, a stimulus to humanity, an inspiring enzyme of humanity. Unfortunately, humanity has so far failed to prevent war altogether. But no war lasts forever, and the impulse to destroy must be weakened in order to continue to live in peace for as long as possible, perhaps bringing us closer to a time when the scourge of war may not be an inevitable event in human history. It is still a long way off, but ethics stimulates the expansion of the field of peace and humanity. unites and brings people together to live together on the small planet called Earth.

Translated by **Eduards Bruno Deksnis**

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LITERARY SCHOLAR MĀRA GRUDULE ON HER ACADEMIC WORK AT THE UNIVERSITY OF LATVIA

INCLUDING HER EXPERIENCE WITH YOUNG RESEARCHERS IN THE FIELD OF LATVIAN AND BALTIC GERMAN LITERARY HISTORY

Interview by academician **OJĀRS SPĀRĪTIS**

In the light of the current critical situation in the development of pedagogical science and the lack of pedagogical methodology as well as reproducible practice in higher education, academician Ojārs Spārītis interviewed Full Member of the Latvian Academy of Sciences, *Dr. philol.* Māra Grudule, professor at the University of Latvia, and Senior Researcher at the Institute of Literature, Folklore and Art. These two related areas of education and scholarly investigation rise above a narrow focus on the history of literature, in a broad way to deal with societal, cultural, art, and music issues as has been demonstrated by recent interdisciplinary research; the humanities are increasingly looking for arguments in the field of the sciences. Māra Grudule is a creative and scientifically active person with a strongly independent outlook and a profound view on life and research. We can therefore be sure that her answers will be as frank as possible, and that she will not wander between her scientific conscience and cowardly political correctness in her assessments.

How long has your teaching career been at university? This leads to a follow-up question, which requires experience. What do you see as the role and purpose of a humanities teacher?

I began lecturing at the University of Latvia (UL) while studying for my PhD, in the postgraduate programme, attending courses offered by Professor Gunārs Bibers at the then Faculty of Education. In 1990, Professor Bibers moved to the Latvian Academy of Culture and I inherited his courses; from 1998 onward, I have been working at the Faculty of Humanities, then the Faculty of Philology. I have more than 30 years of experience at the Faculty of Arts. The task of a lecturer in the humanities is much the same as for any field, to share the lecturer's knowledge with students, to assist them in their studies providing them materials and explanation of difficult issues, etc., and to reinforce their knowledge with periodic tests and examinations and, of course, to stimulate their interest in their field of research.

Māra Grudule, at the ceremony of receiving the Grand Medal of the Academy of Sciences of Latvia, 2022

What methodological and educational tools does the humanities teacher have at his/her disposal when creating a dialogue with the student audience and the individual?

The Faculty of Arts now offers, I think, a variety of methodological courses. The pandemic helped me a

lot in learning to use web-based tools, for example, MS Teams, for working with students – I acquired valuable skills in a short time and through self-study. Honestly, I have not been interested in learning other methodologies. I have learnt the most in this field myself, firstly from participating in open lectures offered by colleagues; secondly, by attending lectures and seminars abroad, in as much as my research fellowships have supported attending universities abroad. This experience has also stimulated work with students at the University of Latvia.

Quantitative and qualitative indicators hold today's academics in their grip. But their application differs between the humanities and the exact sciences. When your colleague Arnolds Klotiņš published his 679-page monograph, *Music in Post-war Stalinism. Latvian Musical Life and Creativity 1944–1953*, the preparation of which involved at least seven years of intensive research, it was awarded one (!) point based on criteria drawn up by our educational quality assessors (one point is also given to 15 authors and co-authors of research in the exact sciences for a three-page report in a Scopus-indexed collection). What are your thoughts on the objective/subjective nature of such criteria and their impact on motivation of individuals to carry out research in the humanities and the exact sciences?

This is a well-known problem that is frequently discussed. In order not to become discouraged, I do not, as far as possible, look at the points in the database of the Faculty of Sciences accorded to my publications. The effort to make the appreciation of all fields of scientific study as uniform or neutral as possible has led to a dead end, not only in evaluation of the professionalism, of for example, at the UL – at least in our field – in the curricula and descriptions of accredited courses. Unfortunately, the dialogue is inadequate between bureaucrats and experts in their fields when new regulations are drawn up. The new standardised course descriptions at the UL, for example, require references to literature that are no more than five years old, and no more than five sources. Neither requirement is enforceable if the course covers 100 years of the literary process. New theoretical reviews of Latvian literary manifestations, covering all fields (history, theory, criticism), are not published every five years. There can be no question of serious study in literary processes were the five references to encompass theory and the texts of fiction. Attempts to differentiate course descriptions for different disciplines have so far led to an impasse. At the same time, students tend to be vigilant and very much hold to the letter rather than the spirit of a course description.

The emphasis on publications in English found in compilation of various international databases has undoubtedly improved the English language skills of our scholars, strengthened international contacts, stimulated interest in European cultural and scientific contexts, and the study of theoretical literature, in addition to stimulating participation in various international projects. This cannot be underestimated. On the other hand, there is a lack of balance between the requirement to publish findings in English and the need to present these to a local audience, thereby not only informing the public about new results but also developing – and this is certainly not unimportant – the national scientific terminology. I know young Latvians who, having pursued Germanic studies in Germany, and who are investigating Baltic-related issues, but who are reluctant to present papers and publish in Latvian, knowing that they are not sufficiently fluent in Latvian scientific terminology. I am afraid that this is not only a problem for researchers in the humanities, but for young scientists in general. A stagnant scientific terminology is a serious threat to the status of Latvian as a modern and equal European language. Developing the language of science is a matter of our self-esteem.

In the years you have been working here, you have had many students who have brilliantly defended their Bachelor's, Master's and Doctoral theses. Which students are you particularly proud of? What have they received from you? Do you see in them what is called a "school" of research?

This is a painful issue. I have studied quite narrow topics: the history of Latvian literature in the 16th–18th centuries, and Baltic German literature. Previously, a whole semester was allocated to appreciation of three centuries of Latvian literary history; subsequently the number of lectures has been reduced. Currently, I have eight lectures remaining on this topic. That is, of course, more than none at all.

However, young people return home from school with very little knowledge of Latvian literary history. It is almost impossible to present, in eight lessons, the far from simple path taken by history, events in the history of writing, and Latvian texts, to work with such texts, analyse them and interpret them. Numerous facts, new names, concepts are involved. Unfortunately, we do not arrive at the point where this topic could be fascinating and worth exploring. I am sad to say that I do not hope to see any new scholars of 16th–18th century Latvian literature appearing in the near future, unless there is a radical change in university education and scholarship policies. The study of Baltic German literature, on the other hand, is bedevilled by ignorance of the German language. In my opinion, serious academic study of the Baltic region, whatever the field, is not possible in regard to the past without knowledge of German, and, given our history, when studying recent times, without knowledge of German and Russian. Unfortunately, the philology programme at the University of Latvia is designed in such a way that students are not allowed to learn extra foreign languages without incurring an additional fee. I used to be able to write a letter of support to overcome this regulation, but now this is no longer feasible.

There are a number of long-standing problems in higher education that have not been solved. At the University of Latvia, at least in our sector, the lion's share of remuneration is based on the number of lecture hours. The University is vigilant in looking for various ways of reducing the occupation of lecture halls. Now, for example, if for a course of study a certain number of students is not registered, the number of face-to-face sessions is halved, and compensation accordingly is also halved. I do not know whether students are aware of this when they enrol in a course of study. They change programmes, they drop out, and our salaries fluctuate accordingly. Often, we have had to sign in a single semester several amendments to our employment contract. In my opinion the premise is flawed, that giving students as many days off and as much free time as possible, will give them more opportunities for independent work. There ought to be a reasonable balance. Half-empty lecture schedules with few classroom hours encourages students to look for outside work, starting already with the first year of study, and most start to work in parallel with their studies. Of course, in time making money rises in importance, and they start to complain that they do not have enough time to study, and cannot prepare properly, etc. This situation arises not because there is too much to learn, but because study starts to interfere with work.

Unfortunately, students who graduated with excellent completed research findings have chosen materially more attractive jobs than PhD studies, research and lecturing at a university. The remuneration of an assistant professor and a lecturer at the Faculty of Arts cannot even be called symbolic. Most young researchers, even if they start lecturing, and are full of idealism, soon realise the considerable effort required to produce a good lecture, seminar, or a whole course of lectures, and disengage. Of course, I am proud of one of my former students, Pauls Daija with whom I continue to have fruitful discussions, but his collaboration with the UL was short-lived.

Have you ever felt helpless in front of an audience of students? This question correlates with the next one: do you feel responsible for the learning outcome?

Yes, I have felt helpless, but this feeling has never been related to insufficient knowledge of methodology. I worked for a while in three programmes at the UL, lecturing in Latvian, English, and German. I never felt that my knowledge of German was sufficient fluently to analyse texts when faced with an audience. I honestly have never thought about my responsibility in terms of the pedagogical outcome of my lectures. It may appear irresponsible, but I am clearly aware that I am working with students for most of whom the courses I teach mean only credits and nothing more. I try to work in the best possible manner, to monitor the reaction of students during lectures, to be attentive to questions both in the classroom and when replying to e-mails; I usually invite a comment on the course as a whole as part of the exam, I read students' feedback, learn from it, etc.; however, I do not believe that I should be held responsible for gaps in their acquired knowledge.

Your "lifelong themes" of research are related to the history of Old Latvian and Baltic German literature.

Contemporary reality is that only one in ten students has any grasp of the German language. Given shortcomings in modern education, what do you think is the prospect for research into the history of Latvian culture? How might students be inspired to investigate material from the past?

I believe that the only problem with evoking such interest is that the number of lectures devoted to the history of Latvian literature is too small; this doesn't allow students to get to appreciate the topic. Because there is no shortage of the truly exciting issues if one is at all interested in the past. Understanding 16th, 17th, and 18th century Latvian literature is inconceivable without knowing the cultural and historical context. In turn, there is a great variety of paths to follow for research – from everyday life to artistic phenomena and philosophical ideas – all of which will be useful and enhance interpretation of texts from the past. As with Baltic German literature and culture in general, what makes the field even more interesting is the realisation that aspects of German culture are still present in the Baltic space. I have witnessed sudden students' revelations, when seeing seeming anew, for example, the path from the main building of the University of Latvia on Rainis Boulevard to the Opera House – the thoughtfully laid out greenery and the curves of the canal, the bridges and sculptures, such as that of the married couple with the poodle on the canal side, and, finally, the building currently home to the Latvian National Opera. Baltic German literature allows us to delve even deeper into a world that seems familiar, but then beckons from a different perspective. Yes, as I mentioned earlier, unfortunately, to study these issues seriously requires knowledge of German.

It is often said that the humanities have no future in today's world without close contact with the exact sciences. What path do you recommend for a researcher in the humanities to follow in order to move closer to the exact sciences? Would this be justified in all cases?

Or should it be taken as axiomatic? I think that each researcher has to come to the idea of communication on his or her own terms, and that it depends on individual research orientation. Communication should not be imposed or declared as a precondition. The first thing that comes to mind is digital sciences, including digital humanities – as the name suggests, communication has already taken place. I am delighted that the Master's degree programme in Baltic Philology at the Faculty of Humanities of the UL includes a course on digital humanities. It is taught by high-level professionals, and the results are really evident. We have students who have produced excellent research based on these methods. Linguists, as we know, have also been working with informatics methods for many years. The choice of scientific methods, like the choice of complementary disciplines, or the choice of interactions with other scientific fields, should be left to the researchers themselves. The most important thing, in my opinion, would be to provide quality and modern education for young people, from the school bench to university. Under these conditions, they will find their own way forward. But modern education can be provided only by talented, well-paid academics who have found their posts through serious and fair competition. A job at a university should be a prestigious goal coveted by young scientists.

Translated by **Eduards Bruno Deksnis**

THE FIFTH COMMANDMENT

GINTA GERHARDE-UPENIECE
Dr. art., Latvian National Museum of Art

Imants Lancmanis (1941) is a Latvian painter, art historian, cultural administrator, and public intellectual. In Latvian society, he is a well-established authority in many fields, but mainly known as the long-serving director of the Rundāle Palace Museum (1976–2018), and Honorary Member of the Latvian Academy of Sciences.

Imants Lancmanis recovered the lost time of the past through tangible artistic testimonies, and over the years, this self-created environment became his spiritual refuge from the Soviet absurdity, greyness, and lies, which he did not believe for a single moment of his life.

The exhibition at the Latvian National Museum of Art can only outline Lancmanis' encyclopaedic knowledge in the field of the Latvian and European cultural heritage. The most important part of the exhibition, "The Art of Imants Lancmanis", is devoted to paintings. The artist has created several thematic sets of paintings, including the series "Kalēti", "The Fifth Commandment. Revolution and War", "Easter Visions", "Latvia's Oaks", "Dance of Death", and "Biblical Themes", which acknowledge the epic nature of the artist's view combined with careful development of detail.

Childhood experiences of war and the world hotspot of the war in Iraq were the reasons for his creation over three years a series of paintings "The Fifth Commandment. Revolution and War" (2006–2009). This is a group of large works (eight paintings) that invites us to reflect on two issues that determine the development of humanity: war and revolution.

THE FIFTH COMMANDMENT. REVOLUTION AND WAR

The Fifth Commandment states: Thou shalt not kill! It is one of the most frequently violated commandments. The harvest of slaughter is largest in wars and revolutions to which is dedicated a series of paintings with reflections on the First World War and the 1905 revolution in Latvia. War is the highest form of humanity's madness and is composed of Hatred, Intolerance, Cruelty and Death. There is killing on both the battlefield and behind the lines in the merciless carrying out of death sentences, where peaceful citizens discover their hidden abilities as executioners. Death and the dead may be depicted in art, not from idle curiosity but out of respect and compassion for the dead and the victims, condemnation of the evildoers.

After the war, however, there is a ripening harvest of monuments, driven by both true feelings of gratitude and national hypocrisy. A big question, however, is the possibility of the Apocalypse. Is St. John's Book of Revelation more or less believable?! And will people manage to organise their Apocalypse on their own?! Imants Lancmanis has offered the following comments on the creation of this cycle: "I watched as hundreds of thousands of soldiers died so that the viewers come to an understanding of, and above all – to condemn these deaths. I was mindful of this commandment when contemplating the theme of violence."

War is the greatest disaster that can befall us. Simultaneously, war and revolution are the greatest turning points in human history.

One of the most challenging and even frightening sections of the exhibition is the Dance of Death (2022–2023), with a plethora of characters and images in compositions that at first appear as excessively decorative, but are quite frightening when they are examined more closely. The artist himself comments: "The inevitability of death forms the ultimate part of human existence. However, life can also be violently interrupted. Murders, wars, revolutions, epidemics, and suicide can change the fate of individuals and that of entire nations. Today death has been exploited in countless films, causing viewers to become accustomed to the thrill of human death, making them forget about the evaporation of the immortal soul."

Fig. 1
Dance of Death

Fig. 2
The fourth horseman of the Apolcalypse

In one of the works, "Peasants and Soldiers in a Danse Macabre (2022)", six peasants and six soldiers dance in a forest clearing. A familiar theme in medieval Gothic art, skeletons dance with all walks of life, ranging from the Pope to simple peasants. There is a continuation of this theme in a different light – "Death at a Fair with a Suicide Tree and Collapsing Carousel" (2022). The author comments on this composition, which resonates in the spirit of the works of the Dutch Old Master Hieronymus Bosch: "It is like a continuous fair for Death wherein the clarity of people's hearts are destroyed even if they do not go to this market to buy poisons, weapons and nooses with which to kill, or to commit suicide. This fair also offers sins, vices, addictions, and the inner collapse of man."

Imants Lancmanis also knows how to surprise and intrigue us, as two empty frames draw attention to paintings, which will be on display at the close of the exhibition in February 2023. The works are currently coming into being in the creative environment of the artist, about which the artist says: "The Dance of Death in Ukraine continues, the paintings "Dance of Death III" and "Dance of Death IV" are in progress. Their final appearance may change depending on what is destined to happen in the real-life Dance of Death ongoing in Ukraine, and what the world will be like in February 2023,

Fig. 3
An assault

when these works shall take their place in the empty frames."

DANCE OF DEATH (DANSE MACABRE)

The inescapability of death forms the outer framework of human life. However, life can be interrupted by violence. Murders, wars, revolutions, epidemics, suicides are capable of altering the fate of both individuals and whole nations. These days death features in countless films, accustoming viewers to the idea that human death is a fascinating event and making them forget about the vanishing of a person's immortal soul. It is like a continuous Death Fair that undermines the clarity of people's hearts even if they don't go to the fair to buy poisons, weapons and nooses for killing or suicide. This fair also offers sins, vices, addictions and man's inner collapse.

Death is a milestone for every human being, but since the pandemic has been taking lives every day and the close-by war has been raging since 24 February 2022, people's dances with Death are becoming more frequent; they happen in reality and in the imagination. There are people who have been enlightened by death and those who have become heroes, but there are also others whose early death is passionately wished for by millions.

Translated by **Eduards Bruno Deksnis**

ENERGY

EUROPEAN ENERGY POLICY AND THE BALTICS: TACKLING MODERN CHALLENGES

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Deep changes in Europe and the world, which have generated growing tensions in politics and economics, need scientists' closer attention. The real challenge is to understand the core and essence of these changes so that national governance can manage them for the common good. Such an understanding is also required in analysing the urgent issues of European and sub-regional energy issues.

BACKGROUND

Among numerous modern challenges, including climate change and sustainability issues, one of the most urgent recent ones is that of the energy crisis, leading to dramatic changes in national priorities, increased inflation, and households' hardships. Ukraine–Russia military conflict just added new parameters in energy issues' complexities and challenges. However, with the EU efforts to mitigate the negative geopolitical effects and the member states' efforts to safeguard national energy security the perspectives look quite optimistic.

Although a specific part of the EU's political agenda concerning "energy union" exists since 2015, the whole spectrum of national and the EU-wide energy security has become so vital presently. Thus, during the last couple of years, and particularly during 2022, the EU institutions have devised, discussed with the states, and approved numerous actions and plans aimed at remedying existing (and quickly mounting) energy supply and security problems.

Among most vital EU-wide measures are: Next Generation EU programme (NGEU), the EU's Recovery and Resilience Facility (EURRF), and some others; particularly, the national recovery–resilience plans (NRRPs) including climate action measures, advised by the EU "green deal" and having serious implications for energy use, as well as sustainability and renewables in perspective national energy strategies. The narrative goes from showing new logistics' facets in the EU and the member states' national political economy followed by application of energy security issues in the national recovery and resilience plans, including the energy component in the Baltic States perspectives in gas supply and security. Besides, the article assesses the EU's trajectory in managing available and perspective renewable energy resources (such as hydrogen and off-shore wind farms, etc.), as well as the European and the Baltics States energy sovereignty through a newly adopted REPowerEU plan and other measures.

ENERGY POLICY: EU-MEMBER STATES' CONNECTIONS

This policy issue has occupied a vital place in a changing political economy's paradigm both in the EU institutions and in the member states' governance. Modern political-economy's narrative has acquired a specific set of national re-designed priorities instigated by the EU's twin transition and social inclusion, as part of a new "instrumental arsenal" in growth with long- and short-term tasks in modern sustainable agenda.

Present energy crisis can serve as an example of a clear lack of long-term thinking among governing elites – particularly in the Eastern and Central European states – in the energy sector's perspectives during last several decades. Everybody knew that the decade-old 40–50 per cent European depend-

ence on Russian oil and gas would sooner or later turn into a political weapon, which has happened already in 2014 with the annexation of Crimea… For example, Lithuanian government has shown a perfect example of an optimal logistics' usage in sustainable energy: during the last decade, it prioritised bio-fuel strategy in energy mix (with sufficient use of EU funds). Besides, it has built a LNG terminal, and hence, presently, it has been the first EU state to abandon its dependence on Russian gas import.

It has to be mentioned that the European energy policy is a shared competence between the EU institutions and member states; energy infrastructure is based on solidarity among the EU states. In achieving regional energy security, the EU states need to adapt their policies to a "common denominator" and take additional measures, whereas the Commission used a two-stage approach: pre-emptive action and the EU alert mechanism.

Many EU states decided to go for renewables, both because of the high energy prices and uncertainties of supply; others are massively buying solar panels, installing heat pumps and looking for various types of alternatives to fossil fuels.

The EU institutions are doing everything they can to diversify gas supply and improve energy security; however, the EU states have to achieve the target of 60 bcm of available gas capacity; besides, the EU is also facilitating joint purchasing of gas and hydrogen, as well as wider use of renewables.

For example, recent reforms in the EU electricity policy acquired unbalanced approach calling the EU efforts superficial and hasty; it was backed by seven states (Germany, Denmark, Estonia, Finland, Luxembourg, Latvia, and the Netherlands) suggesting more "targeted approach" in modernising the EU-wide wholesale market that does "not endanger the decarbonisation efforts and well-functioning electricity market". According to these states' plan (February 2023), "any reform … should be underpinned by an in-depth impact assessment and should not be adopted in crisis mode".

NEW REGULATORY ARSENAL

According to the new EU-wide energy-policy's instrument, the so-called REPowerEU plan, the states have to reduce Russian gas imports by eighty per cent, in 2023. Besides, for present gas vulnerability, more measures are needed: e.g., reducing consumption of gas, "solidarity approach" in energy security amid higher competition on the LNG market, and increasing gas prices. Based on the REPowerEU plan, renewable deployment is to be accelerated and there are examples of very positive moves in green energy production as the energy efficiency has become an even more important part of the member state's recovery plans.

Among the goals in the perspective European energy strategy there are two most vital ones: the first is about consumption's restrictions: every EU state should reduce the use of gas; with the reduction by the EU-wide consumption by 15% by the end of March 2023, it would be equivalent to about 45 bcm of gas saving. The EU will coordinate distribution of gas among the EU states and promote the EU Energy Savings Plan's requirements, and ask all the states to launch awareness campaigns to encourage gas-saving behaviour. The second goal encourages the EU institutions, to provide a safety net for all states according to solidarity clause; some states are more exposed than others to external gas supply, i.e. they are more vulnerable than others to potential energy disruption. Therefore, it is important that all states now contribute to the saving, storing and sharing gas market facilities with the neighbours in case of need. Along the energy solidarity, there is the EU Security of Supply Regulation that foresees some emergency instruments; thus, the EU's approach is both on voluntary cuts in usage and possible mandatory demand reductions.

The Commission's idea is to introduce more flexibility to reflect the specific situations of the states: e.g., some states do not use gas at all, and several states (Ireland, Malta, and the Baltic States) have strongly underlined their intention to reduce demand.

The EU actions are to secure alternative gas supplies: e.g., EU has reached agreements with the US, Canada, Norway, Egypt, Israel, Qatar and is cooperating with Algeria on LNG supply; additionally, the EU is exploring the options to increase LNG imports from Nigeria, which is already the fourth-biggest exporter to the EU.

During March–May 2022, the Commission adopted REPowerEU programme as a joint EU-wide action for more affordable, secure and sustainable energy. The programme was not only a "rapid response" to cut the supply of Russian fossil fuels and accelerate the deployment of the European Green Deal's plan, it was a plan to diversify gas supplies, speed up the roll-out of renewable gases and replace gas in heating and power generation. The Commission also issued a draft of regulation on "green hydrogen", providing the background for the integrated gas-hydrogen infrastructures by 2030.

At the centre of the EU's "re-power" strategy is the EU's Recovery and Resilience Facility (RRF), which provides additional EU funding for the national recovery/resilience plans (RRPs); the latter shall include in their national strategies a new chapter on "re-powering" socio-economic development.

ENERGY SITUATION IN THE BALTIC STATES

Energy independence and security has become a vital issue in the EU member states during last five years; particularly, starting with the Russian–Ukraine military conflict, the energy issues have become quite complicated. On the one hand, the Baltic States' vulnerabilities and risks posed by Russia have been well known. On the other hand, energy independence would not come without significant investment and reforms.

Among the Baltic States, Lithuania has traditionally been the most vocal on energy security; it has taken one of the first bold steps among the EU members towards natural gas independence: in 2014, it launched an LNG terminal in Klaipeda with a floating storage and re-gasification unit after unsuccessful efforts to make a common LNG co-funded by the EU. After about eight years, the Klaipeda LNG terminal remains a Baltic States facility technically capable of supplying gas to the Lithuanian market together with two other Baltic States and Finland. Finnish and Estonian networks are connected by the Balticconnector pipeline, which has been running since 2020; recently established Poland–Lithuanian gas interconnection (being operational since May 2022), also links the Baltic States with other EU countries.

Klaipeda LNG terminal allowed Lithuania to announce in spring-2022 a complete abolishment of Russian natural gas import; Estonia also announced its intention to stop imports by the end of the year. In cooperation with Finland, which already has its own LNG facilities, Estonia is launching already an LNG terminal in Paldiski. Adopting similar measures have been voiced in Latvia, too: national decision-makers agreed to stop Russian gas import by the end of 2022. However, some experts argue that complete ban of Russian gas would raise prices and could even lead to an energy crisis; presently, Latvia has stored sufficient gas amounts at Inčukalns underground storage facility. Besides, Latvian government decided in April 2022 to build by 2023–2024 its own LNG terminal either in Skulte or Rīga; the Ministry of Economic Affairs has already completed a review.

The "disentanglement" from Russia's electricity infrastructure has been also vital due to recent increase in electricity prices. The Baltic States made several successful steps lately: two interconnections were built between Estonia and Finland completed in 2006 and 2014; two more were built Lithuania and other EU states (e.g., NordBalt underwater cable connected Lithuania–Sweden electricity grids and LitPol Link connected Lithuania and Poland). The so-called Harmony Link is expected to connect Lithuania and Poland under the Baltic Sea by 2025. Already in 2018, the European Commission agreed to disconnect the three Baltic States from BRELL and synchronise them with the EU-wide electricity network by the end of 2025; the process has been both complex and costly. As soon as the electricity supply for the Baltic States is fully connected to the EU-wide electricity grid, these states should produce more electricity without using gas. However, the Latvian government ordered Latvenergo (the state electricity-supply company) to acquire two terawatt-hours of natural gas so that, in the event of disconnection, the shortage could be compensated by the thermal power plants.

The European Commission approved "coordination and solidarity" measures in gas imports, as was suggested in the REPowerEU plan adopted in May 2022, rather than having individual member states compete on the international markets and drive prices up.

Some prominent positive trends in energy reforms are evident in the Baltics: e.g., a decade-old successful energy transformation of Lithuania's central heating system, which used to be gas-dominated, now runs at 80 per cent on biofuel; great progress in this regard is in Estonia too.

With low population density in Latvia, there are great opportunities to develop wind farms and other renewable projects, both on land and at sea; it all makes economic sense as gas prices are likely to remain high in future.

In order to reduce dependency, the European Commission has set up a joint gas storage facility which is presently filled at about 90 per cent of total capacity. Besides, the EU has set up a continental Energy Platform for joint outside-purchase of needed energy resources and adopted a special REPowerEU plan. This plan's goal is to put an end to the Union's dependence on external fossil fuels as soon as possible through diversification, renewables and energy efficiency.

SUSTAINABLE ENERGY

European renewables' perspectives are concentrated, mainly, on two main sources: hydrogen and wind power. As to the use of hydrogen, it is expected to significantly increase in the coming years; most important is that hydrogen is a clean fuel that, when consumed in a fuel cell, produces only water. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass, and renewable power like solar and wind; the qualities that make it an attractive fuel option for transportation and electricity generation applications. The EU hydrogen strategy is developing along three directions: a) strong public investment to innovate and scale up; b) international cooperation in the global market for hydrogen; d) partnership with the private sector and researchers.

For the EU and the Baltic it is vital that national policy-makers, industries, and scientific community shall be "open" to new prospects to boost hydrogen agenda as part of complex green transition measures. The latter includes, e.g., deep analysis of the hydrogen's role in the EU "green deal", active measures towards so-called hydrogen economy, the complexities of the EU's "fit for 55" legislation for hydrogen's expansion, and renewed hydrogen cooperation. For example, among seven new projects worth over €1 billion to be financed from the EU's Innovation Fund four are hydrogen-related, i.e. from "green steel" production in Sweden to carbon capture in France, etc.

For example, by the end of 2025, the Netherlands will complete "green hydrogen" value chain: two electrolysers will use the needed renewable energy source, which then will power up industries, public transport, heating homes, and even could be stored underground. Besides, the EU Emissions Trading System may be extended to new type of residential and office building heating, as well as "green transport", which would provide for positive hydrogen position in numerous economic sectors hydrogen to be used in comparison to traditional electricity.

As to the Baltic perspectives in renewables, since 2008, numerous high-level groups worked to implement the Baltic Energy Market Interconnection Plan on sub-regional cooperation to fully integrate the Baltic's electricity systems with the EU states by 2025; strong EU budget financial assistance of more than €1.2 billion is available. The main part of this support is directed towards renewables; there are three pillars in the strategy: a) substantial fossil energy saving measures in all EU states: present agreed level is to save 15 per cent of energy by spring 2023; b) accumulating both a "diversified way" from imported fossil fuels to reliable/sustainable sources and filling-up the states' storages capacities; c) massive investment into renewable energy sources, i.e. clean, cheap, big, and locally produced; the EU proposed to further increase the 2030 target for renewable energy to up to 45% presently. This means a renewable energy capacity of around 1250 gigawatts by 2030, compared to about 340 gigawatts of wind and solar sources, or totally 500 gigawatts taking into account biomass.

With a recent "Baltic off-shore wind project" the EU could reach the desired goal: eight states around the Baltic Sea region have already committed in summer 2022 to increase seven time the current offshore wind capacity in the region to up to 20 gigawatts by 2030, which is already one-third of the overall EU ambition for offshore wind by 2030.

EU-WIDE COOPERATION

The benefits of regional cooperation are immense: when offshore wind turbines are connected to multiple countries, the costs are reduced, the impact on the environment is minimised, and the energy production is never wasted (it can flow towards different markets at different times). In this way, solidarity meets sustainability and security of supply; and the Commission is supporting this regional cooperation project: from planning and organising, to issuing permits and financing.

The states around the Baltic Sea agreed to accelerate wind capacity with huge investment in offshore facilities. In this regard the states agreed on three points:

First is to make a "hybrid approach" as a priority when planning interconnectors and offshore generation. Hybrid projects, which connect wind farms to several states save up to 10% of the total project costs. A great example of cross-border cooperation is the ELWIND offshore wind project between Estonia and Latvia; the Commission selected ELWIND presently as an "important cross-border project" to be eligible for EU funding.

Secondly, wind-grid network development plans shall be fast in implementation based on common offshore commitments. The Commission, with ENTSO-E facilities, will provide during September technical guidance to support this work.

Thirdly, providing political backing will accelerate the permitting process: it often represents the biggest bottlenecks; hence, it is important to fast-forward the permitting within one year.

The Baltic Sea offshore wind project will cover the energy consumption of around six million households by 2030. That is more than the number of households in Denmark, Lithuania, Latvia, and Estonia combined.

This sub-regional cooperation can incentivise using full potential of offshore wind in Europe; and the EU institutions will strongly support such initiatives: e.g., the NextGenerationEU programme makes available € 5.6 billion for the deployment of offshore and onshore wind capacities in Europe.

There is another important issue connected to the wind energy: i.e. electricity price situation in the EU, which is connected to imported gas, mainly from Russia. Besides, the negative and even devastating impact of climate change is already threatening the states' wellbeing. About 94% of the electricity price is composed of gas prices; the European emission trading system, ETS' share is only 6%. But the states have to introduce the ETS to cut CO_2 emissions because it is the CO_2 that causes climate change. Evolution of the price shows that, compared to 2021, the ETS increased by 58%, mainly because more coal is used, but gas increased by 580% – tenfold.

Thus, European climate policy is a security policy, too: the states have to invest in renewables, which are clean, cheaper, and nationally produced; it all makes the states more sovereign and independent of external supplies.

Besides, the pricing mechanisms of the electricity market shall be addressed: the EU intends to develop an emergency tool and to work for a long-term structural reform of the electricity market. However, the electricity market is no longer a functioning market because there is main part of the price-ingredient – gas import, which during the last decades was systematically destroying the stability of prices.

GEO-POLITICAL FACTORS

The biggest present issue is a modern energy crisis as it is closely connected to geopolitical factors, the cost of living and climate change, i.e. the factors dubbed presently as the "polycrisis". For example, it is scientifically proven that achieving net-zero emissions is necessary to avert a climate catastrophe. In order to meet the goals of the Paris Agreement on climate change, it will require massive and transformative action across all sectors of national socio-economic fabric, including, of course big companies and SMEs as the most vital parts of growth.

Wind and solar energy has already overtaken gas as the EU's biggest source of electricity: wind and solar combined produced over 22 percent of electricity in 2022, overtaking fossil gas, which produced 20 percent; during 2023, due to extremely warm weather, the EU's solar capacity grew by a record 24 per cent, i.e. double the previous year's growth.

The energy transition world-wide, according to the

World Economic Forum, is going to require about $2 trillion investment every year; with just $750 billion available from philanthropic capital, the states' governance and corporate entities will experience sever press in the coming years...

It is important to mention that the EU states were collectively prepared to implement long-term plans for competitive, secure and sustainable energy in a fast-changing political economy which required flexibility, capacity to adapt and change. In order to meet the EU's new energy and climate targets for 2030, the EU member states were required to establish ten-year national energy-climate plans for up to 2030.

EVOLUTION TOWARDS SMART GRIDS: DRIVERS AND POTENTIAL IMPACTS

ANNA MUTULE
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Electricity as energy carrier becomes increasingly important in the transition to a sustainable energy future. Electric power systems will undergo major changes. New resources are being connected to the grid, such as distributed storage and electric vehicles, while the share of renewable generation is growing more and more. Moreover, active customer participation is putting the consumer/prosumer at the centre of the grid equation like never before. This leads to larger and more rapid variations and less predictability in power flows, all of which have to be managed in operation to maintain sufficient security and reliability of supply. The need to accommodate these changes drives a shift from conventional to Smart Grid.

The Regulation on guidelines for trans-European energy infrastructure [1] (TEN-E Regulation) defines the smart grid as an electricity network that can integrate in a cost-efficient manner the behaviour and actions of all users connected to it, including generators, consumers and those that both generate and consume, in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety.

The key political priority in energy sector of three Baltic States is the synchronisation of our electricity grids with the continental European network by 2025. The synchronisation process is technically complex and challenging. It requires not only huge investment in reinforcement of power grids and connections between countries, but also application of the innovative solutions (such as synchronous compensators) and modern control systems to ensure system stability. Therefore, the synchronisation project could be treated as a main driver for Smart Grid development in Baltic region.

Smart Grid encompasses a variety of technologies that span the electricity system from generation through transmission and distribution to various types of electricity consumers/prosumers. Smart Grid technologies are enabled by two-way communication technologies, control systems, and computer processing. These advanced technologies include advanced sensors known as Phasor Measurement Units (PMUs) that allow operators to assess grid stability, advanced digital meters that give consumers better information and automatically report outages, relays that sense and recover from faults in the substation automatically, automated feeder switches that re-route power around problems, and batteries that store excess energy and make it available later to the grid to meet customer demand and many other.

The challenge posed by the increased use of bulk power transmission due to growing demand for electricity and proliferation of renewable energy resources (RES) often located in remote areas leads to a change from the quasi-static state of the transmission grid to a more complex and dynamic behaviour. Therefore, the current available supervision, management and control functions need to be adapted. Nowadays, one of the important enablers of the Smart Grid is the deployment of PMUs and development and application of Wide Area Monitoring System (WAMS).

PMUs measure current and voltage by amplitude and phase at selected stations of the power system (Fig. 1). The high-precision time synchronisation via Global Positioning System (GPS) allows comparing measured values (synchrophasors) from different substations far apart and drawing conclusions as to the system state and dynamic events such as power swing conditions. The communication infrastruc-

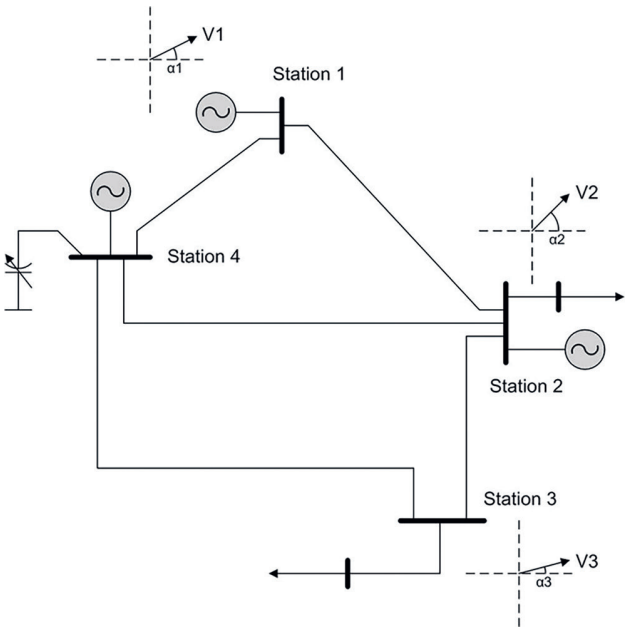

Fig. 1
Phasor Measurement Units installation in the power system [13]

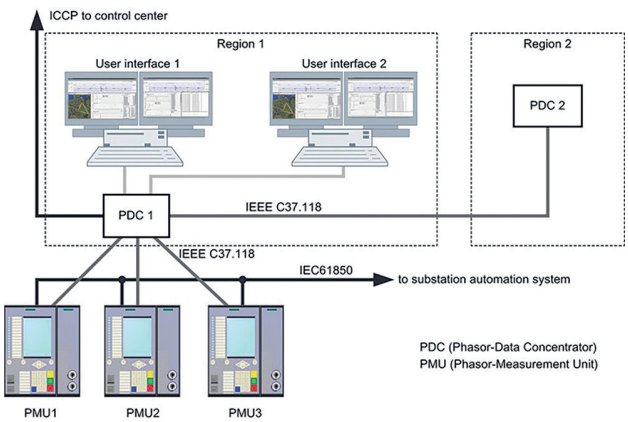

Fig. 2
Phasor measurement system architecture [13]

ture involving the PMUs, communication links, Phasor Data Concentrators (PDCs) must exist to realise the full benefits of the time-synchronised measurements. Figure 2 depicts a generally accepted architecture of the phasor measurement system.

The PMU is a direct descendant of the symmetrical component distance relay introduced in the late 1970s. The inception of the GPS in 1980s added significant features that enabled modern PMU. In 1988, Virginia Tech research team developed the first prototype PMU. Based upon the prototype PMU development at Virginia Tech, Macrodyne Co. began manufacturing PMUs as a commercial product. It also redesigned a measurement system into a real-time wide area measurement system using a data concentrator [2].

Nowadays, all major intelligent electronic device providers in the power system industry manufacture PMU commercially with various features. WAMS based on real-time data streamed from PMUs have been deployed across the world by different Transmission System Operators (TSOs) and successfully contribute to the better operation of power systems [3]. In addition, performances and applications of WAMS are continuously improving as a result of the intensive ongoing research. A lot of research is being carried out to utilise synchronised phasor measurements from PMUs to develop applications like power oscillation detection [4], power oscillation damping [5], voltage stability monitoring [6], power system protection [7], estimation of power system inertia [8], transmission line temperature and sag estimation [9], and other. PMUs and wide-area schemes open up new possibilities in power system control and protection design, including the implementation of model-based (or model-predictive) and/or adaptive controllers that previously have not been feasible or sufficiently useful. Hence, PMUs are crucial tools for the increasing transmission networks observability, and are likely be used in the future in the distribution grids as well [10].

The biggest challenge in implementing the technology is the cost of WAMS. Many researchers are trying to minimise the cost of WAMS by making the system observable with optimal placement of PMUs [11]. However, along with the cost of PMUs, the cost of installing or upgrading communication infrastructure is the most significant factor affecting WAMS deployment. Another issue that must be considered is cybersecurity that can be ensured by adding advanced security layers (algorithms) in the WAMS application architecture.

Latvian researchers (representing Institute of Physical Energetics) have gained experience in developing tools for grid operation and control with focus on PMU/WAMS by participating in international collaborative projects, specifically the STRONg^{2}rid [12]. The projects application developments covered the following areas: power oscillation damping, volt-

age stability monitoring, system state estimation including estimation of transmission line temperature, sag and losses (development of IPE), identifying cascading outages and new ICT solutions. The Smart Grid Research Centre (IPE) is constantly accumulating knowledge and expertise in other areas of intelligent networks and clean energy transition by participating in international project and self-education.

The smart grid technologies are definitely not limited to PMUs/WAMS or widely known smart meters. The Smart Grid development is a multi-dimensional task which includes application of variety of innovative technologies, tools and techniques throughout generation, transmission, distribution and consumption. Moreover, technological development goes hand in hand with changes in culture, behaviour and practice, and thus Smart Grid development is also requiring for social sciences and humanities input in research and policy approaches dealing with energy system transformation. The truly Smart Grid shall be capable of transforming the current grid to one that functions more cooperatively, responsively and organically.

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ENERGY EFFICIENCY: ARTIFICIAL VS HUMAN INTELLIGENCE

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INTRODUCTION TO AI

Nowadays artificial intelligence (AI) is one of the most commonly used terms in our daily life, in the media as well as in industry developments, but there is not really a single definition for it. In the understanding of journalists, this term is often applied to systems that are currently still pure science fiction – systems with a self-aware form. For scientists, it is more related to neural network solutions that are already working and perform high complexity tasks – object recognition, translations from different languages, autonomous driving, chatbots etc. The current "revolution" of artificial intelligence is not related to the discovery of fundamental research, but to the emerging opportunity to effectively use relatively old foundations, such as Bayesian inference (18th century) or formal neurons (1943) in combination with one of the subclasses of machine learning – deep learning.

Historically, there have been two booms in the development of AI in the 1950s–1960s and 1980s, but today's lasting boom in AI occurred in the early 2010s thanks to deep machine learning algorithms in combination with access to massive amounts of data and high-performance computing resources, largely due to the performance of graphics card processors (GPU).

Elon Musk and Bill Gates have predicted that artificial intelligence will overtake the human brain in few years. Indeed, it might seem like nothing can stop AI's triumphant march, as the amount of computing resources as well as available data continues to grow exponentially.

However, these predictions do not take into the account the fact that current models of artificial intelligence based on deep learning are staggeringly expensive, and most importantly, not only in dollars and cents, but also in terms of the energy they use.

Today's AI is not magic, but is advanced mathematics that can help machines perform some well-defined intelligence tasks better than humans. Let's take a brief look at how the deep learning model works. Their operation is not as smart as the human brain, because they do not learn information in a structured way, but are "brute force" statistical methods. For example, if you want to train a deep learning model to identify an object in an image, show it thousands of images of that object that have been labelled by humans. But the model will not be able to understand cause-and-effect, context, or analogies from the image, unless it is specially trained for each case.

The computer power used in training AI systems has rapidly exponentially increased in the era of deep learning as it is illustrated in Figure 1. As it is easy to understand, each computer operation consumes a certain amount of energy. So, for example, one popular model, GPT-3, has 175 billion machine learning parameters and it is estimated that training of this model in typical data centre consumes 1404 MWh [1]. This analysis was based on just one training session for a model which performs a variety of natural language tasks. When it comes to AI trying to approach human intelligence, the power consumption is countless times greater.

In order to reduce energy consumption, work is being done both on improving deep learning models and on how to create less energy-consuming GPUs. If we compare the energy consumption of the human brain, which is a few tens of watts to cover entire thinking ability, with a deep-learning-based AI, whose training to recognise, for example, a penguin from several million images requires several kilowatts, we see enormous difference in energy consumption.

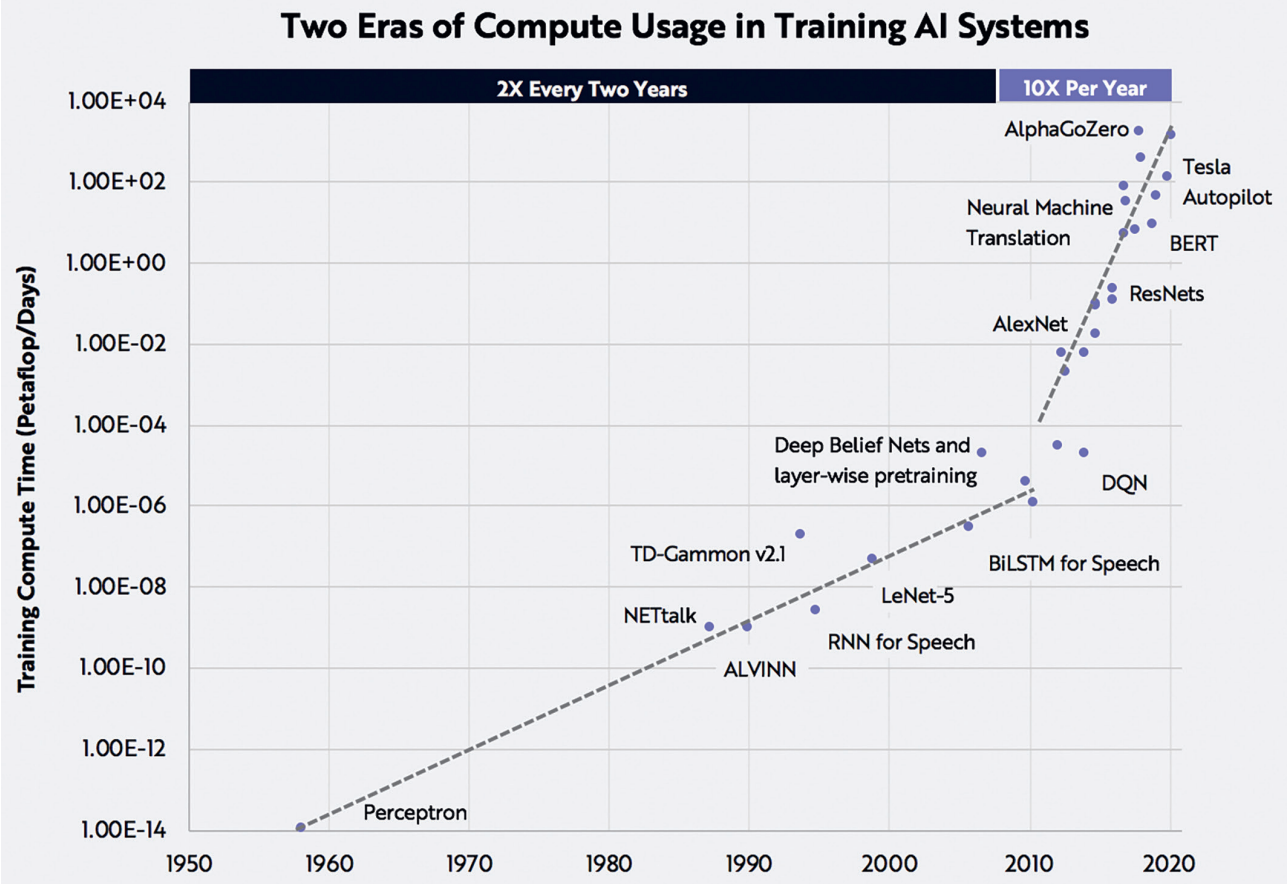

Fig. 1
Computer power used in training AI systems. (Source: https://ark-invest.com/articles/analyst-research/ai-training/)

DEVELOPING AI LIKE A BRAIN

If we could apply human intelligence-based techniques to computerised AI, there is huge potential to considerably decrease the amount of energy used for computations. The high energy requirement of brute force statistical model is due to its several significant differences from how the human brain works – AI, unlike the human brain, requires:

- millions or billions of training examples;
- many training cycles;
- retraining when presented with new information;
- many weights and lots of multiplication.

The main directions in which computer and neuroscientist research should be carried out in order to make AI more effective are related to the following aspects.

Event-driven activity and sparsity. The neural activity in the brain is event-driven and sparse, because only a small percentage (on average less than 2%) of neurons become active in response to sensory stimuli regardless of sensory modality – conversation, abstract thought, planning, etc. Similar situation is regarding the neural connectivity, because neuron receives relatively few (often less than 5%) excitatory inputs from most surrounding neurons. Thanks to this event-driven activity, the brain is incredibly power efficient, and this fact can be "translated" to neural network-based AI as the activity (activation sparsity) and connectivity (weight sparsity) of their neurons [2]. Because sparse representations have many zero elements, when both weights and activations are sparse in a neural network, it is only necessary to compute a product if it contains a non-zero element, hence a large fraction (in case of perfect brain copying ~98%) of products can be eliminated.

Structured data. The model of the world in our brain has a 3-D structure that is acquired through sensory information flows and movements. Such a model represents the location of our body in relation to the

environment, other objects and allows us to form relationships between them. It allows us to move, rotate and change things in our head. We can incorporate the concept that one object can have a relationship with another without having to see millions of instances of those objects in different relationships. In addition, we can imagine objects, for example, in different colours without having to see them in real life. Operating on structured data requires significantly smaller datasets to be trained to recognise objects in alternative views without special training for those views. Thus, the size of the training datasets, as well as the power of the training process, can be reduced by several orders of magnitude without losing accuracy.

Incremental and multi-task learning. When the human brain perceives new information, for example, sees a new object, we try to compare it with objects we already know, to find similarities and differences from known objects, from their typical features. Therefore, we learn information about the new object using effectively what it knew before. The exact mechanism how biological neuron converts incoming signals into action potentials (i.e. spikes) so far is not clear. However, it is clear that the mathematical point neuron model, consisting of a linear weighted sum of inputs followed by a non-linearity (proposed by Lapique in 1907), and which continues to be the basis for deep learning systems is simplified and provide inaccurate functionality. Biological pyramidal neurons are significantly more sophisticated and demonstrate a wide range of complex non-linear dendrite-specific integrative properties [3]. Consequently, this leads to several disadvantages. One of which is that the AI overwrites many of its connections in each learning iteration and thus quickly loses previously acquired knowledge. The second is related to the incapability of multi-tasking, which eliminate the possibility of learning to solve many tasks simultaneously. AI's inability to take advantage of incremental and multi-task learning requires significantly more training processes and significantly more iterations in each of them than a human brain, and therefore energy consumption is much higher.

Appropriative hardware. Today's available semiconductor architectures (such as GPUs) are oriented towards massive deep learning computations, where information is assumed to be always and everywhere and learning is unstructured. But if we want to develop AI that tends to operate on the principles of the brain, we need appropriate hardware that according to event-driven and sparsity principles operates with structured data and perform continuous learning. Furthermore, it must be implemented in an energy-efficient semiconductor platform. Technologies such as event-driven signal processing, compressive sensing, deep and multi-task reinforcement learning, Spiking Neural Networks, as well as System-on-Chip computing platform, which is more energy efficient than GPU, are already known and can be used as examples for the development of the new brain-like AI approach. In the long term, we can envision an architecture optimised for brain principles that strives to the performance of human intelligence and at the same time has energy consumption close to what our brain use.

CONCLUSIONS

If in the future we want artificial intelligence to approach the capabilities of the human brain while doing so with reasonable energy consumption, then we need to work on AI that works smarter, not harder. Huge improvements in power consumption can only be achieved by jointly reducing the number of computations, training samples, training passes, and at the same time creating hardware optimised for it. If we have to do 10× fewer calculations, use 10× fewer training samples, take 10× fewer training passes and that will work on 10× more efficient hardware, the overall system will be closer to how the human brain works, and also 10,000 times more efficient from a power consumption perspective!

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CHALLENGING SCIENTIFIC ISSUES FOR SUSTAINABLE FUTURE ENERGETICS RAISED BY THE ENERGY CRISIS

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Innovative research in the field of green energy is a matter of the national security; determine the relationship between energy and economic growth.

Giorgio Parisi, the Nobel Prize winner 2021 in physics, allowed us to better understand the interrelationships between various factors influencing the climate. He proved that even seemingly chaotic systems have hidden regularities that can be understood and explained, helped science to better understand the Earth's climate and its effects on humans, incl. important ongoing green energy solutions. Countries need to develop a common plan to reduce emissions to limit global warming to 1.5 degrees per decade. The period up to 2030 may become crucial.

Further concise analyse of the energy harvesting sources and technologies, of energy storage facilities and variations on efficient, sustainable, and inclusive energy use will be given, for the development of which an essential contribution of research and innovative thinking is added.

Albert Einstein, a world-renowned physicist has said that there always are opportunities and challenges in difficulties.

Solar power is one of the "green" alternatives to fossil fuels that will help our world address its energy needs. In one hour, the Sun hits the Earth with more energy than is consumed worldwide in a year. Yet harnessing this solar energy requires complex engineering solutions including both Solar Photovoltaics (Solar PV) technology and solar thermal methods such as Concentrated Solar Power (CSP).

Perovskite photovoltaics have demonstrated remarkable efficiencies, with new applications enabled by their low cost, thin film architecture, and tuneable absorption. Efficiencies are already comparable with those of silicon PV. Additionally, perovskite PV does not use toxic or rare materials, and the manufacturing is well-suited to scalable solution-based deposition methods. This gives perovskite PV an edge over the existing dominant thin film alternatives such as organics, cadmium telluride (CdTe) and copper indium gallium selenide (CIGS), among others, which suffer from expensive synthesis and material scarcity (Fig. 1).

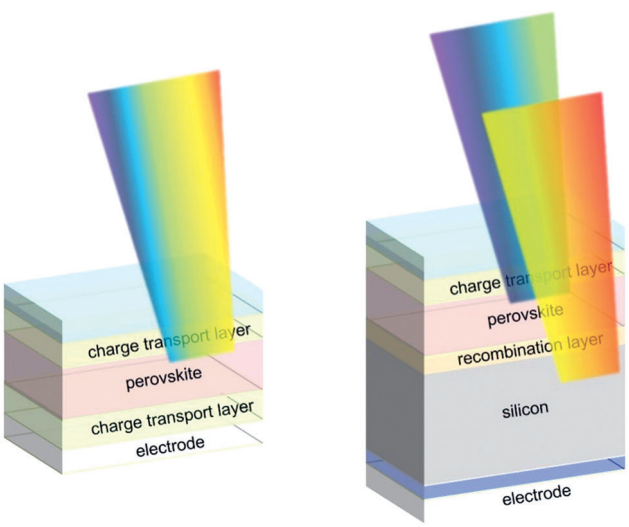

Fig. 1
Perovskite photovoltaics can be utilised in either a thin film (left) or tandem "perovskite-on-silicon" architecture, targeting applications such as indoor energy harvesting or rooftop PV, respectively. Source: IDTechEx

Despite the demonstration of high-efficiency perovskite solar cells, commercial adoption is limited by concerns over long-term stability. Perovskites are well-known to degrade following exposure

to environmental factors such as heat, air, humidity, and UV light. Encapsulation techniques and material engineering are crucial to preventing degradation of the perovskite film.

The researchers of Oxford University reduced the defects of perovskite solar cells by removing the solvent dimethyl-sulfoxide and introducing dimethyl ammonium chloride as a crystallisation agent. This allowed the team to better control the intermediate phases of the perovskite crystallisation process, leading to thin films of greater quality and enhanced stability. The new perovskite solar cells created by the team were shown to outperform the control group, demonstrating resistance to thermal, humidity, and light degradation.

University of Toronto Engineering, North-western University led group develops all-perovskite tandem solar cell with maximum efficiency of 27.4%; it is new record for single-junction silicon cell. The US National Renewable Energy Laboratory (NREL) develop novel thermophotovoltaic cell extracts light power from heat at 40% efficiency beating previous record of 32% (Fig. 2).

Researchers at Helmholtz-Zentrum Berlin (HZB) had produced a small-scale tandem cell with a record-breaking conversion efficiency of 32.5%. However, these beyond silicon record-breaking solar cell mock-ups still have to go through the technology optimisation path to commercialise.

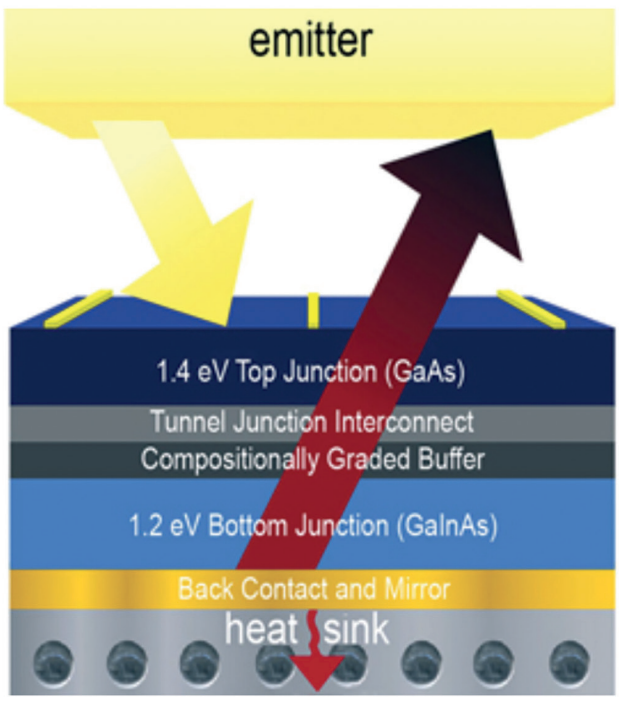

Fig. 2
Novel thermophotovoltaic cell extracts light power from heat, developed by the US National Renewable Energy Laboratory

Solar cell energy conversion efficiencies for commercially available multicrystalline Si solar cells are around 14–19 %.

The currently installed capacity of solar panels in Latvia is approximately 66 MW (mainly micro generators with a total capacity of 56 MW). In turn, the Danish company "European Energy" has announced plans to build a 110 MW solar energy park in Tārgale. Compared to her neighbours, Latvia lags far behind: according to the Latvian Renewable Energy Federation, in 2022, in Estonia the installed capacity of solar energy reached 370 MW, in Lithuania – 259 MW, while Latvia has not yet reached 100 MW.

Wind energy is mostly the use of wind turbines to generate electricity. Wind power is a popular, sustainable, renewable energy source that has a much smaller impact on the environment than fossil fuels. Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind farms have a greater visual impact on the landscape than some other power stations. Offshore wind farms deliver more energy per installed capacity with fewer fluctuations and have less visual impact. However, the construction and service of offshore wind farms is significantly more expensive, especially in Latvia's case.

In 2022 SIA "Latvijas Vēja parki", a joint venture of "AS Latvenergo" and "AS Latvijas valsts meži" was established with the goal of reaching a power of up to 800 MW, which will be almost the same electric power that is produced in Latvia's largest hydroelectric power plant Pļaviņas HEP.

Clean **hydrogen**, produced by electricity from renewable sources (e.g., wind, solar power) to split water, can be used as a feedstock, a fuel or energy carrier, or storage medium (by H_2 storage in low pressure containers). Water (H_2O) can be split into hydrogen (H_2) and oxygen (O_2) using electrolysis technology (electrolysers) as well as by photo-, and thermo-chemical water splitting.

Hydrogen is seen as a vital player in the decarbonisation of the heavy transport sector, with hydro-

gen-powered trains, trucks, locomotives and aeroplanes (e.g., Airbus – 2035 project) being deployed and developed.

For the development of hydrogen technologies, the Latvian Hydrogen Alliance was established in 2022.

A thermoelectric generator (TEG) is a solid state device that converts heat flux directly into electrical energy through a phenomenon called effect. Thermoelectric materials generate power directly from the heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity and low thermal conductivity.

A group of scientists in Latvia working on 3D printed thermoelectric generator technology developed a high-speed electromagnetic radiation sensor TESS that can characterise the shape of very short light pulses in a wide spectral range (UV-VIS-IR). It is 1000 times faster than the ones currently in use. The radiation sensor can be used, for example, in laser surgical equipment, where it will allow precise control of the applied radiation energy and thus allow more safe and efficient manipulations. (It is expected that the article about the TESS sensor will be included in this yearbook). The technology can be used, for example, in laser surgical equipment, where its use will allow precise control of the applied radiation energy and thus allow more safe and efficient manipulations. Licensing and technology transfer agreement with Thorlabs GmbH is signed.

Nuclear energy like solar cells, wind generators, hydrogen energy (including the use of H2 in fuel cells) exploitation reduces carbon dioxide emissions. **Nuclear energy** is an important pillar in electricity system, power plants are the only source of carbon-free energy that can provide stable electricity day and night at any time of the year in almost any place on the planet. In this regard "green" nuclear energy as a long-term solution for baseload capacity is proposed as a complementary low-carbon renewable energy source. Building up electricity grids on renewables will allow power systems to fully decarbonise those phasing out fossil fuel and keeping run nuclear power plants to maintain supplies either when renewable generation is interrupted. The role of nuclear energy will increase in the future. Nuclear power plants with a higher level of safety (fourth generation power plants, modular reactors) will operate there. Of course, a long-term problem remains with the storage of nuclear waste.

Interesting, that the US space agency NASA has announced a competition, who will be able to deliver the best advanced nuclear reactor to the Moon by 2030. It is planned that the reactor will produce 40 kW and will operate for at least 10 years.

An alternative for the future – towards the second half of this century is nuclear fusion – a promising and secure energy source. Fusion is the process that powers the stars themselves from widely available fuel – hydrogen and/or its isotopes deuterium and tritium.

In recent years, fusion can be described as record-breaking research.

During its five-second pulse on 21 December 2021, the Joint European Torus JET generated a spectacular 59 megajoules (MJ) of energy from fusion reactions. That is using only 0.17 mg of fuel, ten million times less than would be needed in the form of fossil fuels.

China's "artificial sun" – the EAST (Experimental Advanced Superconducting Tokamak) has set a record more than 17 minutes (1056 seconds) of burning plasma.

On 5 December 2022, an USA team at Lawrence National Laboratory's (LLNL) National Ignition Facility (NIF) conducted the first controlled fusion experiment in history to reach the milestone meaning it produced more energy from fusion that the laser energy used to drive it. LNLS's experiment surpassed the fusion threshold by delivering 2.05 MJ of energy to the target, resulting in 3.15 MJ of fusion energy output, demonstrating for the first time a most fundamental science basis for inertial fusion energy. The Latvian Fusion Research Unit is involved in theoretical modelling as well as experimental characterisation of construction and functional materials for ITER (the International Thermonuclear Experimental Reactor) is being built in Cadarache, France, using X-ray absorption spectroscopy expertise. Study of material erosion in Plasma-Facing Components (PFC) and development of powerful permanent magnet pumps for liquid metal is a unique achievement. It should be mentioned as well the development of original research methods

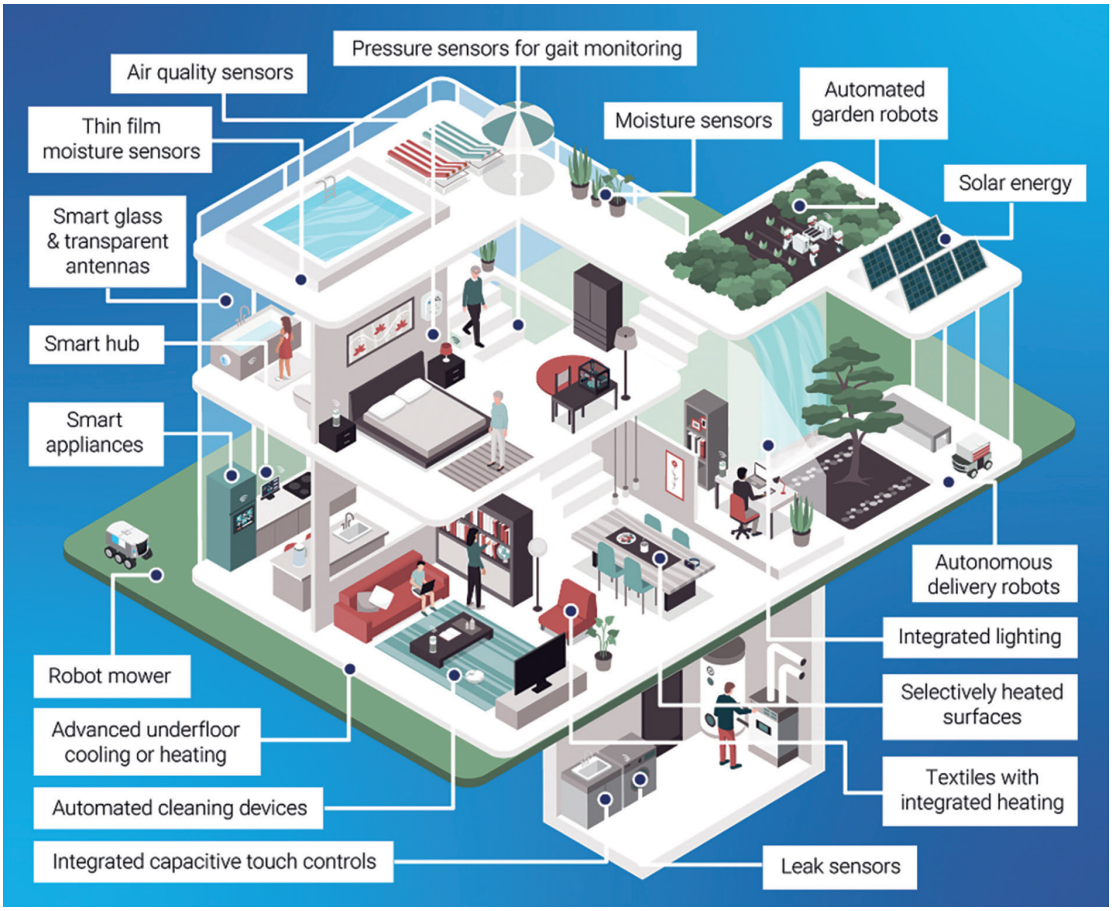

Fig. 3
The House of the Future, represented by IDTechEx

for study of tritium penetration in and release from reactor wall (significant results were obtained on samples delivered from JET).

Designing a **battery** is a three-part process. You need a positive electrode, a negative electrode, and most importantly, an electrolyte that works with both electrodes. An electrolyte is the battery component that transfers ions back and forth between the battery's two electrodes causing the battery to charge and discharge. Although for today's lithium–ion batteries, electrolyte chemistry is relatively well defined, further electrolyte development is one key to progress in making longer-lasting and more powerful batteries.

Solid-state batteries intend to bring the performance of classical battery systems to the next level in terms of energy density, charging speed, weight and volume. In its turn, a solid-state electrolyte for an all-solid battery will be a game changer. The key to a solid-state battery is a metal anode, but its performance is currently limited by the formation of needle-like structures called dendrites, that can short out the battery. By finding a proper electrolyte that prevents or inhibits dendrite formation, the benefits of really existing batteries will be achieved. Quite recently, in December 2022, a team of international researches at the University of Sydney has developed an advanced sodium battery that boasts an energy capacity four times greater than its lithium–ion battery counterparts, but also is much cheaper to produce. The novel battery was fabricated using sodium-sulphur – a molten salt that can be processed from seawater, meaning it costs much less than sourcing lithium.

A team of scientists from the University of Glasgow announced the development of flexible, solar-powered supercapacitors which could underpin new generation of wearable electronics.

An important task and challenge in energetics is **economic and efficient use of energy**, energy saving.

Let us list only a few tasks and activities: to develop a less raw material and energy consuming industry; to take advantage of application of equipment and services operated with lower electricity consumption; the use of LED and OLED lighting; "smart windows" for energy efficient buildings.

Latvian scientists and industry are active players in solving the above-mentioned tasks within their capabilities.

As a final recommendation: it is important that the development of Latvia's energy package will be based on the facts accumulated in the knowledge and experience. International collaboration is one of the most efficient ways to accelerate clean energy innovation.

May the House of the Future, represented by IDTechEx in Figure 3, take care of our well-being.

ENABLING NEXT-GENERATION APPLICATIONS THROUGH EMBEDDED HETEROGENEITY AND OPENNESS

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Dr. sc. ing., Institute of Electronics and Computer Science

Whenever discussing the emergence of innovative technologies and applications, performance growth is frequently assumed to be imminent. Such expectations have roots in prior experience, i.e. industrial revolutions that manifested through the creative application of mechanics, electricity, and semiconductors. Nonetheless, while technological progress seems exponential, one may and should question whether such growth is ever sustainable. Figure 1 famously illustrates [1] the CPU processor performance growth over 40 years. While technology improvement and architectural ideas have increased and maintained this growth, such aspects as slowing down in Dannard's scaling [2], Amdahl's law [3], and high costs for advancing semiconductor manufacturing contribute to the performance saturation and Moore law's stagnation.

The most common approach to further improving computing performance is technology specialisation. Figure 2 illustrates a universality-performance trade-off characterisation of different technologies. While a general-purpose processor is suitable for solving almost any challenge ranging from scientific computing to a complex operating system, it is frequently not the most efficient implementation medium. On the other side of the spectrum, we can sacrifice universality and design a tailored chip for the specific application; nonetheless, the financial feasibility of such a solution usually depends on the demand. Other technologies permit some level of flexibility while delivering different levels of performance. Each implementation medium offers more-or-less specific ecosystem, tools, and skillset requirements.

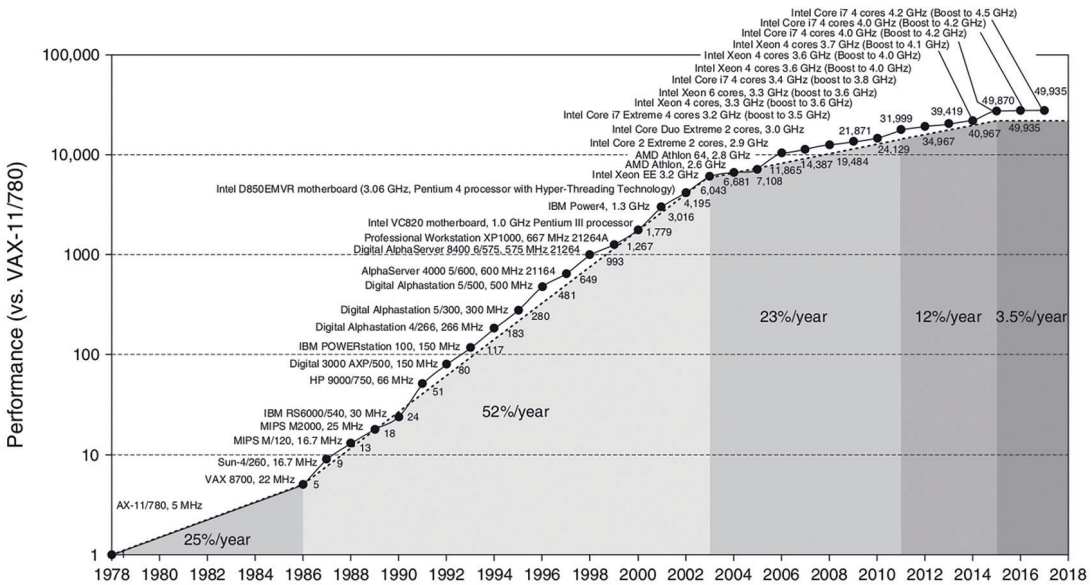

Fig. 1
Growth in processor performance over 40 years

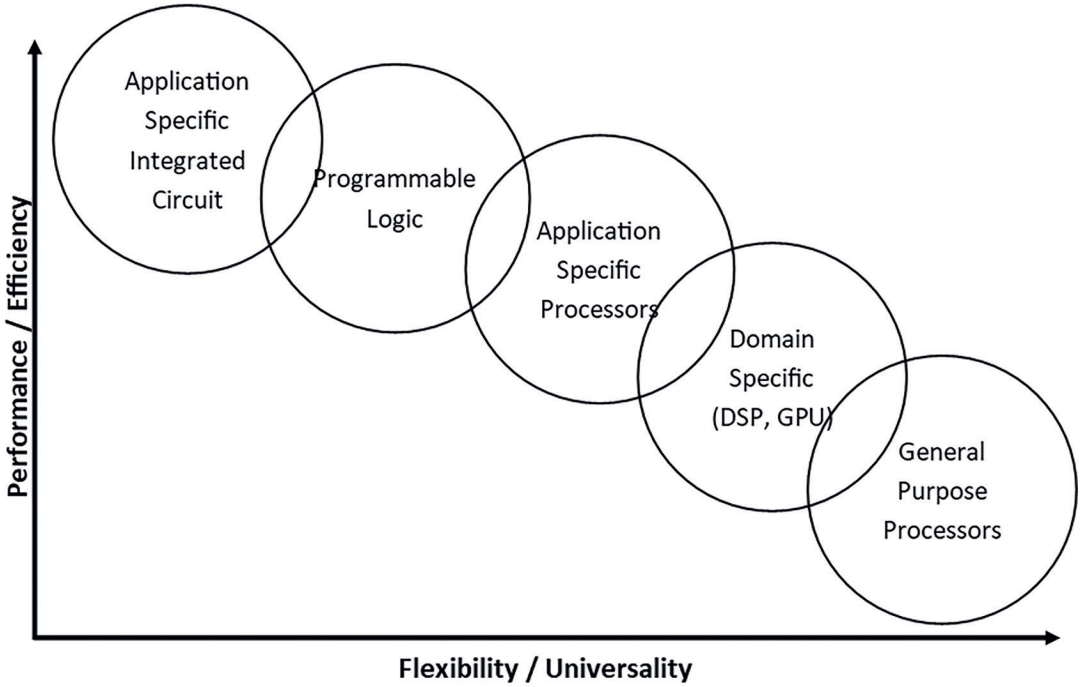

Fig. 2
Universality/efficiency tradeoff for different computing technologies

Another approach considers whether there should be a definitive choice at all. Even a single computing challenge may involve a variety of subtasks suitable for different computing mediums, i.e. suggesting algorithm partitioning. It can be beneficial to tackle each sub-challenge at the most appropriate abstraction level, i.e. logic gates, register transfer level, IP cores, compiled software, scripts, etc. Heterogeneity could be the next step in allowing novel applications that necessitate high efficiency and performance, real-time operation and interoperability with legacy software and interfaces. The capability for such design space exploration introduces extra complexity and the requirement for proficiency at multiple technology abstractions.

Consequently, the Institute of Electronics and Computer Science (EDI, https://www.edi.lv/en/) specialises in Smart Embedded Cooperative systems and tackles computing challenges in various contexts, i.e. overall cost reduction, energy efficiency, mobile computing, improving productivity, and even semiconductor supply chain enhancement. Moreover, a dedicated research unit (Fig. 3) tackles these issues by applying synergies between the heterogeneous computing paradigms. The blend of acceleration capabilities of digital circuit designs and the flexibility of software produces a unique opportunity for a variety of applications.

For instance, infrared (IR) imaging is an expensive yet strategically important sensing technique. EDI's SoC group is a part of an international consortium sharing the goal of lowering technology costs to 100 euros [4]. While the consortium delves into advanced packaging, the EDI group's role has been to improve IR pre-processing algorithms and enable efficient embedded implementation. The initial unavailability of the sensor motivated the team to design a mathematical model for the whole sensor [5]. Further, modelling and analyses led to the design of accelerator correction circuits for bolometer non-uniformity, defective pixels and temperature correction and, eventually, drove the implementation of the demonstrator's heterogeneous system architecture, seen in Figure 3.

Thereupon, a repeating concern encountered by the team is the underlying knowledge level required to efficiently utilise accelerator technologies and deal with the internal on-chip complexities. This precondition presents one of the cardinal challenges in heterogeneous computing, which is productivity. The group seized this opportunity by designing an inclusive, software-based solution for accelerator

Fig. 3
EDI SoC group's picture with HSoC-based IR camera prototype demonstrator

integration into computing pipelines suitable for software engineers – SilHouse. Figure 4 illustrates the overall concept of the framework where the EDI's accelerators, which emerged from research activities in numerous international projects, constitute a catalogue of reusable accelerators. Further, the framework provides a streamlined way for constructing specialised accelerator solutions and a generic control&operation model.

The semiconductor industry is a substantial factor in computing innovations, but unfortunately, it encompasses considerable limitations and no-nutilised potential. Apart from the high costs of modern technological nodes, the industry limits its potential by closing intellectual property, limiting access to design tools and relying on numerous legal agreements. On August 1991, Linus Torvalds famously announced the new Linux operating system that eventually outgrew from being just a "nerd" activity into embracement from the big companies. A key learning from the history of the development of open-source software is that there is a very produc-

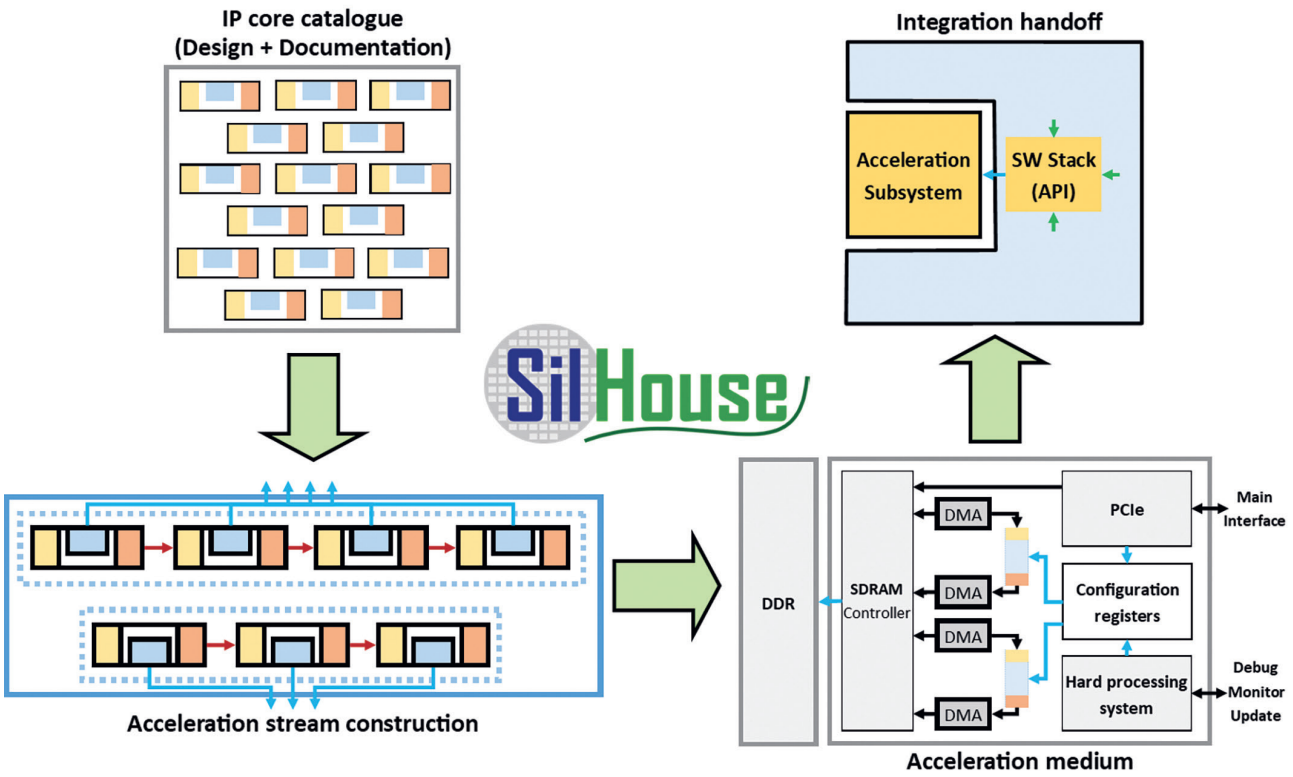

Fig. 4
Concept behind SilHouse framework, accelerator stream construction and handoff

tive untapped resource of developers, hackers and enthusiasts who see the open-source movement as a means to realise their motivations and ideals. The semiconductor industry has neglected this resource, and EDI, alongside partners across Europe, has set a goal to change that. EDI coordinates support activity [6] to solve communities' key challenges – unavailability of design tools and open-source PDKs, absence of a hardware-centric open-source license, and introduction of quality and re-usability mechanisms.

The performance saturation challenge presents "A New Golden Age for Computer Architecture" [7] while forcing the exploration of previously ignored opportunities, even turning to the open-source community. We must embrace that a vital and disruptive idea still might have failed to persist in the "hardware lottery" [8]. Digital electronics is among the most important industries worldwide, while innovative digital circuits, novel sensor design and heterogeneity may constitute solutions for enabling next-generation technologies and future societies.

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RETURNING TO LATVIA FOR SCIENTIFIC OPPORTUNITIES

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Since the regaining of independence in Latvia, many young people have looked towards the West for knowledge and convenience, and they oftentimes don't look back. Recently, however, there has been an increasing number of expats who have decided to return [1]. In fact, the influx of people in Latvia has been rising over the past years, resulting in a net migration of zero for the first time in more than 30 years [2].

I happen to belong to this odd but growing group of people. After having spent about nine years in Germany, completing my studies in Munich, and amassing a fairly respectable amount of experience in academic and industrial institutions, I moved to Latvia about a year ago. Such decisions usually prompt sceptical reactions, and lead to a series of questions from peers. Since these questions are often similar in substance, I would like to share some thoughts in an imaginary interview.

You stayed in Germany for nine years. How would you reflect on your experience there?

Like many others, my initial motivation was education. While considering universities, I certainly didn't ignore the "prestige" component, especially with regard to the engineering fields I was interested in. However, in the bigger picture, this was only one of many factors, since I was also choosing a country and culture to spend a significant part of my life. This is how Munich found itself on my shortlist.

At the Technical University of Munich (TUM), there are no shortcuts for good results, especially during bachelor studies. My study programme had about seven challenging exams per semester, so the only way to get by was to study a lot. While professors are somewhat available after lectures, it has to be stated that many courses are attended by hundreds of students, which is about an order of magnitude higher than typical numbers in Latvian universities. This inevitably means that the lectures are geared towards large audiences, and the level of interaction is rather limited. This holds even more true for practical courses. There are not particularly many of them (relatively speaking), and the number of available participation slots is usually in the order of fifteen. With more than twenty thousand engineering students in 2022 [3] there is definitely a lot of competition for more hands-on experience next to all the theory. This is not a fault in the system, though. Many leading technical universities are oriented around providing strong fundamental knowledge, while leaving the degree of practical implementation in the student's hands. Those who wish to focus on highly practical skills, usually choose universities of applied sciences, which there are plenty of, including in Munich [4]. Nevertheless, the full experience of studying abroad also includes all the opportunities to do internal and external internships and other kinds of initiatives. While I did spend some time at different engineering companies doing programming work next to my studies, the place that stands out the most is the institute where I ended up writing my master's thesis, the Institute of Robotics and Mechatronics of the German Aerospace Center (DLR).

I believe that, in order to find true personal and intellectual growth, one should seek every chance to be the most stupid person in a company. This could not be more true when thinking about what I was able to experience at DLR, a world-class institution acting essentially as Germany's NASA, and hosting one of the largest robotics institutes in Europe. Getting accepted there required a bit of stubbornness

Participants of the teleoperation experiment at DLR

on my part, but the effort was very much worth it. I was able to observe what kind of robotics and AI research is being conducted by some of the world's smartest scientists, and even got a chance to (modestly) assist in an experiment where a robot in the laboratory was controlled by the ISS astronaut Alexander Gerst [5].

While it was fascinating and humbling to experience world-class scientists at DLR doing their work, I wasn't quite ready to stay there any longer. Instead, I looked for opportunities in the industry to broaden my experience. This brought me to Bosch, where I spent about two and a half years working on technology for autonomous vehicles while also learning about Agile development methods [6]. This way of thinking struck a chord with me, and I'm very glad I got to learn about it during my final years in Germany.

Then let us continue with the obvious one: why did you return to Latvia?

Such decisions tend to be the product of many considerations, often going to the deepest core of one's being. Sparing most details, I can say that the decision was easy. After having spent a third of my life in one country, it was about time to change the scenery. I started actively looking for options more than one year before my estimated return time. Having acquainted myself with the Institute of Electronics and Computer Science (EDI) and other intriguing organisations like the Association of Latvian Young Scientists, I was confident that there will be plenty of opportunities for meaningful and rewarding work. At that moment I was also convinced that aiming for a doctor's degree was the way to go.

What made you so confident about EDI?

This may not be a fair comparison, but something about EDI reminded me of my past experience at DLR, albeit with a Latvian touch. The type of technology that's being worked there, the labs, the people: they gave me a generally welcoming feeling during my first visits. But that was only the first impression. The reason I saw potential here is largely due to what this institute had been doing historically:

Visit of Egils Levits, President of Latvia

building an intellectual foundation for a broad spectrum of high-tech fields, and being the first in many achievements in Latvia. For example, the first-ever computers and microprocessors were developed at EDI. From more recent times: a high-precision event timer was also developed there, and this technology is used by more than 50% of the world's satellite laser-ranging stations. And, of course, this story wouldn't be complete without the first self-driving car in Latvia, which was also developed at EDI. Due to its close-to-industry style, the institute has co-operated many times with technology companies. With more than 300 international partners, EDI is and excellent platform for reaching out to nearly every public or private institution in Latvia and a great number of international organisations.

While there is a lot of fundamental research, most of the scientific work is done with practicality in mind, making EDI an excellent bridge between the academic world and the industry. This approach makes EDI an essential asset for the technological development of Latvia in the future, and I've been enjoying being part of that for over a year now.

What about your own work?

At the beginning I joined two Horizon 2020 projects (5G-ROUTES [7] and AI4CSM [8]), both of which are centred around smart and connected mobility, and therefore include a lot of activities with EDI's self-driving vehicles. My own work of the past year or so has mainly involved the development of the architecture, algorithms and other software parts that make our vehicles perform co-operative manoeuvres, combining sensor data and wirelessly exchanged driving information. Some of our first demonstrations involved driving around the Biķernieki racetrack and letting one of the cars move based on communicated data and nothing else [9].

At the time of writing, I'm also in the process of joining a new project, financed by the National Research Programme of Latvia. There, my aim will be to research and apply physics-informed machine learning [10] in robotics. In other words, I will try to let our robots learn new kinds of movements by using mathematical models in an environment that's

EDI's autonomous vehicles on display

intrinsically constrained by the laws of physics. This approach has shown the potential to be applicable for essentially any robotic system, can be bottomless in complexity, and is closer to what I'm envisioning for my PhD thesis.

Would you recommend others to follow a similar path?

Having spent well over half of my life in foreign countries, I am in no position to recommend anyone to organise their lives strictly around their country of origin. For those who have the possibility, living somewhere else for several years is a means to obtain experience and perspective in a way that's impossible otherwise. It is a chance to learn the good and bad practices of other societies. The defining moment of one's personal choice is what to do with this experience.

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LATVIAN FUNDAMENTAL AND APPLIED SCIENCES ACHIEVEMENTS

FROM LAB TO FAB – RESEARCH ON THERMO-ELECTRIC ORGANIC MATERIALS RESULTS IN INNOVATION

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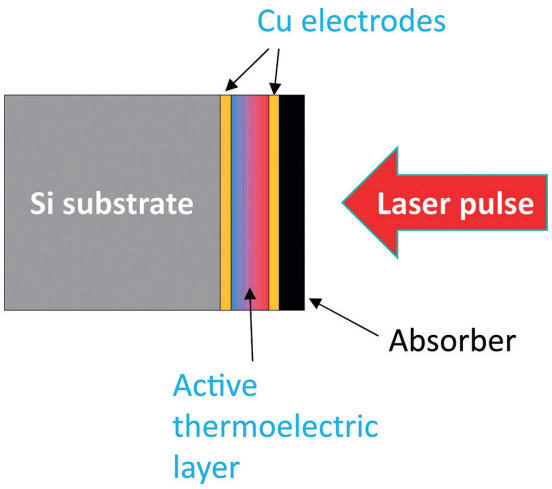
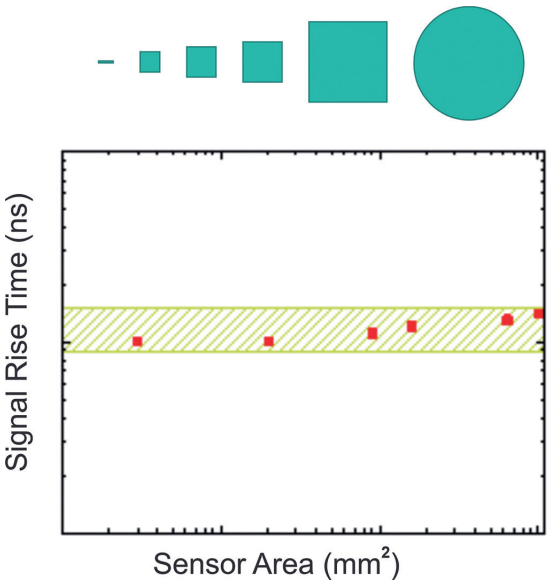
High-speed thermoelectric electromagnetic radiation sensor or TESS is the innovative technology developed at the Institute of Solid State Physics, University of Latvia (ISSP UL) which has gone from the laboratory to production. The ISSP UL is one of the leading research institutions in Latvia, the strong foundations of which were laid 45 years ago. Since 2017, the project CAMART^2 (Excellence Centre of Advanced Materials Research and Technology Transfer) has raised research capabilities by implementing new research strategies and developing infrastructure to fortify the institute's priority research directions – which include materials science, nanotechnology, thin films, photonics, and micro and nanoelectronics. The CAMART^2 has also utilised a new approach to direct fundamental research toward technological needs and industrial challenges or "from lab to fab". Such approach established within the framework of the CAMART^2 has significantly contributed to the development of advanced, unique, and commercializable technologies like TESS which was rated as one of the Latvian Academy of Sciences' Most Important Achievements in Applied Science awards in 2021.

It is not unusual that while researching one thing, something unexpected comes out of it. That was the case with TESS. Technology idea came into existence while researchers at ISSP UL within EC 7FP FET project "Waste heat to electrical energy via sustainable organic thermoelectric devices" (H2ESOT) were developing a thin film organic thermoelectric (TE) generator. Developed "proof of concept" TE generator was not powerful enough to be used in real applications, but researchers have foreseen a huge potential of the developed device as electromagnetic radiation sensor. One of the creators of TESS, *Dr. phys.* Mārtiņš Rutkis says: "TESS once again confirmed my conviction that if someone is investigating a phenomenon or developing a specific product, they should be open-minded and ready for a completely unexpected opportunity to appear. And when it happens, the researcher must be brave enough to take this new pathway to success."

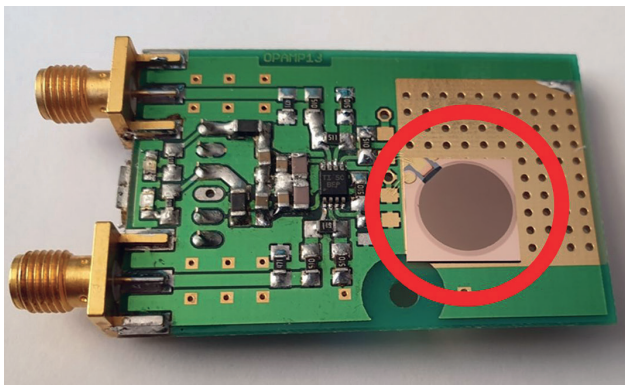
The sensor created by the scientists of the ISSP UL's Laboratory of Organic Materials allows at a high-speed to measure laser power in wide spectral range from ultraviolet to far infrared light. The technology itself is based on the thermoelectric effect in thin films. Active element of TESS is simple (see figure) and could be produced by thermal deposition in vacuum in "one run" The exceptionality of the device lies in the unique properties of the organic material used by the scientists. The material's very low thermal conductivity is combined with the comparatively high material's ability to convert the heat gradient into electricity (characterised by the *Seebeck* coefficient). These combinations of properties provided an opportunity to create a sensor based on thin films that can generate a signal strong enough to be read out from a single laser pulse. At the same time, the employment of films with submicron thickness allows creation of a sensor with exceptionally low heat capacity; therefore, the device could operate at a very high speed. The unique property of TESS – sensor response time is not dependent on the size and shape of the active area, which is not the case for classical semiconductor photodiodes. Another advantage is that TESS can operate in an infrared spectrum region where classic semiconductors do not work. This allows



Concept and thin film structure of TESS active element



Unique property of TESS – sensors response time is not dependent on the size and shape of active area

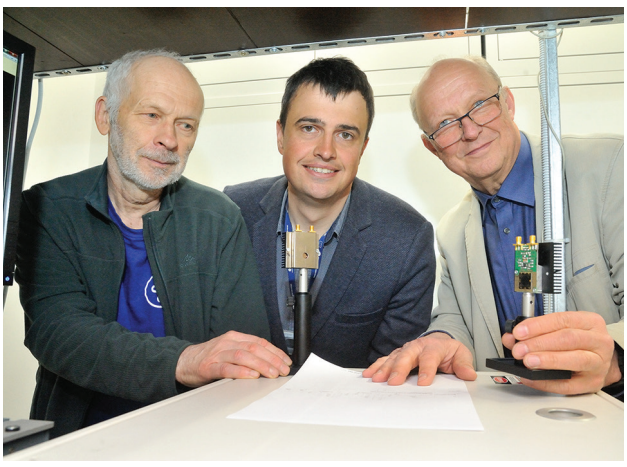


Prototype of the thermoelectric electromagnetic radiation sensor – TESS consisting of active element (circled in red) and readout electronics

characterising individual laser impulses, which until now was practically impossible.

The new sensor device will be especially useful in controlling power in various technologies based on pulsed lasers. TESS is thousand times faster than sensors existing today on the market of TE sensors. Up to now, such sensors were capable of measuring laser power averaged in time, typically averaging many individual impulses. The new thermoelectric sensor can characterise each laser impulse individually. The capacity of this device to measure and control every impulse is particularly important where a laser is used to modify the characteristics of materials. This includes laser welding, cutting, engraving, and numerous laser surgery applications. Using such sensors in various tools based on laser technology will allow them to be operated more effectively and faster and might also develop new possibilities. In laser surgery, the new sensor will allow for performing various surgeries more quickly and accurately. For example, endovenous ablation surgery could be done much quicker when it was possible to control the power of each laser impulse and therefore administer the necessary dose in a shorter time and more precisely.

The thermoelectric sensor is patented in the European Union, the USA, Japan, and China. A licensing and technology transfer contract was signed with Thorlabs, a leading designer and manufacturer of photonics equipment for research, manufacturing, and biomedical applications.



Core team of TESS development (from left) Jānis Busenbergs (electronics), Kaspars Pudžs (thin film technology and TE characterization) and Mārtiņš Rutkis

BIOBASED ACRYLIC RESINS

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As the world moves more and more toward achieving sustainability, the polymer industry is facing challenges, as 99% of it still consists of fossil-based resources [1]. Even more so, according to the often-cited statistic webpage Worldometer: given the ratio of reserves to consumption, we have 47 years left before the resources of petroleum run out [2]. Despite all the research breakthroughs and regulations forcing multiple industries to switch to sustainable materials, there is still a long road ahead. Latvia is interested in bio-based polymer production since it does not have petroleum extraction. However, Latvia does have a long history in wood processing and agriculture. Conveniently, the biomass of cellulose and natural oils from forestry and agricultural crops are viable for obtaining biopolymers.

SUSTAINABILITY

The polymer industry is extensive and the possibilities for sustainable replacements are also growing. While bio-based sources constitute an essential sustainability requirement, they are not the only ones. The energy effectiveness of the production process also plays a significant role. One process that allows low energy consumption during polymer product production is photocuring. The photocuring process uses less energy than conventional melt processing technologies since it needs a light source (UV light) rather than high temperatures. The photocuring process is usually much faster than other polymerisation processes. Two of the most common polymer classes used in photocuring are acrylates and epoxides. Approximately 74% of the world resin market is built on acrylic resins [3]. Acrylic resins can be used in various applications: coatings, 3D printing, clothes, furniture, etc. [4]. Acrylic resins have their benefits and shortcomings; however, one of the most appealing aspects is the ability to use them in photocuring. Low energy requirements for photocuring combined with high accuracy and a fast-curing process are why acrylic resins also overtake the 3D printing industry. Unfortunately, commercial resins for these 3D printers that use UV light are petroleum-based. For example, poly(ethylene glycol) diacrylate (PEGDA), bisphenol A epoxy acrylate (BAEA), and methyl methacrylate. Besides being an unsustainable source, these commercial resins often emit high-concern volatile fumes and require extra caution when working with [5].

Highly potential sustainable replacements for acrylic resins are biomass of cellulose and natural oils from forestry and agricultural crops, which in Latvia are in abundance. Vegetable oils with their unsaturated fatty acid chains (easily modifiable) are already proven viable for photocuring applications, including 3D printing. Unfortunately, the only commercially available vegetable oil-based acrylate is soybean oil acrylate. Hence, most sustainable acrylic resins are based on soybean oil acrylates. However, many agricultural oils have the same unsaturated fatty acid chains that allow soybean oil chemical modification into an acrylate [6]. When looking at Latvian agriculture, the first candidates are rapeseed, hemp, and linseed oils. As usual, sustainable replacements have performance issues when compared to petroleum-based equivalents. Acrylic resins are no exception [7]. For this issue, there are multiple solutions, including reducing bio-based content and using petroleum-based reactive diluents to adjust the performance. One that further supports sustainability, though, is using natural fibre reinforcement. Fortunately for the Latvian economy, our forestry and agriculture industries provide more than enough side streams of biomass for cellulose extraction (sawdust, hemp fibre etc.).

Cellulose is widely known for its ability to improve the performance of different polymers, including resins used for photocuring [8]. Most attention has gone to cellulose nanocrystals and nanofibres. It is

Anda Barkāne, RTU, Faculty of Materials Science and Applied Chemistry, working on modified cellulose

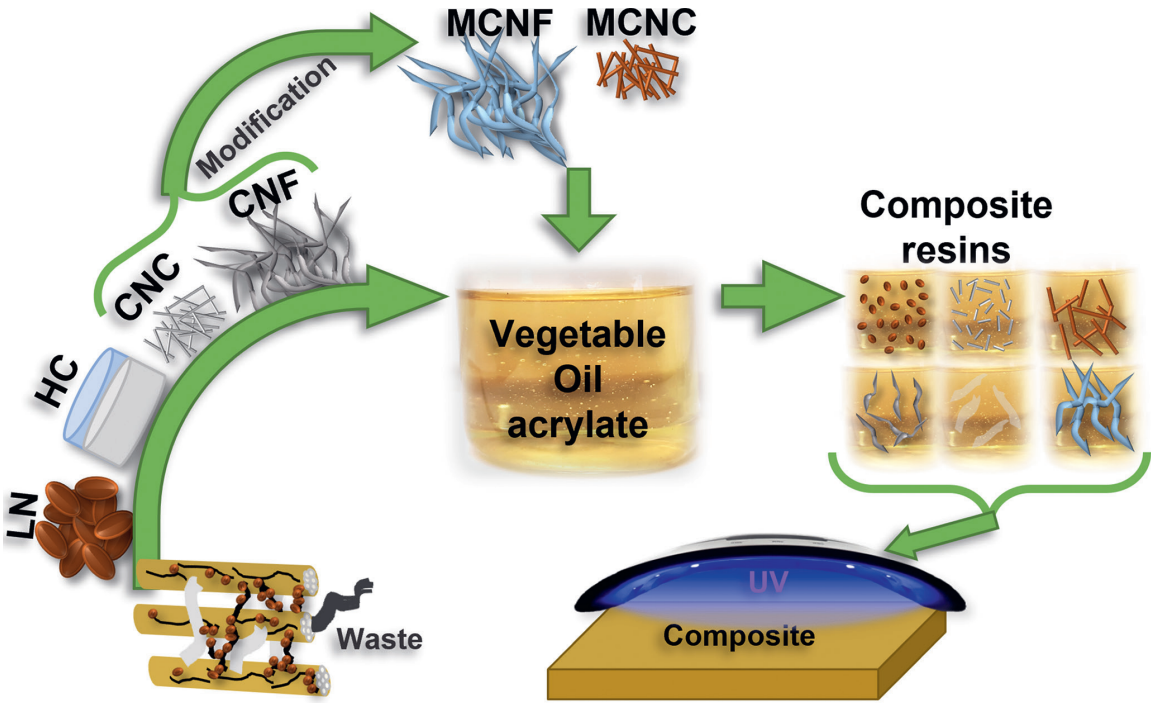
well known that nanocellulose has established its place as a natural reinforcement agent in polymer composites. While not so widely known, when photocuring is in question, beneficial UV light scattering from nanocellulose is also present and sometimes limiting aspect of increasing resin viscosity. Increased resin viscosity is of extreme importance when 3D printing is used [9]. Also, the resin and nanocellulose reinforcement compatibility is not a minor concern. For example, when vegetable oils are used for acrylic resins, one should know that the resin will be hydrophobic and the nanocellulose will be hydrophilic. Hence, arises compatibility issues.

PROFESSOR S. GAIDUKOVS GROUP

Here at Riga Technical University, Faculty of Materials Science and Applied Chemistry, we are working in multiple directions: including aerogels, nanopapers, electromagnetic shielding materials, thermoplastic and thermoset polymers, and polymer composites. In recent years, the majority of our focus has gone to biomass: bio-based thermoplastic and thermoset polymer and polymer composite materials. Along the way of bio-based acrylate resins, we have expanded beyond multiple acrylic resin vegetable oil bio-sources and nanocellulose reinforcement.
In our efforts, we have expanded the biomass filler used in acrylic resins by including lignin and hemicellulose [10] and gone a step further by nanocellulose surface modification techniques for compatibility issues. Lignocellulose is the most abundant biopolymer available. It is mainly composed of 40–50% cellulose, 25–35% hemicellulose (HC), and 15–20% lignin (LN) (content varies depending on plant, origin, and growth conditions) [11]. We have proven that hemicellulose and lignin can be used more for photocuring resins, so they bring their benefits. As it turns out, hemicellulose is a great nonreactive diluent and, providing that the correct amount is added, can reduce viscosity, and provide densification (as in plants) without reducing the photocuring efficiency. Meanwhile, nanocelluloses additional UV-light scattering counteracts the absorption from lignin allowing its presence in the resin and hence possible benefits of antioxidation and hydrophobic properties [10].
Modifying the nanocellulose surface has allowed us to increase the performance improvements from the reinforcement further. Furthermore, by improving the compatibility between the resin and the nanocellulose reinforcement, we have increased the stress transfer from the polymer matrix to the reinforcement. Alongside well-known nanocellulose surface modification in collaboration with our colleagues from the Latvian state institute of wood chemistry, we have even improved the nanocellulose modification approach making it more sustainable. We used suberin fatty acids from outer birch bark to avoid petroleum-based modification groups. Suberin fatty acids are hydrophobic [12], hence providing increased compatibility.

INDUSTRY COLLABORATION

All our extensive research-related photocuring resins give us a unique knowledge base for new biobased material developments. Expanded lignocellulosic filler experience in UV curing resins allows us to broaden the wood mimic material varieties to thermoset polymer composites. Experience working with a wide range of lignocellulosic filler loads (below 1 and above 30 weight %) and various modification methods allows us to adjust resin performance per need. So now, beyond scientific research, we are also looking for industry partners interested in our



Using lignocellulosic waste as performance enhancers for vegetable oil based-acrylic resins

Visit: **CPSM - Complex Systems, Polymers and Soft Matter** (@PolymCPSM)

biobased composite resins and in collaborations for developing specific performance resins. Given the depleting petroleum reserves, the necessity for sustainability sooner rather than later in the acrylic polymer industry, whether resin manufacturers or product manufacturers, will be forced to switch to renewable resources. Our lab can provide competitive biobased acrylic resins and the knowledge to create new biobased acrylic resins.

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NOVEL MATERIALS AND PRODUCTS FROM AGRICULTURAL LIGNOCELLULOSE WASTE

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Cellulose, known as the most abundant renewable resource, is the key to the new industrial revolution. While the primary source of cellulose is pulp from wood processing plants, it also presents environmental issues regarding the chemical and mechanical treatment needed for purification. Non-woody plants, like flax, hemp, jute, and sisal, give the high cellulose content needed for exceptional properties. Various woodworking byproducts, agriculture waste is also a zero-burden resource which meets the modern circular economy principles. This presents the opportunity for cheap, competitive, and sustainable bio-based materials.

Nanocellulose (NC) has seen tremendous interest in the last decade and is often compared to various modern synthetic fibres. Current methods for NC production involve ultra-fine grinding or high-pressure homogenisation for the fabrication of nanofibrillated cellulose (NFC) and chemical treatment for the preparation of nanocrystalline cellulose (NCC). As NFC is produced mainly with mechanical methods, it is only limited by electricity and energy requirements. Furthermore, by avoiding chemical treatments, the resulting material preserves some of its natural aspects.

One of the researchers' primary objectives is converting NC into a network material, i.e. foams, sponges, cryogels, xerogels, or aerogels, depending on the preparation methodology porosity, density, and pore sizes. Several authors [1] have described those efficient, high-quality materials with comparable properties to pure NC that can be prepared from lignocellulosic fibres and regenerated celluloses. It starts with viscous suspensions in the water that transition into gel-like structures at higher concentrations; thus, the preparation of the network involves the extraction of the liquid from the gel through supercritical drying, freeze-drying, or ambient drying. NC foams are highly stable, easy to prepare, and suitable for various modification methods that increase their mechanical properties, customise surface chemistry, and reduce density [2]. The bottom-up process using NC foams yields meso-sized pores in a mesh-like network structure with isotropic material nature and significantly enhanced thermal conductivity range from 0.016–0.028 W/(m·K). Mathematical modelling is commonly applied to discuss the porosity effect of thermal conductivity. Specific surface area is essential for foam application in sorbent and filtering applications. Authors report the experimental specific surface area values to be in the range of 5–600 m^2/g for NC foams; in addition, the surface area above 400 m^2/g is necessary for efficient sorbents and filters. In addition, optical transparency for materials can be achieved using nanofibrillated 3-dicarboxylic cellulose or other chemical treatment methods [3]. Other potential uses for NFC-based foams and aerogels include drug delivery, scaffold fabrication, biosensing, and energy storage systems. Neural stem cell (NSC)-based therapy investigated using biomimetic 3D bacterial cellulose-graphene foam

Fig. 1.
Foam-type material produced from nanofibrillated hemp. Weight used 0.5 kg 2

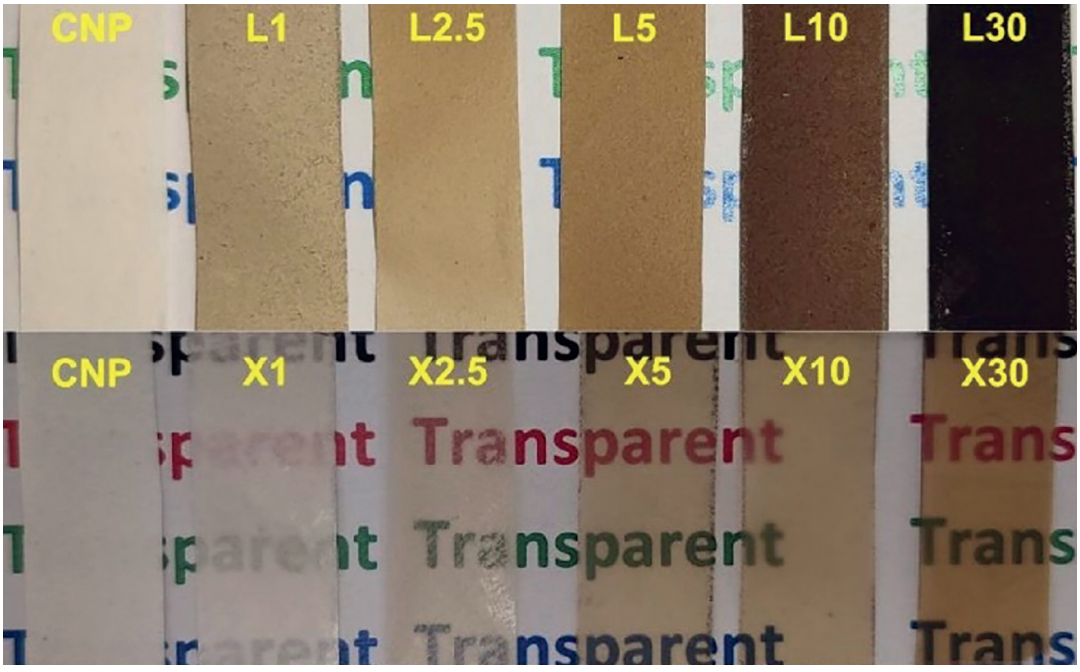

Fig. 2
Cellulose nanopapers (CNP) with lignin (L) and xylan (X) components, where the number shows the component's weight percentage. (Under a Creative Commons license [4])

hybrid scaffolds. It should also be noted that the tailored surface and interface of the obtained fibrils are critical factors in promoting NC application in functional materials, including films, filaments, and aerogels [1].

Within the scope of the project "All-Natural Wood-Like Bioplastics by Reassembly of Lignin, Hemicellulose, and Cellulose (RealHLC)", various lightweight cellulose materials have been developed. We designed nanocellulose foams from wood and hemp biomass wastes with exceptionally lightweight and high mechanical strength in compression [2, 3]. Figure 1 shows the freeze-dried hemp foam, which is light enough to stay on delicate dandelions and at the same time can easily bear the weight of several kilograms (0.5 kg in the picture). These materials were mainly targeted for thermal insulation applications, but research is ongoing to transform them into reusable, water-resistant sorbents. To integrate more energy-efficient solutions, drying in ambient conditions was examined, and materials that fit these conditions are called cellulose films or nanopapers. Using NFC suspension casting in trays and drying them, a large variety of materials that integrate natural polymers such as lignin and xylan can be obtained [3]. As a result, materials show enhanced water and UV resistance and are promising packaging materials. In addition, transparency can be obtained with the addition of xylan, while lignin yields dark brown colours, as seen in Figure 2.

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ECONOMICALLY VIABLE SOLUTIONS FOR PLANT PROTEIN PRODUCTION IN LATVIA

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The Farm-to-Fork strategy, created to develop sustainable food systems, has one of its ambitions to achieve a higher proportion of local produce obtained through environmentally friendly and sustainable methods. The ability to meet the need for local protein is relevant in both the food and feed production sectors. A number of Community documents have highlighted the importance of increasing the supply of plant-based proteins to the EU in order to reduce the EU's dependence on key imported agricultural products and raw materials and improve food security. Following the goal of reducing the use of chemically produced fertilizers and increasing the organically managed areas in the EU, the role of legumes will also increase as soil improvers and nitrogen fixers.

Traditionally, field beans, peas, sweet lupine, winter and spring vetches, as well as perennial legumes – red and white clover, bastard clover and alfalfa – have been grown on commercial areas in Latvia farms. Competing with field crops that are more in demand on the market and more stable in terms of yield, the sown area of legumes, especially pulses, significantly decreased over the course of several decades. Thus, in 2011, pulses were grown in an area of 3.7 thousand hectares in Latvia, and the local production of pulses was only 8.4 thousand tons. The situation changed significantly when the EU started a special support programme for protein plants, farmers have returned to growing pulses on their farms. In the last ten years, the largest area of leguminous plants was registered in Latvia in 2018 – 51.9 thousand. ha, but in 2019 the largest crop of legumes was harvested – 170 thousand tons. Similar trends can be observed in other countries of the European Union. In 2022, EU countries produced a total of around 4 million tons of pulses and 2.6 million tons of soybeans. Although the total area has increased significantly, the EU must import an additional 1.2 million tons of legumes and 14 million tons of soybeans every year (EUROSTAT, 2022). Especially in crisis situations, the ability of each country to ensure self-sufficiency with quality food and fodder products is well understood. One of the researchers' tasks is to create new knowledge and evidence for farmers to motivate them to continue expanding legume cultivation. It is knowledge that can help to understand the importance of different legume species from both an economic and an ecological point of view.

During the last ten years, several studies have been carried out in Latvia, which gathered knowledge about the local genetic resources of field beans (*Vicia faba* L.) and peas (*Pisum sativum* L.), improved technologies for growing and using legumes, created new innovative products from legume seeds (e.g., EUROLEGUME, 2017–2020). Various field trials conducted for the education of farmers, in which cultivation technologies using integrated and organic farming practices are demonstrated. In order to promote a faster transfer of knowledge from laboratories to practice, legume research has been included in collaborative projects between scientists, industry experts and producers, creating thematic European Innovation Partnership (EIP) groups.

AREI led the EIP group that implemented the project "New technologies and economically viable solutions for the production of local feed for pig production: cultivation of non-genetically modified soybeans and new barley varieties in Latvia"

(2018–2021). This is an interdisciplinary study on the effective expansion of the local food production market, evaluating the possibilities of growing and using soybeans and bare grain barley in Latvian conditions, in order to reduce the dependence of the pig farming industry on imported protein feed. The safety and sustainability of the food system can be guaranteed by increasing the amount of locally grown raw materials, thus allowing to reduce the volume of imported soy products. Soy adaptation in the Baltic/Nordic region is a new opportunity and challenge created by climate change in the region, but at the same time it is also a challenge for those interested and researchers – to adapt new, atypical species in the region in agricultural business. Interest in soybean cultivation has been growing in recent years – the area of sowing has increased to 1600 ha in Lithuania (2021) and 500 ha in Latvia (2022). The unique nutritional value of soybeans is the reason why this crop raw material is so important to consumers.

The study comprehensively analyses the technological and economic side of local fodder production, including the contribution of various legumes and cereals, especially soybeans and barley, to the production of high-quality feed produced from local resources.

For the purposes of the study, soybean cultivation experiments were carried out in four different agroclimatic regions of Latvia in order to find out the most suitable soybean varieties and cultivation technologies, identify risk factors affecting soybean yield, evaluate the quality of local soybeans and requirements of producers in both the conventional and organic farming sectors.

To obtain a successful soybean harvest, it is important to select cultivars that are able to reach maturity in the Baltic region, i.e. genotypes that are less sensitive to long day conditions and low temperatures during the growing season. The results of the three-year study showed that it is possible to adapt soy to Latvian conditions. In the climate zones most suitable for soybean cultivation, in the conditions of Latvia, two and more tons of soybeans can be obtained per hectare.

The first soy studies in Latvia show that currently soybean cultivation is most promising in mixed farms, where self-grown soybeans can be used for fodder production. Six private crop and feed production, pig-breeding companies were involved in

Project team after the publicity seminar of the project

Soya Erica at Rubuļi farm before harvest

Biologically grown soya at BIOGUS farm

the implementation of the research, implementing various experiments in industrial conditions. This provided evidence that in the environmental conditions of Latvia, extruded cake of self-grown soybean is equivalent to imported soybean products. In local grown soybeans, the protein content in dry matter varied from 29.8 to 44.7%. These results are in line with data on soybean quality in Poland and Germany. The value of soybeans is also determined by the oil content. In Latvian conditions, soybeans can accumulate from 18 to 22% of oil, which is a valuable by-product when processing soybeans for fodder or food. This is positive news for farmers who still have doubts about the prospects of growing this field crop in Latvia.

The traditional approach to assessing yield value is based on the assumption that certain crops or crop products are considered a source of certain nutrients, e.g., cereals and corn – a source of starch, legumes – a source of protein, rapeseed – a source of fat. In fact, all crops contain all of these basic nutrients (proteins, fats, starches, and sugars). A research team from AREI and EDO Consult offers a new approach by developing the Economic Nutrient Units (ENU) concept. This concept is broader. The content of basic nutrients varies considerably between different crops and crop products. Therefore, it is difficult to compare crops (including crop products) and evaluate their performance objectively, taking into account both economic and environmental benefits. ENU is a complex indicator that measures the content of these basic nutrients in crops. Basic nutrients are added up according to the reciprocal ratios among market values of nutrients. The cheapest nutrient (sugars and starch) is selected as a base to calculate the ratios. Thus, ENU indicates the content of the basic nutrients contained by crops in terms of starch/sugar market value. The ENU for a crop or a product is calculated by applying the following formula:

$$ENU_{p(DM)} = \alpha \cdot \lambda_{pr\_p} + \lambda_{s+s\_p} + \beta \cdot \lambda_{f\_p},$$

where $ENU_{p(DM)}$ – *ENU* for a product, tonnes per tonne of a product DM;

α – ratio of the market value of protein to the market value of sugars and starch;

λ_{pr_p} – protein content in a product (% of DM);

λ_{s+s_p} – content of sugars and starch in a product (% of DM);

β – ratio of the market value of crude fat to the market value of sugars and starch;

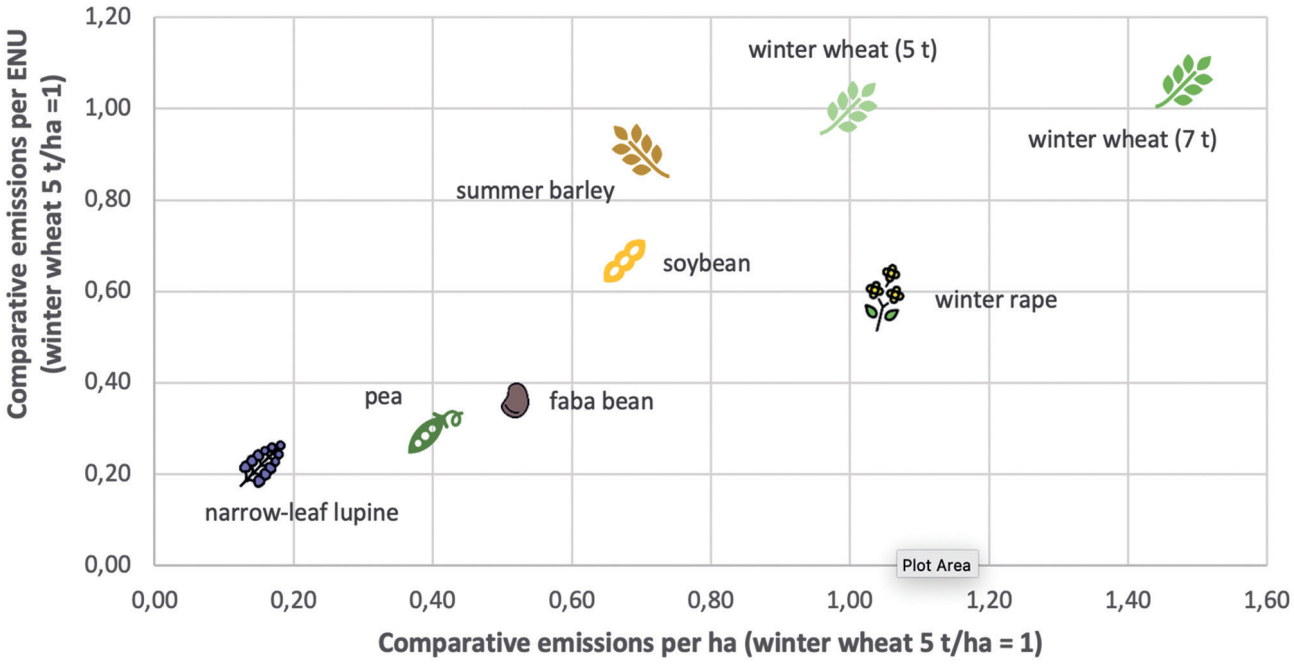
λ_{f-p} – fat (crude fat) content in a product (% of DM)

The market value of proteins, fats, sugars, and starch is determined by the three reference products, taking into account their market price. These are canola oil (source of fat market value), soybean meal (primary source of protein market value, but also affects sugar and starch market value) and corn (primary source of starch and sugar market value, but also affects protein market value). At the same time, the ENU concept is flexible and allows the use of other reference products.

The ENU concept also allows the use of more than one indicator to determine protein content (λ_{pr_p}). Depending on the goal, the authors recommend using, for example, four indicators characterising protein content: crude protein, sum of selected amino acids, or basket of amino acids and sum of selected amino acids. For example, for the assessment of pig feed raw materials, it is preferable to include lysine, methionine, cystine, threonine, isoleucine, leucine, valine, histidine and phenylalanine in the amino acid basket as the most important. This concept allows changing the amino acids included in the basket, as well as using other indicators to measure proteins value.

ENU can be used as a unit to evaluate both economic indicators (crop cultivation and processing costs and gross profit, EUR per ENU) and environmental indicators (e.g., greenhouse gas emissions from crop production, kg CO2-eq. per ENU).

The figure shows the relative value of produced greenhouse gas emissions per hectare and per ENU for the cultivation of various crops. It can be concluded that in the context of climate change, the cultivation of legumes and barley is the most environmentally friendly, and from the aspect of fulfilling the state obligations regarding the climate policy, attention should be paid to the high green-



Comparative greenhouse gas emissions from crop cultivation, kg CO2-eq per ENU and per ha

house gas emissions per ha that are generated by the cultivation of winter wheat. This concept allows for a more objective comparison of crops with different yield potential and nutritional value. We hope that such an approach will help to change the attitude of producers, farmers and also politicians towards some currently undervalued but important agricultural species, so that they return to commercial circulation and help to restore agro-biodiversity in farm crop rotations and the supply of local products.

INTERNAL DISEASE STUDIES AND RESEARCH: INTERDISCIPLINARY, INTERINSTITUTIONAL, AND INTERNATIONAL LEVELS

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Over seven decades, Rīga Stradiņš University (RSU) has developed from being a local medical institute into an internationally recognised research university in the fields of medicine, health care, and social sciences. Of the nine faculties at RSU, the Faculty of Medicine is the most extensive in terms of the number of departments. From these, the Department of Internal Diseases is the largest. The department employs more than 150 professionals representing a range of specialties: cardiology, nephrology, pneumonology, endocrinology, gastroenterology, rheumatology, and others. The experienced staff at the department implement the university's strategic objectives. Here also, an academic education is interwoven with scientific activity in an increasingly interdisciplinary framework. In addition to prospective doctors, promising researchers and lecturers are also growing under the auspices of the department.

GROWTH AND DEVELOPMENT

The Department of Internal Diseases is increasingly involved in international and interdisciplinary projects and involves future physicians from the early years of their studies. Under the guidance of the department's lecturers, students and medical residents choose and develop high-quality research papers in a range of internal medicine specialties: cardiology, rheumatology, pneumonology, endocrinology, gastroenterology, haematology, and others. Looking at the overall performance of RSU, the number of high-quality publications has increased dramatically from 179 to 445 (or by 248%) between 2017 and 2021. Part of this is due to the contribution of staff at the Department of Internal Diseases. The university research grant system enables many young medical scientists to gain important international research experience. RSU ranks high among research institutions in Latvia in terms of projects submitted to the Latvian Council of Science, the number of research support grants received, and has been ranked the best higher education institution in Latvia in the SCImago Institutions Ranking of academic and research institutions for the fourth year in a row. The scientific achievements of the lecturers, medical residents, and students of the department are presented at RSU Research Week, which is a remarkable, Baltic-wide scientific event, held every two years.

ACADEMIC EDUCATION AND SCIENCE MODULES

For a more systematic process, the scientific work at the Department of Internal Diseases is divided into several modules that are closely linked to the implementation of the academic curriculum.

The Pneumonology Module is led by Assistant Professor Madara Tirzīte (PhD), whose research interests focus on chronic obstructive pulmonary disease (COPD) that affects more than 5% of the world's population. Under her supervision, a team of researchers, among them young pneumonol-

ogists and medical residents, is analysing saliva samples from COPD patients to identify a new biomarker (CORSAI – Raman project) that could be used in the future to assess and treat the disease. Participation in the project offers the opportunity to collaborate with experienced peers in Italy, Germany, and Spain, joining forces and developing expertise in the field. The Pneumonology Module allows researchers to contribute to the development of opportunities offered by artificial intelligence in respiratory medicine.

The Endocrine Diseases and Metabolism Module is led by Professor Ilze Konrāde, Corresponding Member of the Latvian Academy of Sciences. It has been developed on a networking basis, seeking collaboration with the best research institutions in Latvia, including the Latvian Institute of Organic Synthesis (IOS) Laboratory of Pharmaceutical Pharmacology and the Latvian Biomedical Research and Study Centre (BMC).

Continuing the work started at Heidelberg University, Prof. Konrāde together with peers from the IOS – Prof. Maija Dambrova, Edgars Liepiņš, PhD in Biology, and Elīna Škapare, PhD in Biology – investigated the mechanisms that delay the development of late complications of diabetes mellitus. Part of this work was carried out under the European Economic Area Financial Mechanism's academic research funding scheme project No. EEZ09AP-57, "Investigation of Novel Molecular Markers of Late Complications of Diabetes Mellitus". A team to study the iodine intake of the Latvian population, including by pregnant women, has been formed within two national research programmes with the RSU Department of Obstetrics and Gynaecology, Lolita Neimane, Head of the Nutrition study programme, the E. Gulbis Laboratory, and the IOS. The large-scale study was also successfully carried out by university students, who gained practical experience in organising the research, analysing the data, and disseminating the results. The findings showed the seasonality of iodine intake and significant iodine deficiency during pregnancy and resulted in recommendations for dietary supplementation. In collaboration with the IOS team, which has been successfully studying the molecular mechanisms of energy metabolism for a long time, endocrinology residents and RSU students are also actively involved in research, investigating the use of trimethylamine-N-oxide as a diagnostic marker of cardiovascular risk and long-chain acylcarnitines as new drug targets. This collaboration has continued with a joint application to the new national research programme.

At the same time, researchers from the Endocrine Diseases and Metabolism Module have investigated the impact of metformin on changes in the gut microbiome that may cause intolerance to the drug in collaboration with the BMC. Another aspect of research is the molecular mechanisms of pituitary adenomas and the approach to "liquid" biopsy to facilitate the diagnosis and prognosis of adenomas. The scientific collaboration with IOS and BMC is also invaluable in expanding diagnostic methods for severe, complex patients: diagnosis of new genetic variants, immunohistochemistry, and gene expression of undetectable substances such as IGF-2, measurement of long-chain acylcarnitines in blood samples from patients with mitochondrial pathology, and decompensated diabetes mellitus are just a few examples. These have been published as case reports or are being prepared for publication in peer-reviewed journals.

Assoc. Prof. Vitolds Mackēvičs is also studying metabolism. His research interests focus on diabetes, metabolic syndrome, and adiposity. The associate professor studies cytokines involved in the development of aortic valve sclerosis and the pathogenesis of migraine in neurology. These studies have been published in international cited journals and presented at international conferences.

Meanwhile, a team of RSU researchers led by Prof. Jūlija Voicehovska has completed a project to develop a cream that restores the barrier function of the skin on the face and has strong antioxidant properties. The cream's active substances are selenium of natural origin, squalane, and vitamin E, which together nourish and moisturise the skin, create a protective layer, neutralise free radicals, and prevent premature ageing. The cream's formula is patented and will soon be tendered. This research has its origins in the European Regional Development Fund (ERDF) project "Development of a New Dermocosmetic Product to Restore Skin Barrier Function for

Patients with Metabolic Syndrome". Commercialisation efforts are currently underway.

The Cardiovascular Module is headed by Prof. Oskars Kalējs, and his team includes professors and assistant professors, as well as young researchers, medical residents, and students, among them international students from RSU representing 65 countries. Employees of other RSU structural units, as well as lecturers from the University of Latvia (UL) Faculty of Medicine are often involved in the implementation of projects. Since cardiovascular problems are one of the most important contributors to mortality, from a research point of view this module covers a variety of projects. Cardiovascular research is carried out in collaboration with Pauls Stradiņš Clinical University Hospital (PSCUH) and the UL Institute of Cardiology and Regenerative Medicine, in close cooperation with the Director of the Institute, Prof. Andrejs Ērglis, Full Member of the Latvian Academy of Sciences.

Research activities and doctoral theses in various fields are carried out as part of the Cardiovascular Module:

- Mechanisms of atrial fibrillation, pharmacological and non-pharmacological treatments of atrial fibrillation, risk reduction of strokes and thromboembolism.
- Genetic determinants of rhythm control efficacy in patients with atrial fibrillation after electrical cardioversion.
- Investigation of early recognition and risk prevention of life-threatening cardiac rhythm disturbances, cardiomyopathies, and heart failure.
- Identification and prevention of the risk of sudden cardiac death.
- Sports cardiology and early identification of cardiovascular risk/sudden cardiac death.
- Early identification, monitoring, and prevention of risk factors for sudden cardiac death and life-threatening clinical events in individuals of different ages (from 14 to 85 years). Fitness levels in young athletes, veteran athletes who participate in competitions, and the general population are also analysed and studied. The multidisciplinary project was launched in 2019 as a collaboration with the RSU Department of Internal Diseases with members of the RSU Cardiology Student Scientific Interest Group as programme implementers (Loreta Briuka, MD, cardiology resident at RSU, Baiba Norīte-Lapsiņa, physician at the Children's Clinical University Hospital Sports Medicine Centre, Sandra Rozenštoka, MD, PhD, representative of the Latvian Sports Medicine Association, Andris Rudzītis, professor at the Latvian Academy of Sport Education, Prof. Kārlis Strēlis, Member of the Latvian Basketball Association Senior Council, Prof. Oskars Kalējs, Ingemārs Grēvelis, Zigfrīds Grēvelis, and others.
- Cardiomyopathies and associated risk factors in the practice of internal medicine.

As part of the Cardiovascular Module, Assoc. Prof. Kārlis Trušinskis' team is conducting research into the role of genetic variations in the early development and progression of atherosclerosis in collaboration with PSCUH and the UL Institute of Cardiology and Regenerative Medicine. As atherosclerosis and complications thereof are a global problem, the risk factors that contribute to atherogenesis in the majority of patients are being investigated and proven. However, they are incomplete, as cardiovascular disease can be observed in apparently healthy and young patients without recognised risk factors contributing to atherogenesis. Therefore, there is a need to research and find new risk markers for early diagnosis of atherosclerosis to prevent serious cardiovascular complications in these patients and in the general population. With the increasing interest in the negative impact of genetic variation and gene regulation on atherogenesis, the aim of this study is to analyse the impact of genetic variation and microRNA expression on the early development and progression of atherosclerosis in a population of young patients with coronary atherosclerosis. The study's hypothesis is that the expression of circulating microRNA and the polygenic risk score correlate with plaque progression and long-term vulnerability. MiRNA-126, -145, and -155 are being investigated with the hypothesis that expression may predict the development of atherosclerosis with a higher percentage of lipid and necrotic tissue and a lower fibrotic tissue content. This is important because such patients are at increased risk of atherosclerotic plaque rupture leading to acute coronary events and myocardial infarction.

Meanwhile, several scientific studies related to pulmonary hypertension are being carried out under the leadership of Assoc. Prof. Andris Skride. A European pulmonary hypertension registry COMPERA (Comparative, Prospective Registry of Newly Initiated Therapies for Pulmonary Hypertension) is being developed and analysed together with international peers.

They also contribute data to the RIETE registry of acute venous thromboembolisms, the world's largest database of patients with venous thromboembolism. The Pulmonary Hypertension Centre at PSCUH is actively involved in the ELEVATE-2 trial, which is investigating a completely new pathogenetic pathway in the treatment of pulmonary hypertension. The title of the ELEVATE–2 trial is A Phase 2, Dose-Ranging, Randomised, Double-Blind, Placebo-Controlled, Multicenter Study of Rodatristat Ethyl in Patients with Pulmonary Arterial Hypertension, and the Pulmonary Hypertension Centre leads this project in terms of patient recruitment.

At the same time, a project to introduce balloon pulmonary angioplasty and evaluate its effectiveness in the treatment of chronic thromboembolic pulmonary hypertension patients at the PSCUH is actively underway. This is a Latvian Research Council project, and both students and medical residents are involved in the research. The result of the project is "tangible" for patients – a new treatment method has been introduced and registered.

Regular education of current and future medical professionals is carried out jointly with specialists from the Latvian Alliance for Rare Diseases. Rare disease centres have been set up in all three university hospitals together with RSU. Conferences on rare diseases are held twice a year and the Baltic Pulmonary Hypertension and Conference is held every two years.

The Systemic and Rheumatic Diseases Module is supervised by Asst. Prof. Anda Kadiša. Asst. Prof. Kadiša, and rheumatologist Mihails Tarasovs have participated in the VirA project "Reducing networking gaps between Rīga Stradiņš University (RSU) and internationally leading counterparts in viral infection-induced autoimmunity research" since 2020. The specific challenge of the VirA twinning project is to promote networking activities between RSU and leading international partners on an EU level in the field of autoimmunity research. The project aims to strengthen close scientific collaboration with partners in Italy (the University of Ferrara), Germany (Ulm University) and Israel (Tel Aviv University). These partner universities are centres of excellence, flagships in immunology, virology, morphology, and clinical data management and modelling. They are able to stimulate positive change in the research field by making a significant impact on its future development through joint activities with RSU.

The leader of the **Kidney Disease Module** is Prof. Aivars Pētersons. Under the supervision of Assoc. Prof. Viktorija Kuzema and Harijs Čerņevskis, work is currently in progress on the national research programme project "Dissecting the interplay between intestinal dysbiosis and B cell function in the pathogenesis of immunoglobulin A nephropathy" on immunoglobulin A nephropathy (IgAN). It is an autoimmune disorder and the most common form of primary glomerulonephritis worldwide. The disease presents with variable clinical features, histological changes in renal biopsies, and progression to terminal renal failure, but the pathogenesis of IgAN is not yet clear. The project involves experienced scientists, PhD students and medical residents, nephrologists, immunologists, and molecular biologists. The aim of the project is to develop a better understanding of IgAN immunopathogenesis and disease progression, which in turn could lead to new investigation and treatment strategies for patients with IgAN. The PSCUH Centre of Nephrology has an IgAN patient registry with a biobank of patients' blood, urine, and faeces. The project is being developed by the RSU Department of Internal Diseases, the RSU Department of Biology and Microbiology, the RSU Institute of Oncology, and the PSCUH Centre of Nephrology. Morphological and immunohistological changes in renal biopsy material of patients with IgAN are being evaluated in collaboration with the Vilnius National Centre of Pathology (Prof. Arvydas Laurinavičius).

THE TEAM

The Department of Internal Diseases is the most extensive department at RSU, not only in terms of the number of people actively involved in pro-

jects, but also because of the breadth of topics that it covers. The lecturers actively participate in the work of European institutions of various medical disciplines creating recommendations and guidelines: Prof. Oskars Kalējs in cardiology, Prof. Sandra Lejniece in oncology and haematology, Assoc. Prof. Aleksandrs Derovs in gastroenterology, Assoc. Prof. Andris Skride in pulmonary hypertension, and Prof. Ilze Konrāde in endocrine diseases. Professional networking at the local, national, and international level is one of the keys to successful academic and research work.

Group picture of the staff of the Department of Internal Diseases

OPTICAL METHODS FOR MEDICAL APPLICATIONS: FROM SKIN MELANOMA AND RARE DISEASE DIAGNOSTICS TO RAPID MICROORGANISM RESISTANCE DETERMINATION

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Sight is a very important human sense. About 80% of all information that a healthy person receives from the outside world and creates experience, he gets with the help of vision. In order to facilitate the routine work of medical specialists and speed up the diagnostics, our group from the Biophotonics Laboratory at the Institute of Atomic Physics and Spectroscopy, University of Latvia, in cooperation with industry specialists from Riga Technical University, Pauls Stradiņš Clinical University Hospital, Latvian Oncology Centre, Semmelweis University in Hungary, and others, develop various optical technologies that analyse multimodal digital vision information for specific purposes.

A DEVICE THAT ACCUMULATES EXPERIENCE IN DERMATOLOGY

In a profession such as a dermatologist, experience is a very important factor in the diagnosis of skin lesions, and it takes a long time to acquire such experience. Technologies based on optical methods, which accumulate visual and multimodal images, or accumulate experience using artificial neural network algorithms, can be a good support and helper for new doctors or medical personnel without experience in dermatology. Our group has been working on this technology for more than ten years. Initially, a multispectral melanoma diagnostic parameter was created that distinguishes nevi from melanomas with high accuracy (>95%) [1, 2]. But to create a classifier capable of distinguishing many more classes of skin lesions, an artificial neural network algorithm was created that was trained on multispectral and autofluorescence images of various skin lesions accumulated over the years [3]. In order to bring this knowledge to the initially set addressees – dermatologists, as well as medical specialists without experience in dermatology, we have chosen to establish our own start-up company, with the help of which we can commercialise the developed methods. This study demonstrates the entire research cycle from problem definition, method development to device construction and commercialisation.

Continuing the direction of multispectral and autofluorescence research, attention is paid to patients with rare diseases, one of the signs of which are lesions on the skin. In order to update this topic and help discover undiagnosed patients, in addition to multispectral and autofluorescence imaging, a special patient search tool is being developed in cooperation with LTD Longenesis, which will allow in the future, based on the patient's medical data, to find the patient and invite him to multispectral and, if necessary, genetic analyses.

RAPID DETECTION OF MICROORGANISM RESISTANCE

Another area of medicine where optical methods can significantly speed up diagnostics and decrease

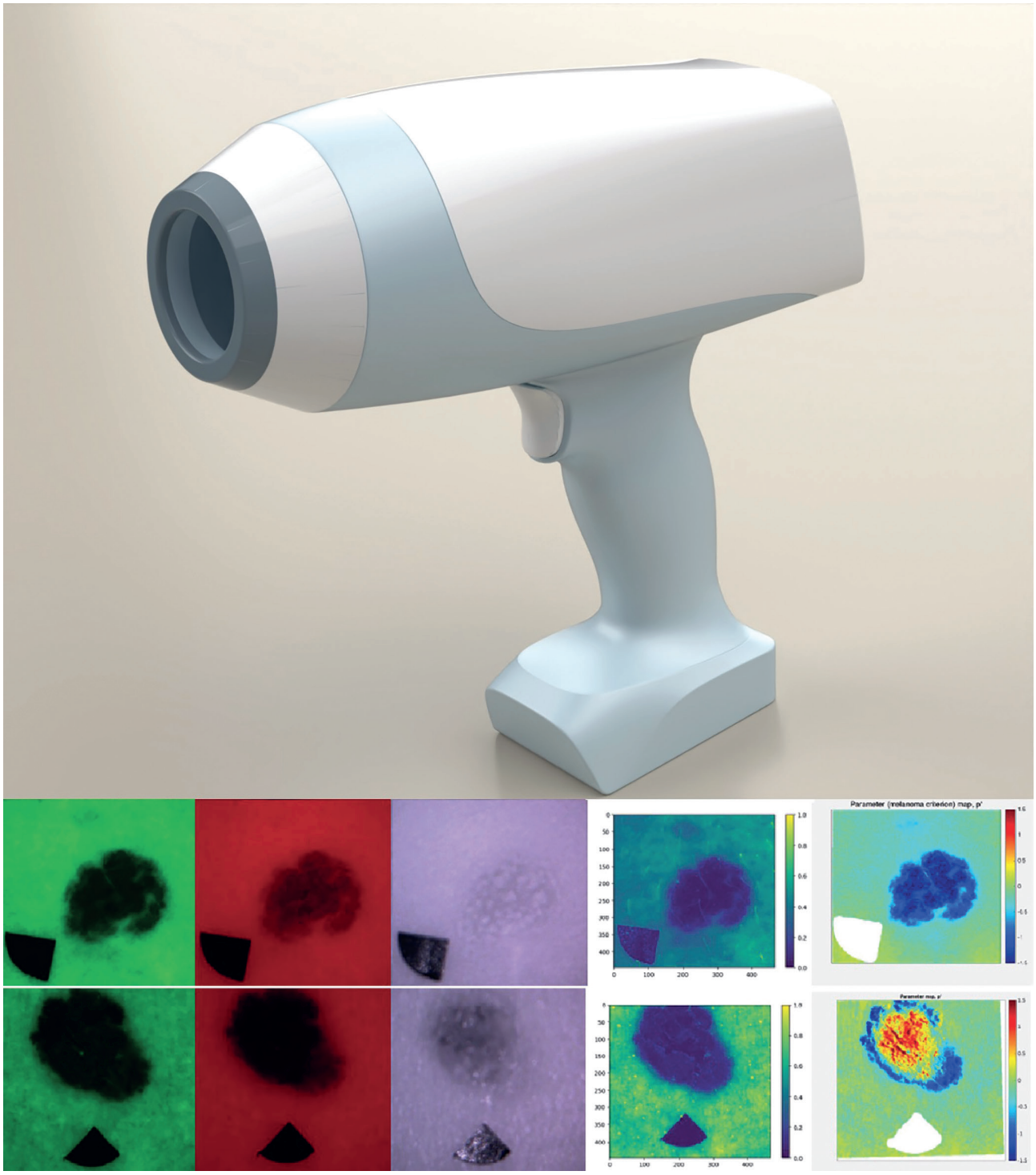

Fig. 1
Melanoma detection and skin lesion classification device prototype and the resulting G, R, IR and diagnostic criterion *p'* maps for nevus and melanoma

delays in receiving a targeted therapy, is the determination of antibacterial susceptibility. Antimicrobial susceptibility tests are performed to determine antibacterial resistance and sensitivity to antimicrobial agents. Rapid identification of the antimicrobial susceptibility plays a crucial role in sepsis treatment. Currently identification of antimicrobial resistance (AMR) is provided by phenotypic or genotypic tests. There are several phenotypic antibacterial susceptibility tests based on bacteria growth (disk diffusion and E-tests) and molecular methods for genotypic AMR tests (e.g., polymerase chain re-

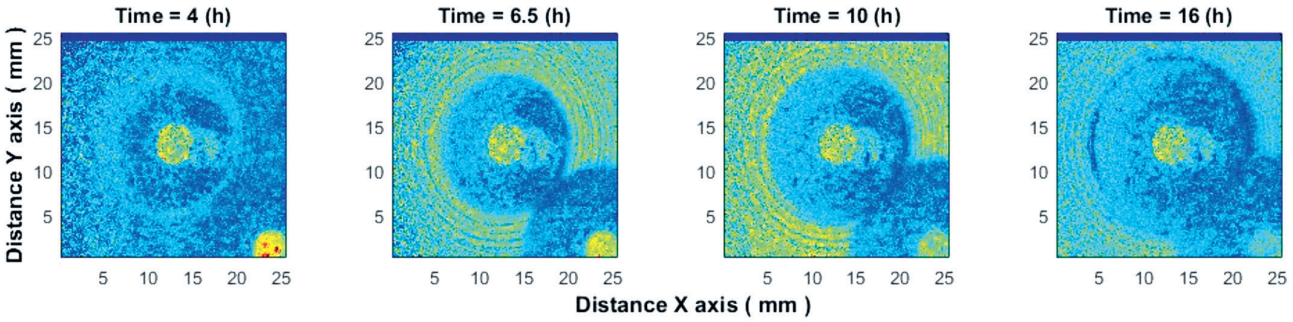

Fig. 2
Laser speckle technique with sub-pixel analysis for calculation of sterile zone diameter for disk diffusion method.

action (PCR) and others). The gold standard to determine the phenotypic AMR is the disk diffusion test based on the growth of microorganisms under the influence of antibiotic diffusion from the antibiotic-saturated paper disks. In the disk diffusion method, bacteria are seeded on an agar medium and targeted antibiotic disks are placed. After 12–48 hours, the diameter of the sterile zones formed around the disks is determined visually. Despite the fact that genotypic AMR tests are significantly more rapid (results are obtained within several hours) than disk diffusion tests, they should still be confirmed with phenotypic tests [4]. Using the laser speckle imaging with a sensitive sub-pixel analysis method, it is possible to predict the sterile zones much earlier than the standard method using human vision. We expect to be able to improve and speed up the execution time of the existing standard method.

SUMMARY

Optical, multimodal techniques can supplement the visual information we get with sight. Augmented digital vision in medicine can help obtain information that cannot be done visually using vision. By using these technologies, we can significantly improve industries that use visual information. Our group is made up of scientists, multidisciplinary experts and entrepreneurs that enable us to create research methods, incorporate them into technologies and further commercialise them for public use.

ACKNOWLEDGMENTS

This work has been supported by the European Regional Development Fund projects “Effective identification and multimodal diagnosis system for rare skin diseases” (No.1.1.1.1/20/A/072), “Rapid assessment system of antibacterial resistance for patients with secondary bacterial infections” (No. 1.1.1.1/21/A/034), and L’Oréal-UNESCO For Women in Science Young Talents program – Baltic 2022.

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NOW IS THE TIME FOR OPEN INNOVATION

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Amidst the gloom and doom of the early months of the COVID-19 crisis, something surprisingly uplifting started to happen: companies began to come together to work openly at an unprecedented level, putting the ability to create value before the opportunity to make a buck. The German multinational Siemens, for instance, opened up its Additive Manufacturing Network to anyone who needs help in medical device design. Heavy truck maker Scania and the Karolinska University Hospital have partnered, too: Scania is not only converting trailers into mobile testing stations, but also directed some 20 highly skilled purchasing and logistics experts to locate, acquire, and deliver personal protective equipment to health care workers. Similarly, Ford is working together with the United Auto Workers, GE Healthcare, and 3M to build ventilators in Michigan using F-150 seat fans, portable battery packs, and 3D printed parts.

Collaboration can obviously save human lives, but it can also produce huge benefits for companies – even though it is often overlooked in normal circumstances. For more than a decade, we have studied open innovation and have taught thousands of executives and students how to innovate in a more distributed, decentralised and participatory way. The classroom response is usually, "My company needs more of this!" But despite the enthusiasm, companies rarely follow through. We have also witnessed how companies have used hackathons and other forms of open innovation to generate heaps of creative ideas that never reach the point of implementation, leading to frustration among employees and partners. At many companies this kind of distributed, decentralised, and participatory way of innovating remains an ambition that has not yet come true.

The recent burst of open innovation, however, reminds us of the massive potential that open innovation comes with – whether you are in a crisis or not. Open innovation has the potential to widen the space for value creation: It allows for many more ways to create value, be it through new partners with complementary skills or by unlocking hidden potential in long-lasting relationships. In a crisis, open innovation can help organisations find new ways to solve pressing problems and at the same time build a positive reputation. Most importantly it can serve as a foundation for future collaboration – in line with sociological research demonstrating that trust develops when partners voluntarily go the extra mile, providing unexpected favors to each other.

While concerns over intellectual property, return on investments, and various unforeseen consequences of open innovation are all valid, what we are experiencing now is an opportunity to innovate through and beyond the crisis. We have discovered several lessons that can help companies to not only take advantage of open innovation during the COVID-19 crisis, but to embrace open innovation once the pandemic is over.

Here is how companies can overcome some well-known challenges in open innovation.

FORGET ABOUT THE IP FOR THE MOMENT

Earlier research has found that many companies are extremely worried about value "leaking" from collaborations with outsiders. As a result, they often stick to their knitting and collaborate on a few peripheral tasks, but not on the most important business issues. For example, we are aware of several chemical companies in Europe and the U.S. that made it practically impossible for their open innovation partners to pro-

From the left: Academicians of the LAS Baiba Rivža and Ivars Kalviņš, President of the LAS; and Dr. Kannan Vishwanatth having been awarded the Diploma of the Honorary Doctor of the Latvian Academy of Sciences

vide help and advice. How? They wouldn't reveal what their most critical problems entailed, as that could endanger future patenting. Instead, the innovation partnerships slipped into irrelevance.

These intellectual property concerns are of course real and important, but they risk blocking any open innovation initiative from gaining momentum. However, during the COVID-19 crisis it could be wise to focus more on creating value than capturing value. Smart companies take a leap of faith, collaborating on important stuff, without risking negative exposure. For example, if heavy truck maker Scania – a company known for its world-class manufacturing system – sends some of its best manufacturing experts half an hour north to work at Stockholm-based Getinge to ramp up their ventilator production, it risks none of its core technological assets but by contributing to the effort to build medical capacity and combat the virus, hopefully it is speeding up how quickly its own plant will be back up and running.

LEVERAGE TWO-SIDED MOTIVATION

As the initial open innovation enthusiasm has settled, companies often realise that they rely on voluntary and active participation of employees and partners to succeed – traditional means of command and control have little reach. Instead companies need to rely on a combination of hard and soft incentives to motivate internal and external collaborators.

Companies need to identify – and respond to – their partners' true motivation. For example, our own research on open-source software development has demonstrated a diverse set of motivations among developers. Some developers are motivated to freely share their code because of labour market signalling. Other developers are driven by strong ethical concerns, vigorously opposing any move to develop software that cannot be inspected, modified, and openly shared. And some companies are motivated to donate time and resources because it is an effective means to access complementary skills and assets.

Aligning all of these motivations with what companies wish to achieve takes effort, curiosity and a portion of humbleness. While this might be easy in the early stages of a collaboration that is responding to the pandemic, companies should not expect collaboration beyond the pandemic to go as smooth. Instead, it is worth putting the work in ahead of time to discover – and potentially nudge – partners' motivation.

EMBRACE NEW PARTNERS

A common challenge in open innovation is to take on new partners. New partners always entail costs in terms of search, validation, and compliance, as well as the forming of new social relationships between people. And we know that when it comes to big thorny problems like COVID-19, new partners are necessary to provide complementary skills and perspectives.

The massive scale of the COVID-19 crisis may have alleviated these challenges in at least two ways. First, top management has assumed a lot of the risk associated with new partners, by sending strong messages that open innovation is the way to go. For example, Jim Hackett, Ford's president and CEO says he has empowered his engineers and designers to be "scrappy and creative" when collaborating with GE Healthcare to find solutions to the crisis.

Second, not only the spread of the virus has grown exponentially but the pool of potential partners as well. When companies across the globe are affected by the same crisis, and many are searching for new ways to conduct business, a combinatorial exercise suggests that there are many better partners available now than a month ago. A crisis can prompt companies to explore a greater number and even new kinds of partners. Preserving some of that openminded attitude towards new partners after the crisis can help companies stay on top of innovation.

URGENCY LEADS TRANSFORMATION

The initial steps towards open innovation in "normal times" are relatively simple. For example, hire some consultants, set up an innovation tournament, wait for ideas to come in. The results though are usually quite meagre. To fully reap the rewards from open innovation, companies need to recognise the transformational challenge ahead. These initiatives are often the tip of the iceberg, and successful open innovation often requires operational and structural changes to how business is done. Such changes are difficult for any one employee, team, or even business unit to undertake.

In a time of crisis, the necessary executive focus is suddenly there. Smart companies seize this opportunity to rethink their innovation infrastructure. Perhaps our own sector, higher education, could stand as a beacon of hope that open innovation can work on a truly grand scale – and that a conservative sector can change. Many of us were told that classes starting the day after had to be replaced by digital alternatives. Much was left for individual teachers to figure out, but university presidents sent reassuring messages endorsing experimentation and clearing bureaucratic hurdles. In the past few weeks, academics across the globe have been collaborating, sharing tips, tricks, teaching plans, and experiences to turn an often slowmoving colossus into an agile digital sprinter. It shows that often the biggest barrier to successful open innovation is simply the reticence to commit to it.

LOOKING AHEAD

These are promising developments. But to what extent will these observations hold true in the future? As business will one day go back to normal, how many of the altered ways of innovating will stick inside companies? And how will we as a society face other grand challenges, such as global warming, that are no longer looming on the horizon but are already here? We hope that the world's response to the novel coronavirus has taught us that a truly shared experience of a common enemy can unlock the speed, strength and creativity needed to address even the greatest challenges.

For managers, an important reflection is to think about what needs to be delivered after the crisis. A

big crisis often alters the behaviour of customers, employees, and partners. Perhaps you have reason to believe the customer preferences will stay the same, but often they do not. Having established new ways of doing open innovation during a crisis can then bring much-needed flexibility and, in the end, secure the company's viability. Don't waste those experiences by planning for how to get back to the old normal. Plan for a new normal.

CULTIVATION OF SHIITAKE MUSHROOMS IN LATVIA

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We Latvians are proud of our forests and underrated nature gems like mushrooms. Although shiitake mushrooms have not traditionally been grown in Latvia, it is possible to cultivate these mushrooms outdoors, the vagaries and occasionally harsh weather conditions encountered in Latvia notwithstanding.

During the mid-1990s, growing shiitake mushrooms became popular in Latvia. Cultivation of these mushrooms was advocated by Professor, *Dr. habil.* biol. Indriķis Muižnieks of the Faculty of Biology, University of Latvia, and research was carried out, as well as in-house production of the mycelium. The Latvian Association of Shiitake Mushroom Growers (LASMG) was founded in 1998 and in cooperation with the University of Latvia, it engaged in educational work about shiitake cultivation for Latvian and foreign growers as well as researchers of shiitake mushrooms. From 1998 onwards, Imants Urpens a member of the LASMG, cultivated shiitake mushrooms at his property within the farm "Sita&ke", the latter registered in 2001 as a commercial entity (located in Aloja comprising 45 ha of woodland) is one of the venues for training recognised by the LASMG. Circa 2000, the LASMG had almost 200 members from various regions of Latvia. Of these members, active mushroom cultivation now takes place only at the "Sita&ke" farm. Imants Urpens offers fresh shiitake mushrooms, in addition to holding classes on growing shiitake mushrooms both outdoors and indoors. Shiitake (*Lentinula edodes*) is an edible mushroom belonging to the Agaricomycetes class. It has been cultivated in Asia for centuries. Shiitake fruiting bodies are rich in B and D vitamins, polysaccharide lentinan, and contain high concentrations of essential amino acids as well as trace elements of copper, iron, phosphorus, potassium, calcium, manganese, and magnesium. The stem of shiitake mushrooms is a significant source of zinc (83µg/g) [1]. Concentrations of active substances in shiitake mushrooms has attracted healers in various countries, and these mushrooms have been used throughout Asia to treat colds, to prevent and to cure cancer, to treat various liver diseases, to reduce chronic fatigue, to enhance libido, and to address other health conditions. Furthermore, in China shiitake mushrooms are used to improve libido – research carried out at the University of Latvia on drosophila [2] and small rodents supports this theory. Current ongoing worldwide research and clinical trials on humans continue to substantiate knowledge that originates in Asia.

CULTIVATION OF SHIITAKE MUSHROOMS AT THE FARM "SITA&KE"

Shiitake cultivation starts with first choosing a suitable environment for the mycelium. Shiitake mushrooms may be grown on straw, on various types of bran, on logs cut from deciduous tree, on shavings, and other media. The taste and appearance of the mushrooms depend on the substrate and the nutrients available to the mycelium. Thinner shiitake mushrooms grown in modest conditions are known as Koshin, while those with thicker caps and a richer taste are known as Dongo.

The production process at "Sita&ke" farm begins with identification of high-quality trees for use as mushroom logs. Logs for shiitake mushrooms, must not be damaged in any way, nor have any branches, and must have a clean core without the slightest suspicion of the presence of the mycelium of any other mushrooms. Typically, a single log will suffice to produce shiitake fruiting bodies over 2–4 years.

A typical burst of shiitake fruiting bodies growing outdoors on a log

Presently, the farm is experimenting with recourse to high-quality oak logs with a diameter greater than 30 cm. Mycelium inoculated into such logs has delivered a mushroom harvest over fifteenth years and is likely to produce mushrooms for at least another five years. It is crucial scrupulously to follow the following procedure when shaping logs intended for the cultivation of Shiitake mushrooms.

Once selected trees have been cut to produce the desired logs, they are cleaned and mycelium is inoculated. Shiitake mycelium inoculation is careful and delicate manual work and it is not automated at "Sita&ke" farm, to avoid errors that accidentally ruin the delicate mycelium. In the early 2000s, the mycelium required for mushroom grafting was obtained via the University of Latvia, but presently high-class mycelium is sourced directly from Polish growers of Shiitake mushrooms. With a view to increase the mushroom yield in Latvia, logs are grafted with 20% more mycelium than in the classic method [3]. Routine implementation of this approach the Shiitake mycelium has grown in 100% of all samples with

Outdoor cultivation of shiitake mushrooms in the deciduous forest at "Shita&ke" mushroom farm. At harvest time – logs are replete with shiitake mushroom fruiting bodies

the logs delivering an impeccable harvest.

After their inoculation, the logs are brought out of doors and placed in the middle of the forest located on farm territory. This is the only outdoor Shiitake mushroom farm in the Baltic States where the mycelium development processes within the logs proceed undisturbed for 2–4 years.

For the mycelium to multiply and produce fruiting bodies, logs must undergo rapid fluctuations in temperature and humidity, akin to conditions in Japan resulting from earthquakes and rapid changes in climate that Shiitake mushrooms undergo in their homeland. In Latvia change of humidity levels result from rain and by soaking logs in the river or in special baths. Supplementary temperature fluctuations are induced by heating the logs in a sauna and then allowing them to cool in the anteroom. Oscillations that imitate an earthquake are achieved by

moving the mushroom logs several times, turning them upside down.

Mushroom fruiting bodies begin to appear on logs after they have been subjected to "stress". Shiitake mushrooms can produce D vitamins in sunlight, so it is exceptionally important that the farm be located in a forest and that the mushrooms also receive sunlight even on cloudy days. Once the fruiting bodies of the mushrooms have grown, they have to be split off by hand. One mandatory requirement is to break off the whole fruiting body together with the stem. Each precisely broken stem will have a small piece of wood attached: one that attests to a properly developed and correctly harvested mushroom. No knife or any other sharp object should be used during harvesting, because leaving part of the fruiting body on the log, i.e. a remnant of the stem may start to rot, or open the door to another mycelium and thus destroy the Shiitake mycelium in an entire log. Typical logs, made of alders, are productive for two to four years until the mycelium has processed all the wood.

Shiitake mushrooms are available at the "Sita&ke" farm all the year round with an annual output of 4 tons. Both fresh and dried mushrooms are on offer. Before drying, mushrooms are cut into slices, thereby expanding the surface facing the sun. Mushrooms are dried outdoors, thus additionally increasing the vitamin D content [4] that is produced while growing in the forest. The finished product is in the form of an entire dried mushroom, shiitake mushroom chips, and powder format. The grower also offers five varieties of teas with specially selected ingredients that promote the healing properties of these mushrooms. Today, they are used in Latvia for prevention of malignant tumors, to stabilise sugar levels, to relieve chronic fatigue, to lower cholesterol levels, and to improve liver function.

Two groups of people constitute the demand in Latvia for shiitake mushrooms. The first group comprises gourmets who enjoy these mushrooms for their taste. The second group uses the mushrooms to improve their health. Correspondingly, Latvia can be proud of the ability to endure other nations' natural resources characteristic of folk medicine and adapt them to the climate of Northern Europe and use them for alternative treatment methods.

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Translated by **Eduards Bruno Deksnis**

ON PEAT ART AND RESEARCH

EDGARS AMERIKS
B. A., peat researcher, artist

Peat Workshop. Riga, 2018

TRADITIONS AND THEIR SIGNIFICANCE

Our future depends on our level of responsibility, knowledge, skills, determination, and culture. Over the course of more than ten years gaining experience in research and innovative use of peat, new traditions were born in Latvia that are unique and to be found nowhere else.
The opportunities our land provides should be studied and appreciated to facilitate future development. The use of peat in art and design has defined a wide range of brand new opportunities for application and research principles. Peat has defined a new culture that requires a more deeply evaluated and conscious attitude to the developments of our time.

ART AND INNOVATIONS

Art and innovation are in absolute harmony and they are dependent on each other. Creative work can change perceptions and experimental and practical aspects drastically. I believe that innovation cannot be planned and defined ahead. Instead it should be discovered and practically substantiated step by step. An artist, as opposed to a scientist, works on an emotional level and tends to achieve emotional enjoyment. Those are basically natural processes that facilitate research which is dependent on emotion. The peat extraction and swamp management industry of today is still quite primitive. It is fairly recent and based on historically accepted principles that are stagnating and do not match the age. Historically, the experience of the West and the Soviet Union point to an unwelcome scenario in swamp and peatland management. Latvia is at a starting point to become a role model in the management of swamp and peat extraction areas. In this industry innovation can only be anticipated and developed in carefully and responsibly prepared areas.

ALTERNATIVE USE OF PEAT

Ever since 2008, I have been using peat in my creative process and have got to know this unique material from a whole different perspective. Alternative ways of using peat were created – from geological research to preparation work. Ways to use peat in the production of premium products:
Peat coated plywood,
Peat composite materials
Decorative peat plaster
were studied.
These materials have been used in a number of projects in Latvia and abroad, their practical endurance is inspected. It has been proven that peat may be used in the production of finished materials, furniture, and decorative items.
In order to use the full potential of peat as a resource it is extremely important to assess the swamp industry as a whole and define its strategy on a national level. Peat extraction should be supported by products with the highest added value and adapted to consumer demand. Currently, peat extraction areas have been prepared experimentally and technologies have been developed specifically for this alternative use in Latvia.

EDUCATION AND CULTURE

It surprises me how it is still possible to discover a natural resource with potential that has not yet been tapped into. Technologically it could have been possible centuries and even millennia ago, however, the human mind can only grasp the true meaning and value of nature today. It points to the cultural level of the 21st century that encourages an in-depth study of this industry. Nowadays, the survival instinct has changed and it is in balance with nature.
In order to prepare peat material for use in art and design all the underlying processes had to be acquired anew. There was no advice or educational information available. These circumstances define a brand new and unique work culture that may be acquired only through practical learning from mistakes. Public opinion plays a significant role in this process. Educational cultural events are organised to this end.
Peat allows one to learn about nature and technical skills. This material can be processed easily and fast using only one's skills and manual work. This technique is especially effective and suitable for the new generation development. The phenomenon of

Restaurant L' Ecorce Concept Store. France, Courchevel 1650 (Moriond), 2016

Peat Art Studio. Gallery. Riga, 2018

peat is a never-before-seen contrast determined by its texture, content and qualities. Moreover, there is currently a lack of understanding in society regarding the material itself and its origin, consequently new knowledge about our rich natural resources and their influence is imparted.
The influence of peat on art is especially significant. The unique material palette is defined as the artist's original technique and raises great interest in the process as a whole. Conceptually all artwork made from peat is primarily positioned as the human understanding and responsibility towards nature. The pieces are very fragile and the slightest physical touch breaks them down. It means this artwork can be affected negatively by human beings just like nature. These items show one's cultural level and attitude.

MISSION

To develop the significance of peat and its impact on education, culture, science, and art. The philosophy of peat sets higher standards for subordinated fields and one's responsibility. Participation in international projects and events clearly points to the impact of peat as a significant resource in education and culture. The rapid development of peat innovation shows that a considerable contribution is required for the development of the industry. In the context of Latvia, the potential of this resource should be assessed and a strategically substantiated action plan should be developed.

EXTERNAL LINKS

http://www.edgarsameriks.com
https://www.discoverthepeat.com
https://www.facebook.com/kudrasmakslasdarbnica
https://www.instagram.com/peat_house/
https://www.instagram.com/discoverthepeat/
https://www.linkedin.com/in/edgars-ameriks-85b11960/
https://www.youtube.com/channel/UCtxf4nUYilFiZNflsr-ySqA
https://pin.it/7eEQUEd

ABOUT THE LATVIAN ACADEMY OF SCIENCES

ILZE TRAPENCIERE
International Department, Latvian Academy of Sciences

The mission of the Latvian Academy of Sciences is to identify, select, and unite distinguished scientists at a national level, to carry out scientific expertise, to care about development and promotion of national science, and endorse implementation of the national science policy aimed at facilitating competitiveness and growth of the national economy. With its almost 400 full members, corresponding, foreign, and honorary members, and support from the entrepreneurs, Latvian Academy of Sciences is a significant centre of intellectual and scientific life, a place of the technology transfer, place of rapprochement between science and entrepreneurship at the shores of the Baltic Sea. Latvian Academy of Sciences organises its work in line with the common European Science and innovation policy in collaboration with government officials, policy executives, scientific and educational institutions, entrepreneurs, local municipalities and non-governmental organisations, as well as foreign partners. The Latvian Academy of Sciences endorses acknowledgement of scientific achievements, participates in the development of national economy and provision of a sustainable society. All the important issues are discussed at the Senate of the Academy, but the decision making is the prerogative of the General Meeting of the Academy.

STRUCTURE AND MANAGEMENT OF THE LATVIAN ACADEMY OF SCIENCES

The Latvian Academy of Sciences works in accordance to the Charter of the LAS (adopted in 1996, with amend.), Statutes of the LAS (1992, with amend. 2012), and the Code of Ethics (1997, amend. 2017).

The highest decision-making body of the Latvian Academy of Sciences is the General Assembly, where elected full, honorary, foreign, and corresponding members participate.

The General Assembly elects the President, three Vice-Presidents, the General Secretary, International Secretary, the Senate and the Board of the Academy. In between General Assemblies, the work of the Latvian Academy of Sciences is headed by the President and the Senate. The Senate of the Latvian Academy of Sciences is a decision-making body. Together with the President of the Academy and the Secretary General the Senate coordinates the work of the academy between the General Meetings.

The composition of the Latvian Academy of Sciences is the following:

- full members (academicians),
- honorary members,
- foreign members,
- corresponding members.

The number, nominations and discussion of the candidates is determined by the Statute of the Latvian Academy of Sciences (1992, with Amendments).

The Board of the Latvian Academy of Sciences regularly discusses and audits the fulfilment of the objectives and tasks of the academy, including the economic activity of the Academy. The Board is headed by the General Secretary.

There are four core structural units forming the Academy, taking responsibility on stepping up research results, increasing academic qualification, exchanging research experience and mobility of scientists, and organisation of workshops and conferences.

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https://www.facebook.com/latvijaszinatnuakademija

https://www.youtube.com/user/lzalatvia

GOVERNANCE

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