LITHUANIAN
ENERGY
INSTITUTE

ANNUAL REPORT 2022

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FOREWORD

MESSAGE FROM THE DIRECTOR

In 2022, the Lithuanian Energy Institute (LEI) further expanded its cooperation with business and research institutions, actively participated in national and international research projects, with a special focus on addressing energy transition, climate change mitigation and other challenges related to the implementation of the European Green Deal.

LEI actively participates in international networking organisations. At the end of 2021, the Institute became a member of EARTO, the European Association of Research and Technology Organisations, and was actively involved in its activities throughout 2022. The Institute also participates in specialised networking organisations such as the European Energy Research Alliance (EERA) and the European Technical Safety Organisation Network (ETSON). A successful example of such collaboration is the LEI coordinated Euratom (a complementary *Horizon Europe* sub-programme) project HARMONISE "Towards Harmonisation of Licensing of Future Nuclear Energy Technologies", which was initiated at ETSON and launched in June 2022. Moreover throughout 2022 LEI started participation in 9 new international projects.

A large part of the Institute's projects portfolio consists of contracts with business entities. In 2022, important new contracts were launched with the Port of Klaipėda, Ignalina NPP, electricity distribution system operator "Energijos skirstymo operatorius" AB and other customers. Notable contracts initiated in previous years were continued in 2022. Contracts funded by electricity transmission system operator Litgrid AB, Krško NPP (Slovenia), Axis Tech UAB and other business partners were completed.

In addition to research activities, infrastructure development projects were intensively pursued in 2022. All LEI staff felt the impact of the two projects to improve the energy efficiency by implementing modernisation of the Institute's buildings, as they had to temporarily adapt to the schedules of ongoing construction works. The modernisation of buildings will be completed in 2023, however, we are already enjoying a reduction in heating costs due to increased energy efficiency. Another important infrastructure project is a 500 kW solar power plant, which will be completed on the LEI site in 2023 and will reduce the Institute's electricity costs. In order to improve working conditions for staff during the summer heatwaves, air conditioning system was installed in one of the buildings in 2022. Further expansion of air conditioning system for other buildings is planned for 2023 – 2024.

In recent years, increasing State budget funding for R&D&I activities, rising revenues from international projects, contracts of Lithuanian and foreign companies and national competitive funding have ensured that the Institute's annual revenues have almost doubled over the last 5 years. This has led to the average salary of LEI staff being one of the highest among Lithuanian State research institutes and universities.

The consistency and effectiveness of the Institute's activities and its prospects depend to a large extent on attracting young people to the Institute. With the LEI's active participation in organised career and public events this has been a major focus for several years. Encouragingly, this is bearing fruit, with the number of PhD students at the Institute more than doubling in the past 5 years (from 19 in 2017 to 42 in 2022). However, attracting young people and PhD students remains a challenge, and we actively encourage young people to come to the LEI for internships, employment and PhD studies. We are delighted with the activity and recognition of the LEI's young scientists – in 2022 Dr. Andrius Tamošiūnas has been elected as a member of the Lithuanian Academy of Sciences Young Academy and became the fourth representative from the Institute.

Dr. Sigitas Rimkevičius, Director of LEI

CONTENTS

MISSION

To conduct research and develop innovative technologies in the fields of energy, thermal engineering, environmental engineering, measurement engineering, materials science and economics, to carry out fundamental and applied research, to participate in study processes, to transfer the results of applied research and innovations to industry, to advise the state, the government, public, private institutions, and companies on issues related to the development of sustainable energy in Lithuania, to cooperate actively with higher education institutions in the preparation of specialists for the Lithuanian society.

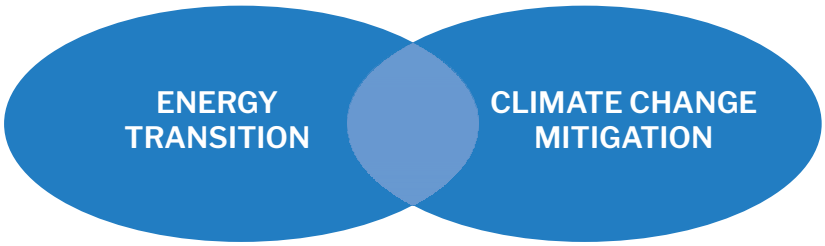
LITHUANIAN ENERGY INSTITUTE (LEI) IS INTERNATIONALLY RECOGNIZED ENERGY-RELATED RESEARCH, DEVELOPMENT AND INNOVATION (R&D&I) COMPETENCE CENTER.

OBJECTIVES OF THE INSTITUTE'S ACTIVITIES

- To perform long-term international level fundamental and applied research, to ensure international excellence in the fields of technology and social sciences, and carry out long-term fundamental and applied research and innovations of an international standard, which is necessary for the sustainable development of the Lithuanian energy sector and the rest of the Lithuanian economy sectors, and for its integration into the European energy systems and the European Research Area;
- In cooperation with industry, government and society, to transfer knowledge and innovations into technically and commercially useful processes and equipments, ensuring the development of energy technologies and the rational evolution of energy systems, the security and reliability of energy supply, the efficient use of energy resources, the protection of the environment and the reduction of climate change;
- To disseminate knowledge to the public and contribute to the creation of an innovation- and knowledge-based Lithuanian economy;
- Initiate and actively participate in Lithuanian and international programme's projects, expand cooperation with Lithuanian and foreign research and educational institutions and scientists;
- To carry out the functions of the designated Institute in accordance with the provisions of the Law on Metrology of the Republic of Lithuania;
- In cooperation with universities, to train scientists of the highest competence for research in the fields of economics, energy and the environmental engineering, and to ensure the attraction and career development of doctoral students.

LEI STRATEGIC R&D TOPICS

Research and development activities in the fields of technology and social sciences.



- Research on economic development in the transition to a climate-neutral society
- Impact of climate change and human activities on water and energy resources
- Smart energy systems and Climate-neutral cities
- Advanced materials, Thin films and Nanomaterials
- Hydrogen technologies
- Bioenergy, Waste-to-Energy
- Nuclear Fission and Fusion energy
- Thermal physics, Fluid dynamics and Metrology

INSTITUTE'S RESEARCH AND DEVELOPMENT DIRECTIONS

- Renewable energy and technologies enabling it;
- Environmental impact of climate change and anthropogenic activities;
- Economic development research towards climate-friendly economy;
- Modelling of energy systems and research of their control systems;
- Safety and reliability of industrial and energy facilities;
- Thermal physics, gas and fluid dynamics and metrology;
- Decommissioning of nuclear facilities and radioactive waste management.

LEI IN NUMBERS

220+	EMPLOYEES
130+	RESEARCHERS
40+	PhD STUDENTS
10+	RESEARCH LABORATORIES
10+ mln. Eur	R&D INFRASTRUCTURE
10+ mln. Eur	ANNUAL INCOME
60+	ANNUAL R&D CONTRACTS

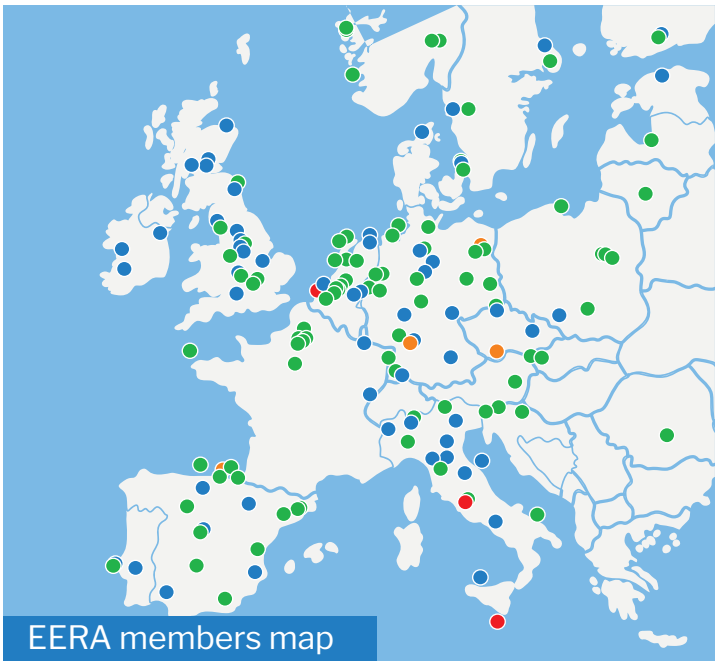
LONG-TERM RESEARCH AND EXPERIMENTAL DEVELOPMENT PROGRAMMES (2022-2026 M.)

- Development and integration of advanced energy technologies.
  Manager – Dr. Raimondas Pabarčius
- Interdisciplinary research on decarbonisation and adaptation to climate change.
  Manager – Dr. Vidas Lekavičius
- Investigation of process regularities and resulting products in innovative energy/technological systems that use renewable resources.
  Manager – Dr. Robertas Poškas
- Numerical investigations of safety issues and processes in the facilities for spent nuclear fuel and decommissioning radioactive waste storage and final disposal.
  Manager – Dr. Artūras Šmaižys

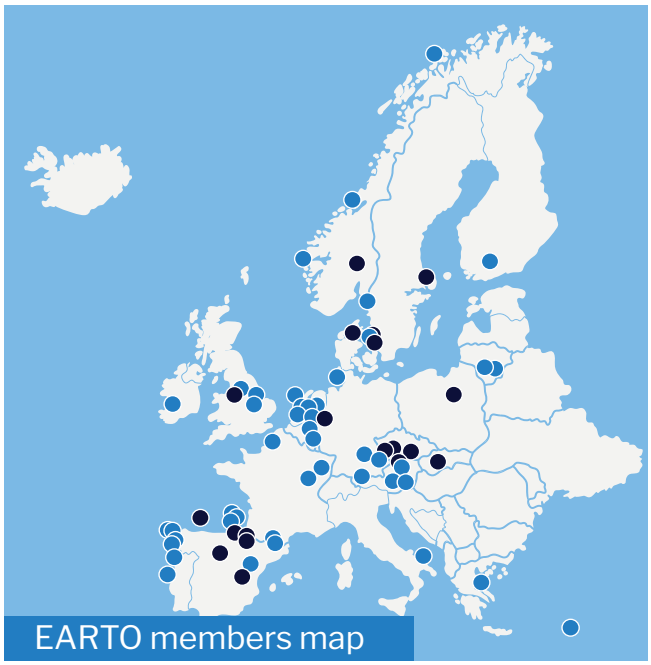
MEMBERSHIP IN INTERNATIONAL ORGANISATIONS

- European Association of Research and Technology Organisations (EARTO)
- European Energy Research Alliance (EERA)
- European Safety, Reliability & Data Association (ESReDA)
- European Network of Freshwater Research Organisations (EurAqua)
- The European Association of National Metrology Institutes (EURAMET)

- Sustainable Nuclear Energy Technology Platform (SNETP)
- Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP)
- Nuclear Generation II & III Association (NUGENIA)
- European Technical Support Organisations Network (ETSON)



EERA members map



EARTO members map

MAIN LEI EVENTS

- **30-31 March 2022.** LEI took part in the international conference “Career & Studies” held at LITEXPO exhibition centre , an international exhibition on learning, knowledge and career planning.
- **24-28 May 2022.** The annual international conference CYSENI was held online. The conference was organised jointly by LEI, LAMMC, FTMC, RTO.LT.
- **5 June 2022.** Lithuanian Energy Institute scientists took part in the “Green Ideas Festival” at the Presidential Courtyard, Vilnius.
- **10 June 2022.** Scientists from the Institute participated in the event “Sustainable Future Developers’ Lab WITHOUT WASTE. 2022”, Klaipėda.
- **26 October 2022.** LEI participated in the KTU “WANTed” Career Days.
- **15 November 2022.** LEI participated in the VMU “My Career 2022” Career Day.

ACHIEVEMENTS OF OUR EMPLOYEES

- Dr. Andrius Tamošiūnas, Deputy Director of LEI, has been elected a member of the Young Academy of the Lithuanian Academy of Sciences.

- Dr. Vytautas Akstinas, a researcher at the LEI Hydrology Laboratory, received an award at the *LMA Young Scientists' and Doctoral Students' Best Research Paper Awards* in the Biology, Medicine, and Geosciences subsection for his work on the assessment of the historical extreme hydrological phenomena of the Lithuanian rivers and their prognosis in the context of the climate change.

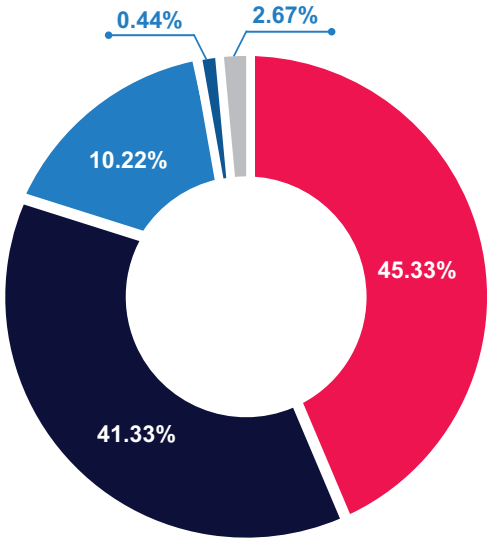
- Four employees of the Lithuanian Energy Institute were awarded at the celebration organised by the Lithuanian Electric Energy Association (LEEA): Dr. Sigitas Rimkevičius, Dr. Arvydas Galinis, Dr. Virginijus Radziukynas and Dr. Vidas Lekavičius.

A. Tamošiūnas

V. Akstinas

SCIENTIFIC ACTIVITY RESULTS

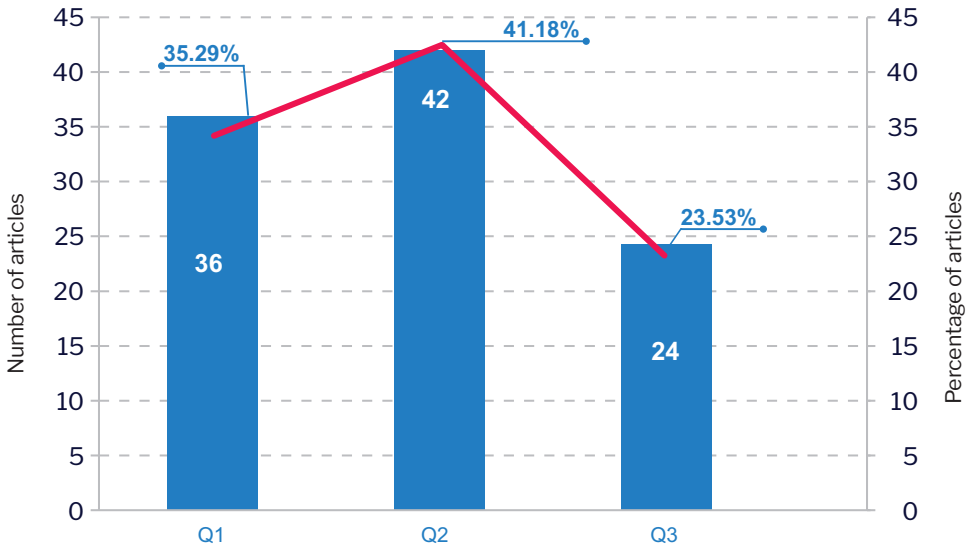
STRUCTURE OF PUBLICATIONS OF THE INSTITUTE IN 2022



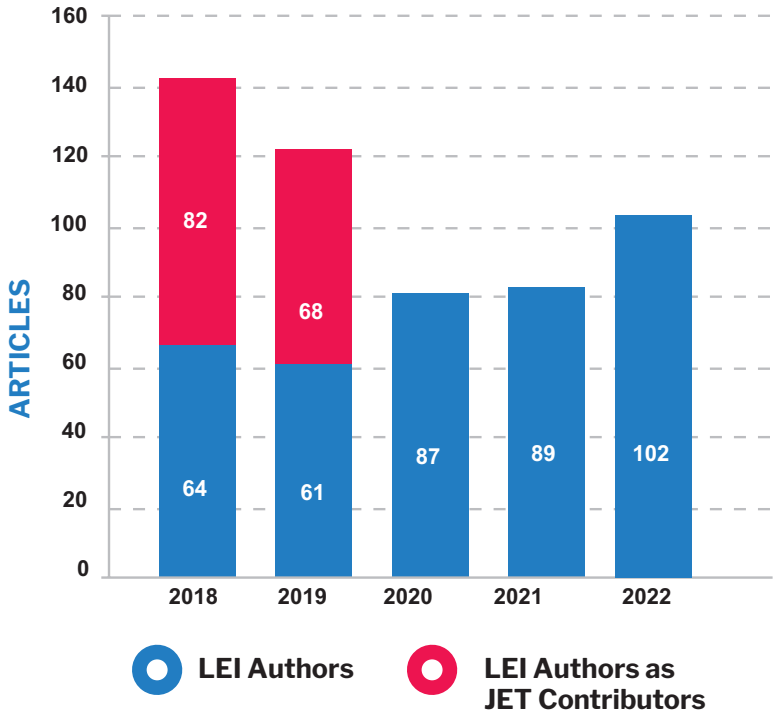
- Articles referenced in international databases
- Other peer-reviewed articles
- Monographs and book chapters
- Proceedings of conferences held abroad
- Proceedings of conferences held in Lithuania

Scientific publications:

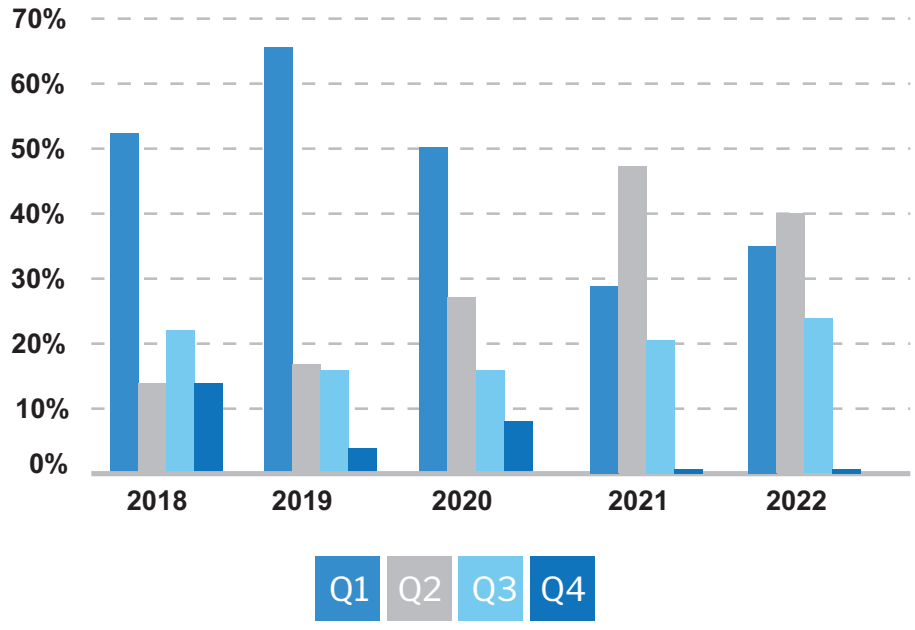
PUBLICATION OF RESEARCH RESULTS BY CA WOS QUARTILES



Dynamics of articles referred in the Clarivate Analytics WoS database



Dynamics of articles referred in the Clarivate Analytics WoS database by quartiles



LEI PROJECTS

International programmes' projects implemented in 2022

Horizon Europe and EURATOM	5 projects
Digital Europe Programme	1 project
Horizon 2020	11 projects
Nordic Energy Research Programme (NERP)	3 projects
Baltic Research Programme	2 projects
LIFE Programme	2 projects
INTERREG Programme	3 projects
International Atomic Energy Agency (IAEA)	5 projects
COST Programme	8 projects
Other international projects	4 projects

Institute in International programmes (projects portfolio)

Horizon Europe and EURATOM	5 projects
Digital Europe Programme	1 project
Horizon 2020	26 projects
7 Framework Programme	24 projects
6 Framework Programme	14 projects
5 Framework Programme	11 projects
LIFE Programme	2 projects
Intelligent Energy Europe	31 projects
INTERREG Programme	17 projects
Nordic Energy Research Programme (NERP)	7 projects
Baltic Research Programme	2 projects
International Atomic Energy Agency (IAEA)	18 projects
International partnerships (EuropeAid)	4 projects
COST Programme	29 projects
EUREKA	4 projects

INTERNATIONAL PROJECTS STARTED IN 2022

Horizon Europe and EURATOM:

1. Towards harmonisation in licensing of future nuclear power technologies in Europe (HARMONISE) [LEI coordinated].
2. HARmonised PracticEs, Regulations and Standards in waste management and decommissioning (HARPERS).
3. Safety Analysis of SMR with PAssive Mitigation strategies – Severe Accident (SASPAM-SA).
4. OPEn HPC theRmomechanical tools for the development of eAtf fuels (OperaHPC).

Digital Europe

1. European Digital Innovation Hub for Industry, Agrofood and Energy sectors in Lithuania (EDIH4IAE.LT).

LIFE Programme:

1. Monitoring the Energy Efficiency Pillar for Climate Neutrality (Odyssee-MURE).

INTERREG:

1. Photovoltaic for All (PV 4 All).

COST:

1. Techno-economic analysis of carbon mitigation technologies (CA21127).
2. Waste biorefinery technologies for accelerating sustainable energy processes (CA20127).

NATIONAL PROJECTS STARTED IN 2022

Lithuanian Academy of Sciences

1. Nuclear analysis of high power molten targets at MEDICIS and ISOLDE for the production of radioisotopes.

Research Council of Lithuania

1. P-LU-22-66 Investigation of plasma-induced effects in efficient energy waste processing technologies for hydrogen extraction.
2. S-REP-22-4 Import diversification and economic impact assessment system.
3. P-MIP-22-113 Application of metal hydride-based hydrogen for two-phase flow generation.
4. P-MIP-22-257 The development of plasma and pulsed electric field technologies for the treatment of the marine algae. FTMC, LEI.
5. P-LUP-22-66 Investigation of plasma-induced effects in efficient energy waste processing technologies for hydrogen extraction.
6. P-SV-22-173 The influence of the shape of the subarachnoid space and the peculiarity of the cerebrospinal fluid flow on the removal of harmful substances from the subarachnoid space.
7. P-ST-22-155 Research of Gasification of Three-Layer Disposable masks used during Covid-19 and Analysis of the Obtained Products.
8. P-IRA Infrastructure projects (P-IRA-22-11 , P-IRA-22-14, P-IRA-22-16, P-IRA-22-55, P-IRA-22-70).
9. P-PD-22-021 Implementing Energy Justice and Dealing Energy Inequality in the Transition to a Climate-neutral Society.
10. P-PD-22-156 Numerical and experimental studies on the removal of solid particles produced during the combustion of biomass fuel using acoustic agglomeration.

DOCTORAL STUDIES

LEI IN COOPERATION WITH LITHUANIAN UNIVERSITIES IMPLEMENTS JOINT DOCTORAL STUDIES IN THE FOLLOWING SCIENCE FIELDS:

Energetics and Power Engineering (T 006)

Environmental Engineering (T 004)

Economics (S 004)

TECHNOLOGICAL SCIENCES, two programmes in cooperation with Kaunas University of Technology and Vytautas Magnus University.

SOCIAL SCIENCES, one programme in cooperation with Kaunas University of Technology and Klaipėda University.

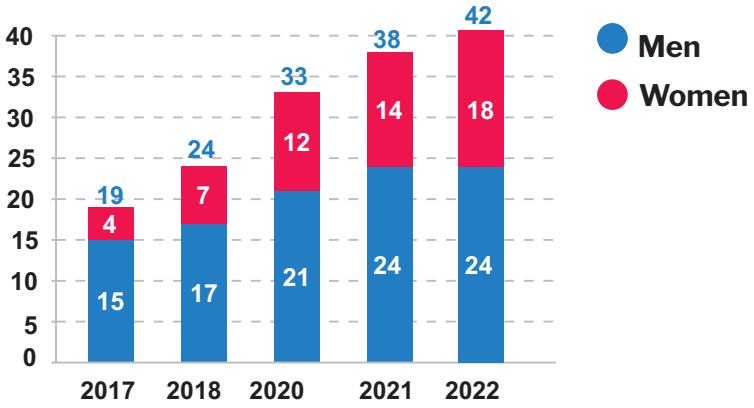
PhD STUDIES IN NUMBERS

During 1992-2022, 84 doctoral theses have been defended at the Lithuanian Energy Institute

In 2021, 42 doctoral students have been admitted

By the end of 2022, 10 doctoral students

PhD STUDENTS DYNAMICS



DOCTORAL THESES DEFENDED IN 2022

10 June 2022. **Andrius Zuoza**, PhD student at the Laboratory for Energy Systems Research has defended his PhD thesis "Evaluation of industry competitiveness dimension of energy efficiency" (Social Sciences, Economics – S004). Scientific supervisor: prof. dr. Vaida Pilinkienė (Kaunas University of Technology, Social Sciences, Economics – S004). Scientific advisor: Dr. Inga Konstantinavičiūtė (Lithuanian Energy Institute).

CYSENI CONFERENCE

SINCE 2003 LEI ORGANISES ANNUAL INTERNATIONAL CONFERENCE OF YOUNG SCIENTISTS ON ENERGY ISSUES (CYSENI).

The main goal of the Conference is to discuss issues and perspectives of energy sector worldwide; as well as to allow young scientists to develop their skills and networking.

PhD students, postdocs, master students and all other young scientists doing research on energy issues are welcome to the Conference as speakers and participants.

From 2021 onwards, LEI has added its RTO partners LAMMC and FTMC to the conference organising team. In 2022, in cooperation with the MDPI publishing house, selected conference papers were published in a special issue of the *Clarivate Analytics WoS* refereed journal *Applied Sciences* as well as in the journal *Energetika*.

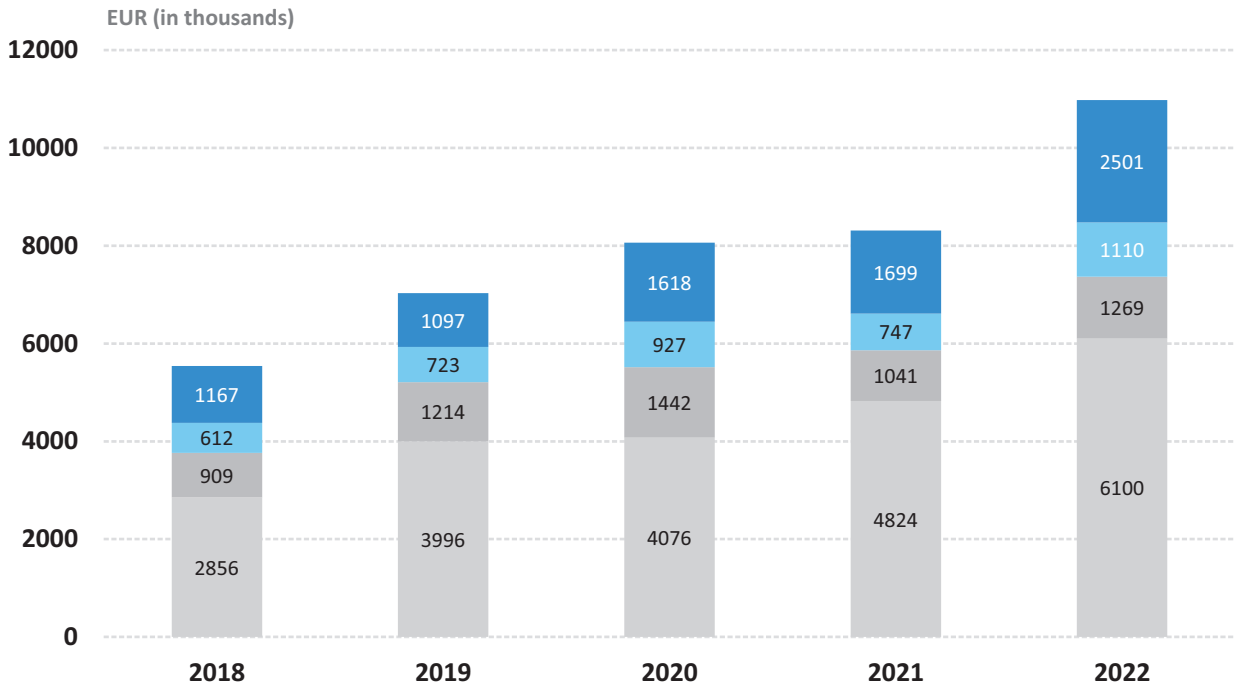
Participation in the Conference is free of charge

More information at
www.cyseni.com

FINANCIAL ACTIVITY RESULTS

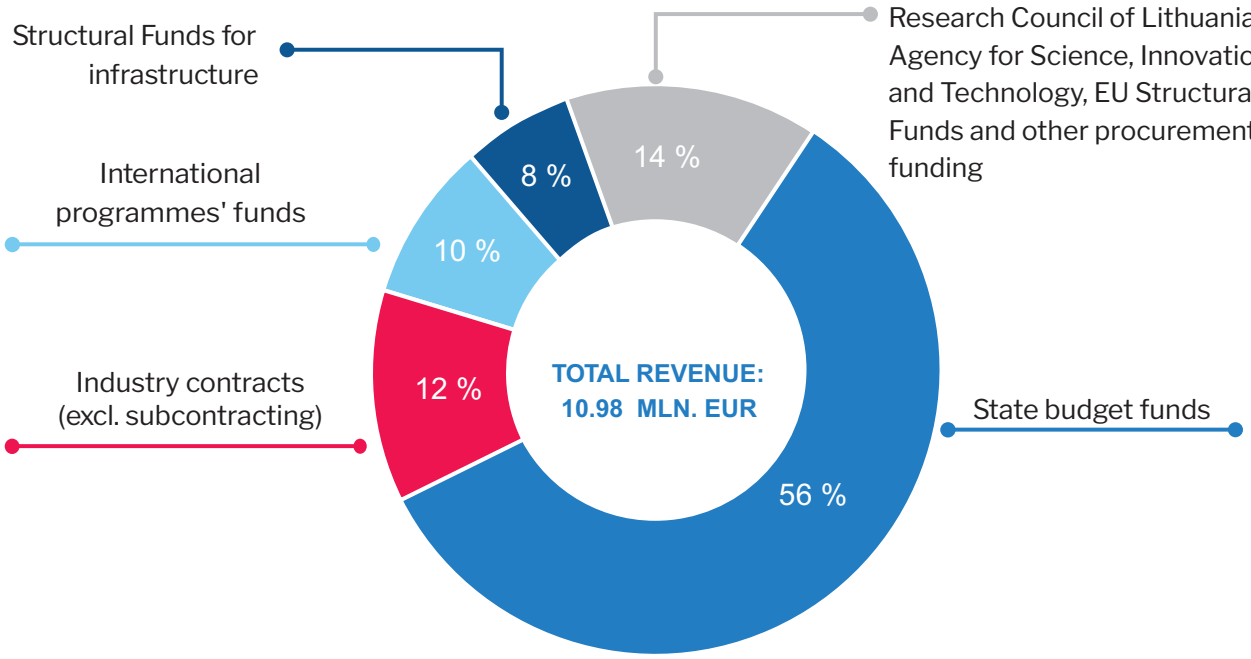
FINANCIAL DYNAMICS 2018-2022

The institute's income has almost doubled over the past five years. This was achieved due to increasing R&D funding from the State budget and more active participation of LEI researchers in national and international projects.

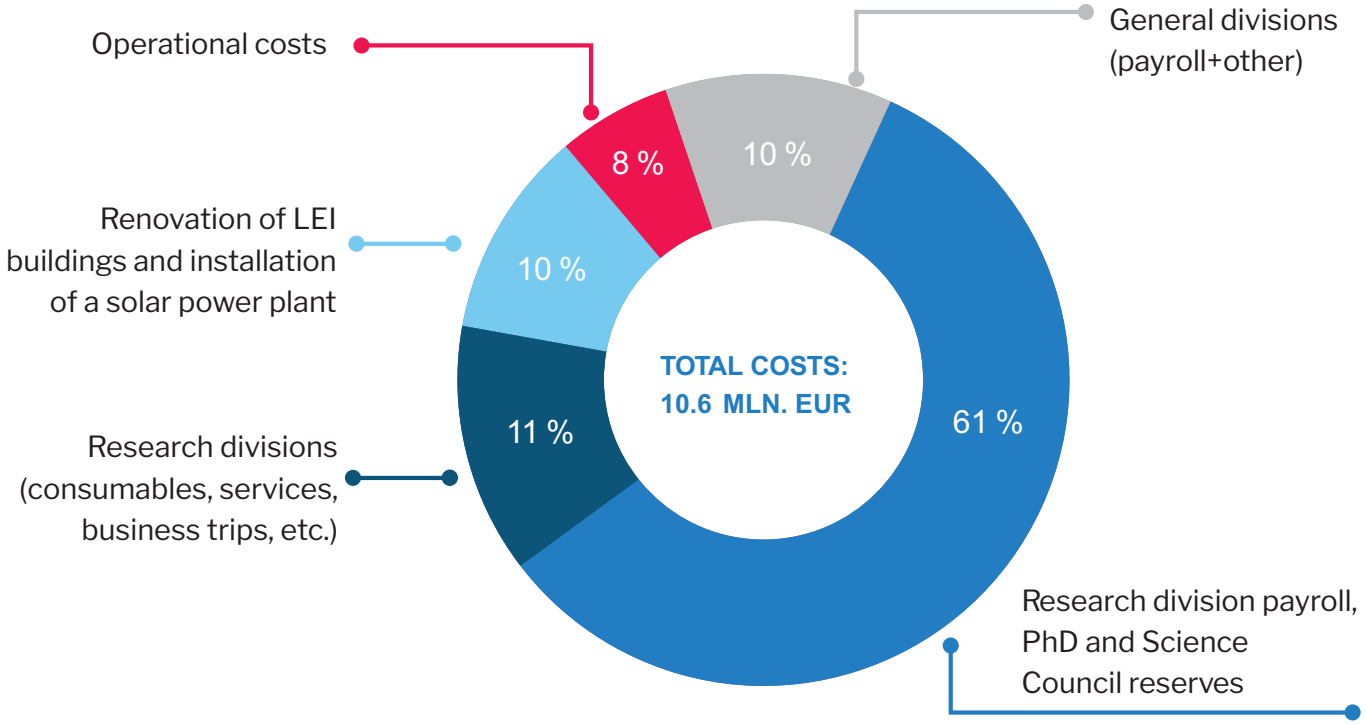


- Budget subsidies – funding from the budget of the Republic of Lithuania according to the achieved results.
- International programmes funding – funds received during the reporting year for the results of implemented projects of international programmes (Horizon Europe, H2020, LIFE, INTERREG, International Partnerships, etc.).
- Industry contracts – funds received for the services and works performed for companies and institutions.
- Research Council of Lithuania, Agency for Science, Innovation and Technology, EU Structural Funds and other procurement funding – the funds received for the projects financed by state institutions.

REVENUE STRUCTURE IN 2022



DISTRIBUTION OF COSTS IN 2022



COLABORATION WITH BUSINESSES

37 contracts with business partners signed in 2022 (not including small orders).

The following new contracts are worth mentioning:

- "Sweco Lietuva" UAB for the preparation of the Environmental Impact Assessment Report and procedures for the development of the southern part of Klaipėda Port;
- Ignalina NPP for the safety justification of the storage of unused nuclear fuel;
- "Energijos skirstymo operatorius" AB for studies on electricity distribution networks.

Business is increasingly interested in hydrogen energy technologies and their potential to support the transition from fossil fuels to renewable energy sources. The appropriate competences and expertise are needed to accelerate and smooth the uptake and deployment of these technologies. In 2022, scientists from LEI's Center for Hydrogen Energy Technologies organised a training course on hydrogen energy technologies for representatives of "Amber Grid" AB and "Achema Group" AB companies.

Notable contracts initiated in previous years were also continued in 2022. Projects financed by "Litgrid" AB, "Kršk" NPP (Slovenia), "Axis Tech" UAB and other business partners were completed.

PARTICIPATION IN THE NETWORKS OF LITHUANIAN INDUSTRIAL ORGANISATIONS

Lithuanian Energy Institute is a member of:

- Lithuanian Confederation of Industrialists (LPK),
- Association LITBIOMA,
- Biopower Plants Development Cluster,
- Food Technologies Digitalization LT Cluster,
- Smart Energy DIH,
- Smart Technology Cluster (SMARTTA),
- Lithuanian Engineering Industries Association (LINPRA),
- Lithuanian Electricity Association (LEEA),
- National Lithuanian Energy Association,
- National Defence Industries Association,
- Liquefied Natural Gas Cluster,
- International Energy Cluster,
- Hydrogen Energy Association,
- Hydrogen Platform,
- Lithuanian Nuclear Energy Association.

In 2022 two inter-institutional SANTAKA VALLEY projects were implemented:

- Artificial Intelligence Based Determination of River Hydromorphological Features by Unmanned Aerial Vehicle (DRON4WAT), coordinated by Vytautas Akstinas (LEI) and Andrius Kriščiūnas (KTU).
- Application of nanotechnologies in the development of bio-safety enhanced face masks (NANOMEDIMASK), coordinated by Agnė Giedraitienė (LSMU) and Darius Milčius (LEI).

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VYTAUTAS MAGNUS UNIVERSITY

LITHUANIAN ENERGY INSTITUTE

OBJECTIVES AND TASKS OF LEI. PERFORMANCE EVALUATION CRITERIA

The strategic objectives of LEI activities are as follows:

- Conduct both fundamental and applied research and development work at the international level;
- Train specialists of the highest qualifications for the development of research in the energy field.

For the attainment of these objectives, two tasks for continued activities have been set. The tasks and measures planned under them are as follows:

1. Create high level knowledge that increases the country's competitiveness.

Measure 1.1 – Conduct R&D in the areas of energy, thermal engineering, environmental engineering, and energy economy;

2. Increase the efficiency of doctoral studies.

Measure 2.1 – Ensure preparation and completion of doctoral theses.

LEI has implemented a Quality and Environmental Management System that meets the requirements of the international standards ISO 9001:2015 and ISO 14001:2015. A key performance indicator's (KPI) system is used for monitoring progress in the attainment of the LEI's objectives and tasks and for controlling the efficiency of activities. The system comprises key indicators focussed on the final result and included in LEI's Strategic Plan of Activities (SVP), as well as additional indicators the monitoring of which contributes to the improvement in activity planning and a smoother process of attainment of the objectives, tasks and key indicators. The indicators are focused on the development of the international dimension, creating new scientific knowledge, commercialisation of research results, and attracting new talented researchers to the Institute. The application of the KPIs covers all research divisions of LEI, and they are planned and monitored according to the Institute's Quality Management System.

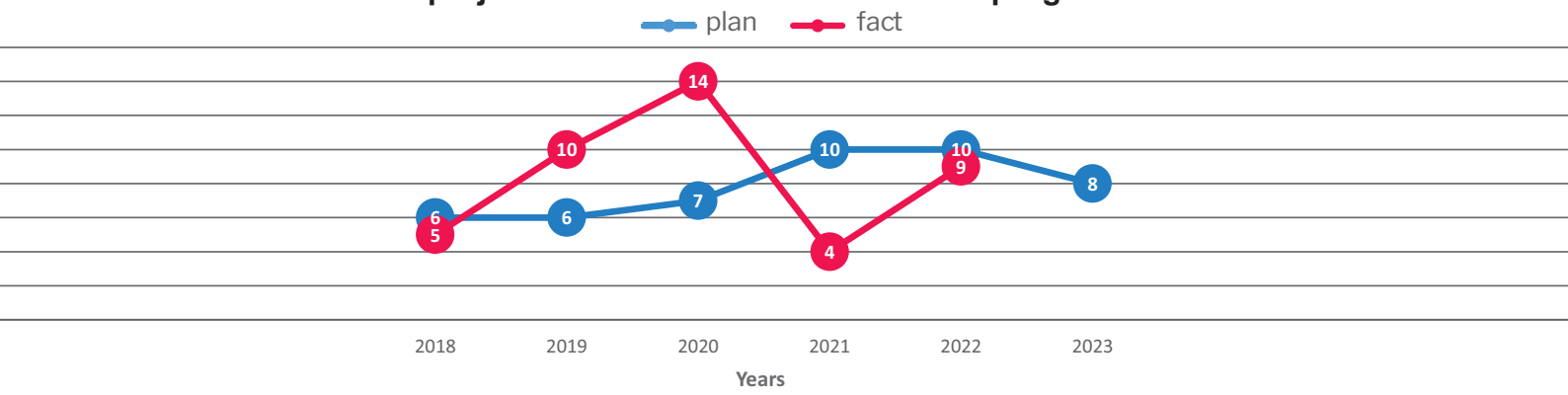
LEI tasks, measures and key performance indicators for 2018-2023

(SVP indicators – on blue background)

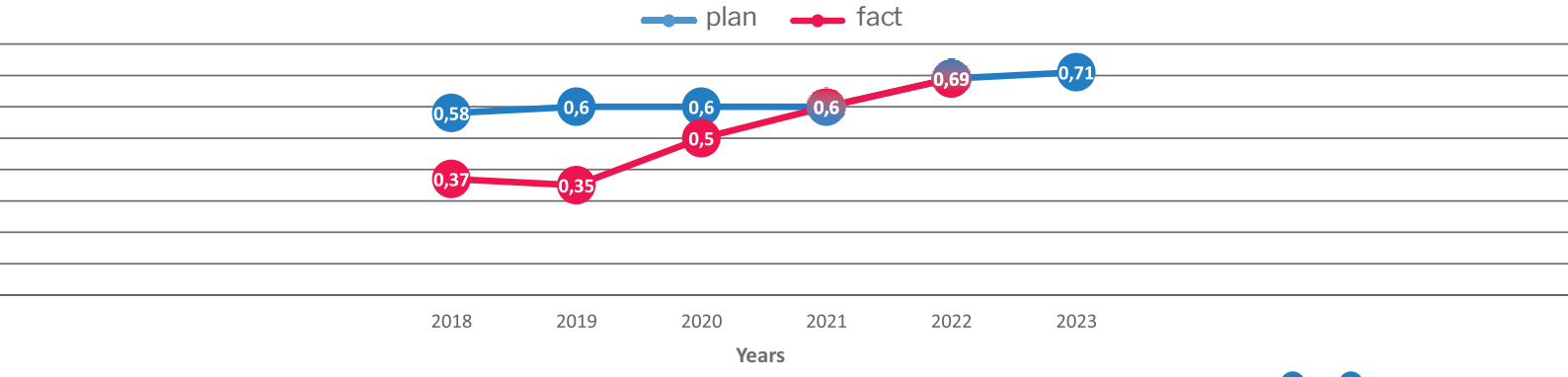
LEI tasks & measures	Key performance indicators (KPI)	2018	2019	2020	2021	2022	2023 target
Task 1. Create high level scientific knowledge that increases the country's competitiveness.	New projects under international programmes launched in the current year, number	8	10	11	4	9	8
	Additional indicator: Number of project applications submitted to international programmes	38	25	31	23	35	20
Measure 1.1 – Conduct R&D in the areas of energy, thermal engineering, environmental engineering, and energy economy	Number of articles in journals referred to in Clarivate Analytics WoS list (Q1-Q3) per scientist	0.37	0.35	0.5	0.60	0.69	0.71
	% share of articles in journals referred to in Clarivate Analytics WoS, in quartiles Q1 and Q2 (from 2019)		79.7	79	77.5	76.5	75
	Additional indicators:						
	Number of articles submitted to journals referred to in Clarivate Analytics WoS list (Q1-Q3) per scientist	0.52	0.74	0.65	0.93	0.96	0.99
	Funds from contracts, EUR '000	2687	2830	3843	2920	3586	2610
	Funds for the improvement of research infrastructure, EUR '000	102	129	210	251	459	178
	Number of papers at international scientific conferences, per scientist	0.63	0.72	0.31	0.76	0.92	0.58
Task 2: Increase the efficiency of doctoral studies	Successful completion of doctoral studies, %	67	44	57	33	50	75
Measure 2.1: Ensure preparation and completion of doctoral theses	Number of doctoral students	19	24	33	38	42	36
	Number of doctoral theses defended during the year	4	4	4	1	1	4
	Additional indicator: Number of doctoral students admitted	5	10	12	7	10	10

Selected LEI planned and achieved key performance indicators for 2018–2023

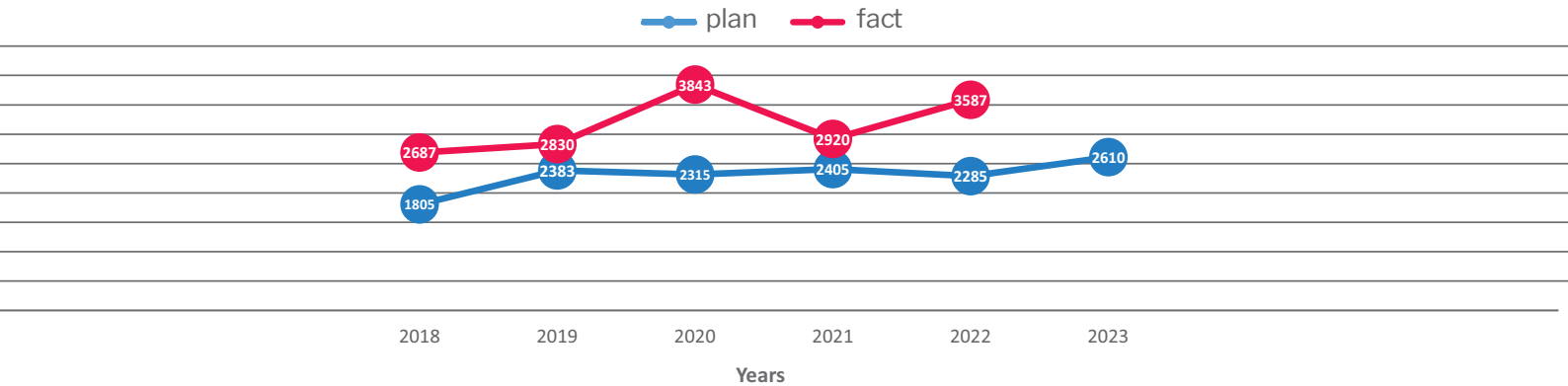
New projects under International research programmes



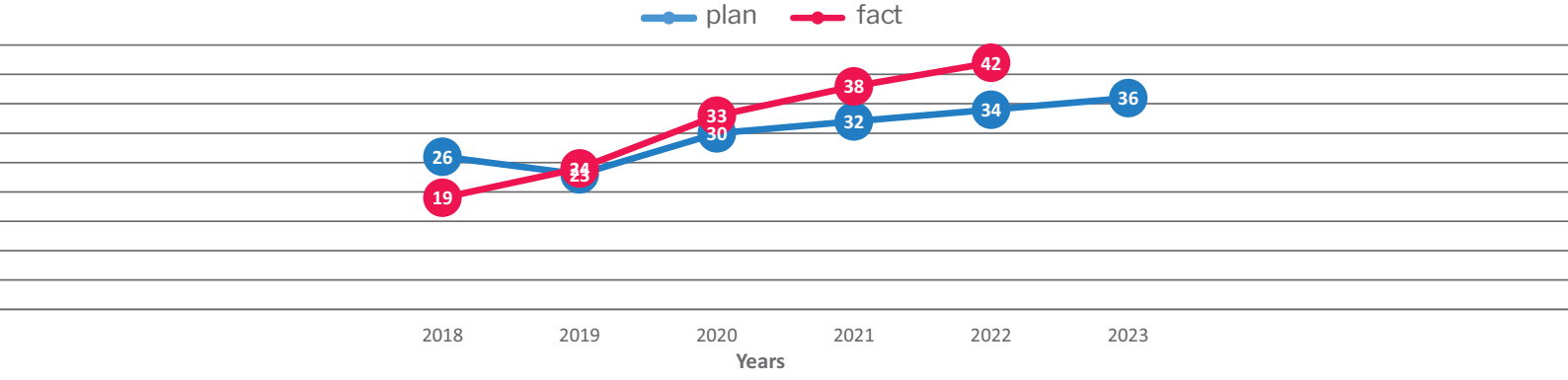
Number of articles in journals referred in Clarivate Analytics WoS list (Q1-Q3) per scientist



Contracts, thous. EUR



Number of PhD students



ACHIEVEMENTS OF RESEARCH DIVISIONS

RESEARCH DIVISIONS OF THE LITHUANIAN ENERGY INSTITUTE:

- Center for Hydrogen Energy Technologies
- Laboratory of Energy Systems Research
- Smart Grids and Renewable Energy Laboratory
- Laboratory of Combustion Processes
- Plasma Processing Laboratory
- Laboratory of Materials Research and Testing
- Laboratory of Heat-Equipment Research and Testing
- Laboratory of Hydrology
- Laboratory of Nuclear Installation Safety
- Nuclear Engineering Laboratory

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HYDROGEN RESEARCH AND NANOTECHNOLOGIES

CENTER FOR HYDROGEN ENERGY TECHNOLOGIES

MAIN RESEARCH AREAS OF THE CENTER

- Research in the field of hydrogen energy technologies.
- Synthesis of hydrogen separation membranes and analysis of their properties.
- Hydrogen production using water reactions with metals and nanoparticles of their alloys.
- Synthesis of metals and their alloy hydrides designed for hydrogen storage: analysis of their properties.
- Synthesis of hydrogen fuel cell components (anodes/electrolytes/cathodes) applying physical vapour deposition methods.
- Analysis of battery material properties.
- Synthesis and analysis of photocatalytic materials.
- Application of physical vapor deposition methods for thin films formation and surface modification.
- Surface modification of various materials by application of glow discharge plasma.

Application of nanotechnology in the development of face masks with increased biological safety

- In 2022, a novel low-temperature plasma technology was developed at the Center for Hydrogen Energy Technologies, which allows the deposition of various metals and/or metal oxide nanoclusters onto the middle layers of medical grade masks (Fig. 1)
- This research was carried out in cooperation with the researchers of the Lithuanian University of Health Sciences
- Using the synthesis method developed by LEI researchers, it is possible to synthesize not only Ni nanoclusters, but also other single-element clusters (Ag, Au, Cu, CuO, Ti, TiOx, C-based structures, etc.) and their complex (e.g. Ag2O- CuO).
- This study utilized clinical strains of microorganisms that are commonly found in hospitals or in the community, in order to replicate natural conditions as closely as possible.

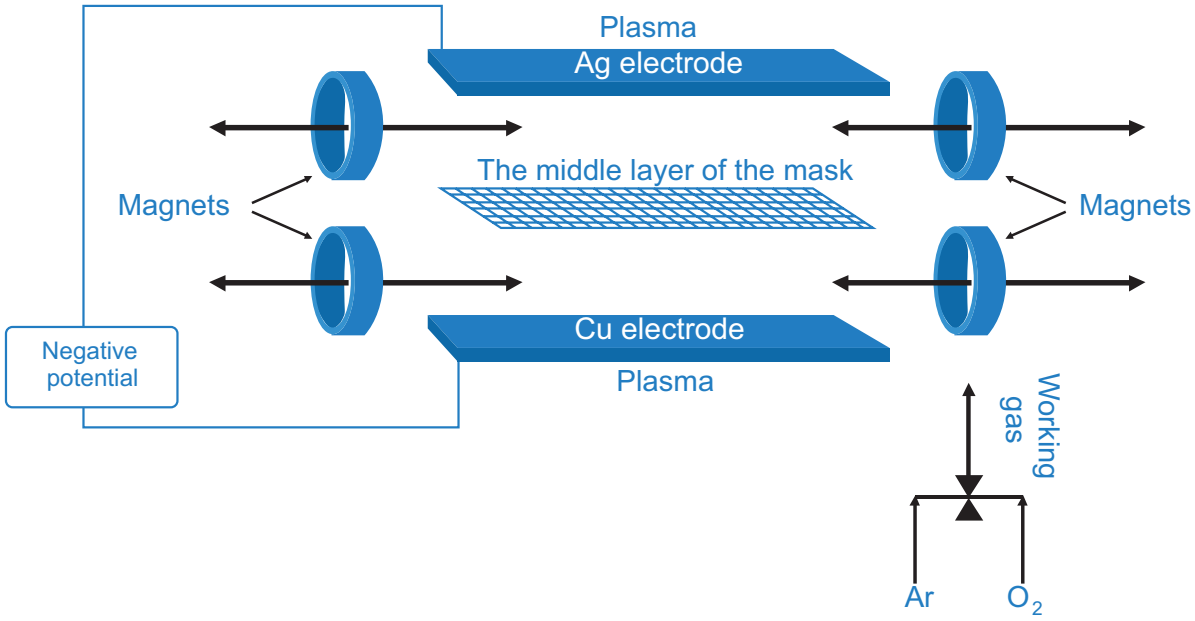
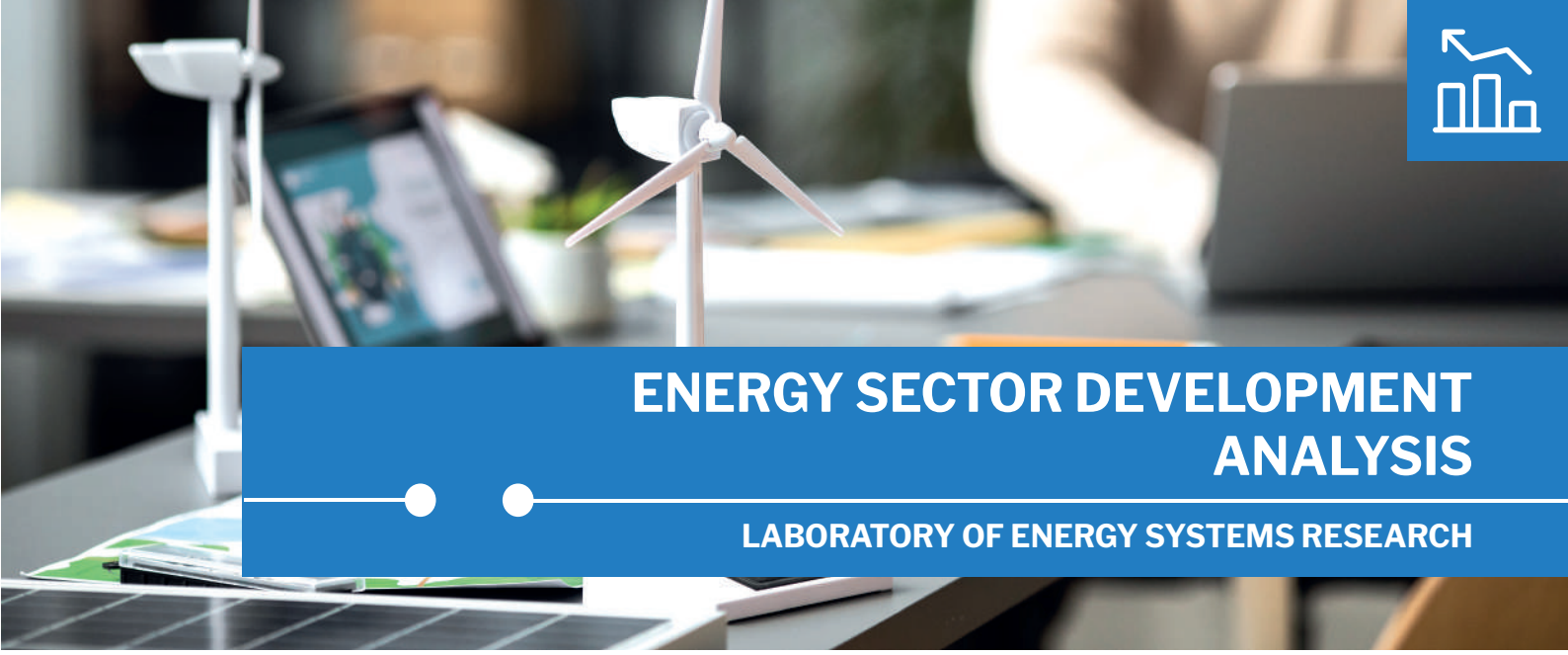


Figure 1. A scheme for coating the middle layer of a medical mask with Ag and Cu nanoclusters

The deposition process of nanoclusters occurs within a vacuum chamber with an atmosphere of working gases such as Ar or O_2 or Ar+O_2, at a pressure ranging from 1-10 Pa. The process takes place in a low-temperature plasma that does not exceed 50 °C, using a plasma generation power of 120-200 W. The samples are positioned between the electrodes in the plasma for a duration of 15-180 min. Magnetic fields are employed to regulate the deposition of nanoclusters.

Using the proposed method the resulting modified textile-based fabrics acquire resistance to the following (including but not limited to) pathogens: Enterobacter cloaceae (*E. cloacae*), Klebsiella pneumoniae (*K. pneumoniae*), Salmonella enterica (*S. enterica*), Citrobacter freundii (*C. freundii*), Pasteurella multocida (*P. multocida*), Acinetobacter baumanii (*A. baumanii*), Staphylococcus haemolyticus (*S. haemolyticus*), Enterococcus faecium (*E. faecium*), and Candida tropicalis (*C. tropicalis*).

An application (number LT2023 505) has been submitted for the issuance of a patent in the Republic of Lithuania, based on the developed technology. The application of CuO nanoclusters and their interaction with pathogens were tested during the experiments. The joint publication by LEI and LSMU describes the best results obtained: Giedraitienė, A.; Ruzauskas, M.; Šiugždinienė, R.; Tučkutė, S.; Milčius, D. Antimicrobial Properties of CuO Particles Deposited on a Medical Mask. Materials 2022, 15, 7896. https://doi.org/10.3390/ma15227896



ENERGY SECTOR DEVELOPMENT ANALYSIS

LABORATORY OF ENERGY SYSTEMS RESEARCH

MAIN RESEARCH AREAS OF THE LABORATORY

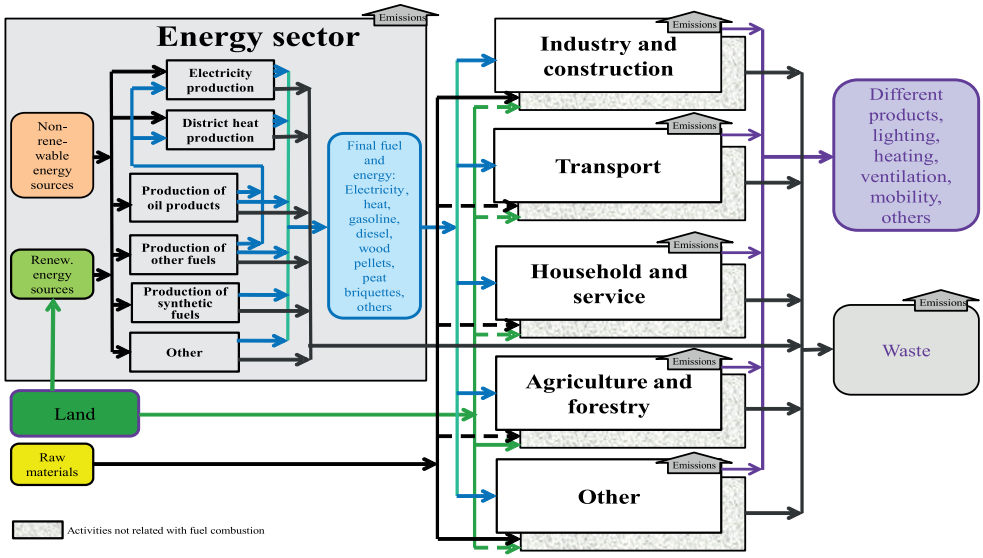
- Economic modeling at the micro and macro level. Analysis and solutions of economic and social problems. Development and application of various types of economic models (microsimulation, input-output, general equilibrium).
- Analysis of optimal allocation of generation, reservation and balancing capacities in energy systems and interconnectors. Elaboration of optimal approaches for balancing intermittent energy generation from renewable energy sources.
- Transport decarbonisation research. Investigation of possibilities to balance intermittent electricity generation from renewable energy sources by means of smart charging of electric vehicles and alternative fuel production.

A methodology for a comprehensive analysis of the country's deep decarbonisation has been developed, based on mathematical modelling and guided by the following key principles:

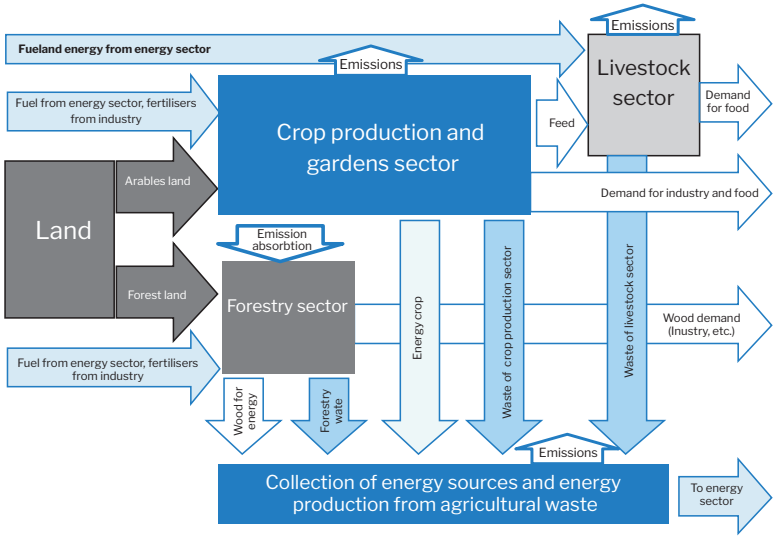
- decarbonisation processes are analysed in the context of the long-term development of the economy;
- objective accounting of GHG emissions is achieved by modelling the development and functioning of economic sectors as accurately as possible;
- the focus is on the detailed modelling of technological processes and emissions in individual sectors of the economy and the assessment of inter-sectoral linkages;
- the development of sectoral models is progressive in both coverage and process detail, adapting to the quantity and quality of available input information and accumulated competences.

The methodology developed is being applied in an ongoing LIFE project in the country to improve the preparation of the National Energy and Climate Plan and to build competences.

Structure of the mathematical model for economy decarbonisation



Functional relationships in a mathematical model for decarbonising the agriculture and forestry sectors

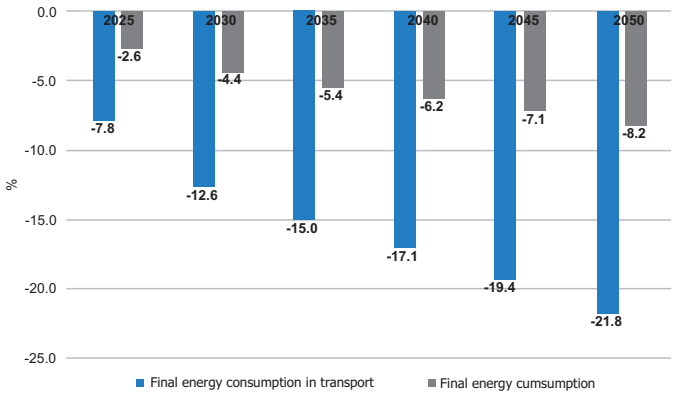


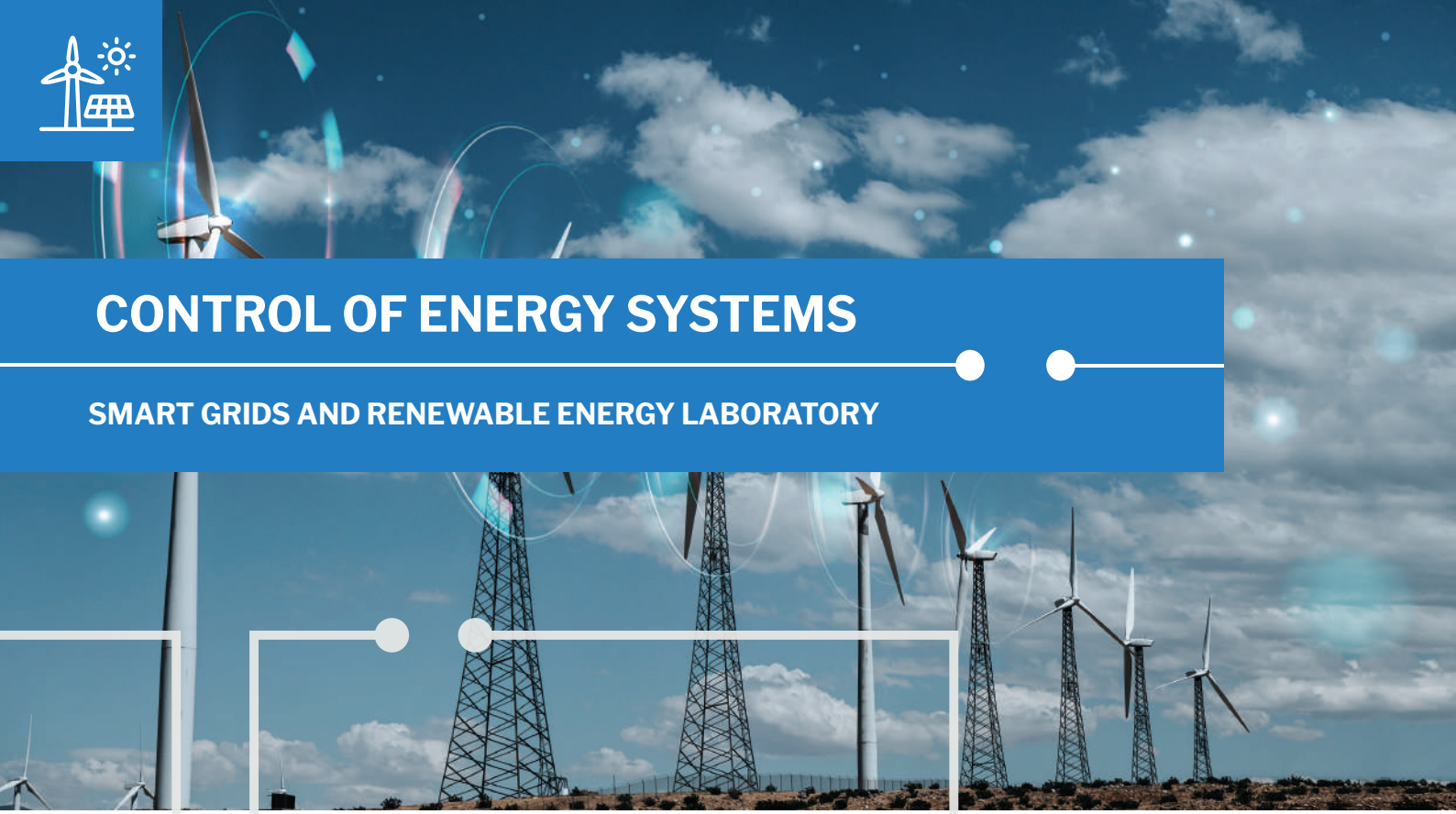
Consolidating Ambitious Climate Targets with End-Use Sufficiency (CACTUS)

- **Assumptions of energy sufficiency for the energy sectors of Central and Eastern European countries (Lithuania and Hungary) were developed:**
  - Key energy sufficiency indicators were identified;
  - Theoretical energy sufficiency potential was assessed in 2050;
  - Relevant policy measures to promote energy sufficiency were identified;
  - Analysis of the local economic and socio-cultural context and trends was carried out.

- **Quantitative and qualitative evaluation of energy sufficiency potential was performed:**
  - Energy sufficiency goals for 2050 were set taking into account the national context;
  - The foundations for the development of ambitious climate change mitigation strategies by integrating energy sufficiency were laid;
  - The formation of energy sufficiency policy was initiated by informing decision-makers about the concept of energy sufficiency and its role in mitigating climate change.

Assessment of energy sufficiency potential in Lithuanian passenger transport





CONTROL OF ENERGY SYSTEMS

SMART GRIDS AND RENEWABLE ENERGY LABORATORY

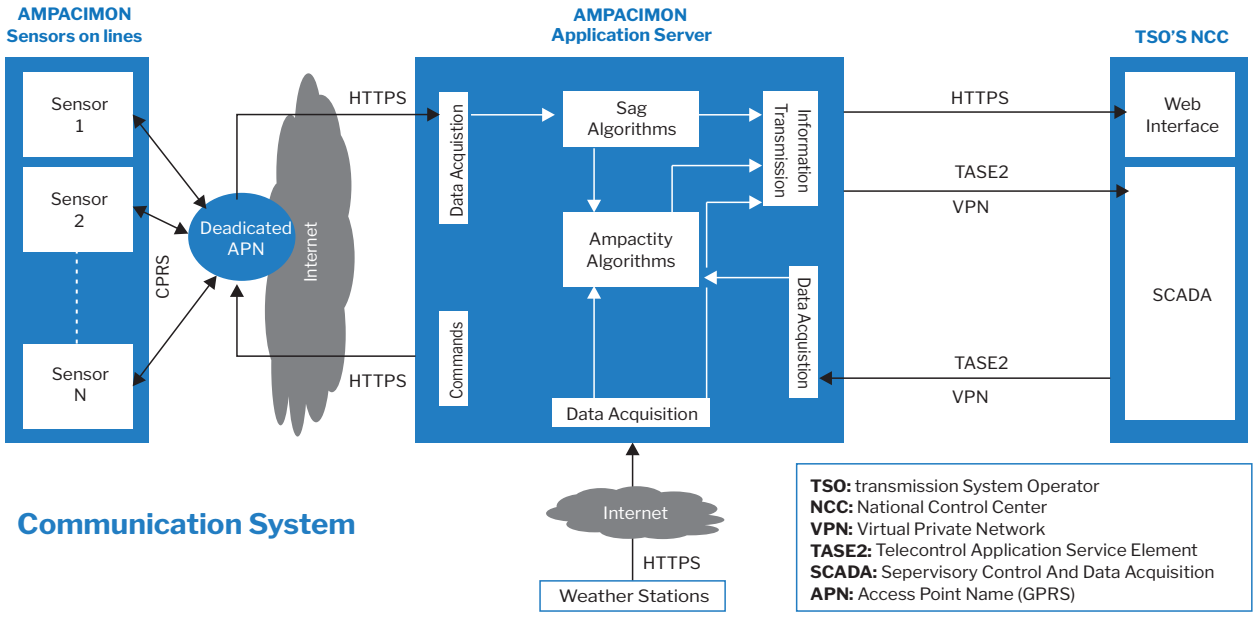
MAIN RESEARCH AREAS OF THE LABORATORY

- Mathematical modelling of power systems and networks, investigation of their control issues;
- Modelling and optimisation of ICT-based control systems of power systems;
- Research of integration of renewable energy sources (wind, solar, etc.) and distributed generation into power systems.

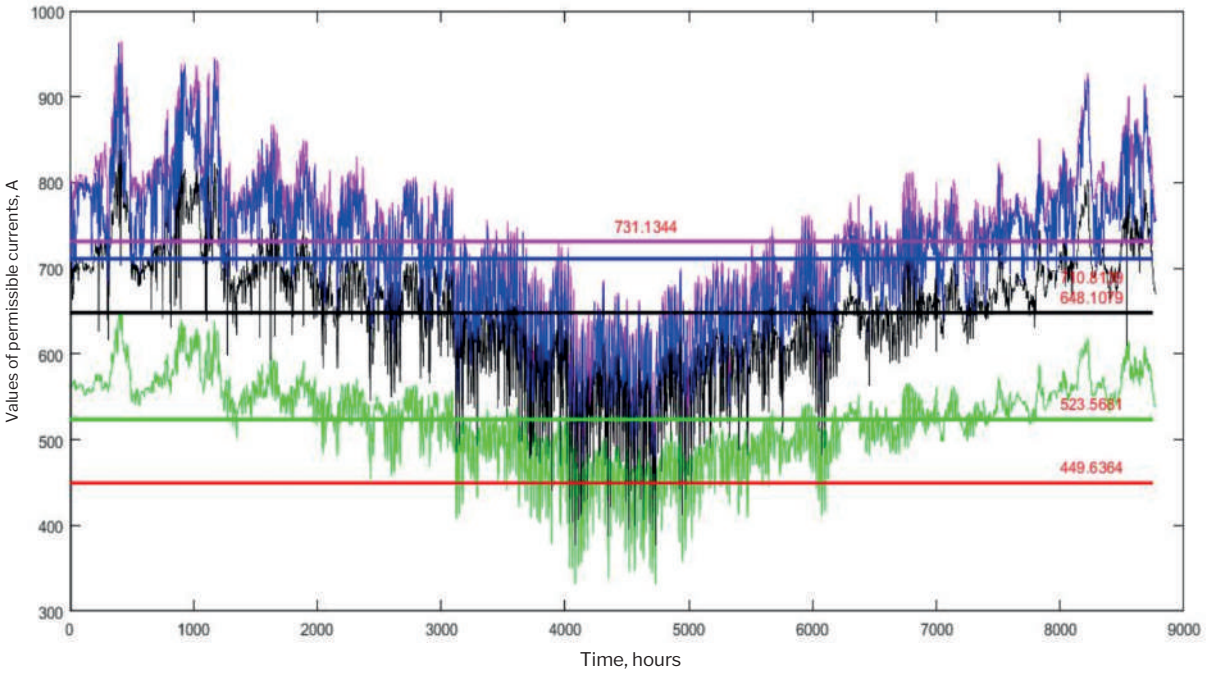
SMART GRIDS AND RENEWABLE ENERGY LABORATORY

Successful implementation of project "Study on the application of innovative measures for the integration of renewable energy power plants and methodology for the elaboration of optimal solutions". Contracting entity: Lithuanian transmission system operator AB "Litgrid".

- The study investigated the opportunities and challenges of integrating the renewable power plants into transmission grid with focus on advantages and disadvantages of integration technologies and building of optimal integration solutions.
- The study developed a methodology for calculation of grid connection capacities of renewable energy plants with and without real-time dynamic line rating (DLR) technology.



DLR system data transmission architecture



Dynamics of the variation of the permissible currents for different application cases of AS150 wire type using Kaunas air temperature data (2021)

COMBUSTION RESEARCH

LABORATORY OF COMBUSTION PROCESSES

MAIN RESEARCH AREAS OF THE LABORATORY

- Investigation of gaseous, liquid and solid fuels combustion processes;
- Development and optimization of industrial combustion devices;
- Thermochemical (gasification, pyrolysis, carbonization) processing of biomass and non-hazardous waste;
- Liquid and gaseous biofuel synthesis research.

Investigations of combustion and other thermochemical processes in order to valorize a biomass and waste usage for alternative biofuels and production of chemicals, reduce the environmental emissions and increase technology efficiency.

Thermochemical treatment of used COVID-19 face masks for energy recovery (No. 13.1.1-LMT-K-718-05-0017)

The main idea of the project was to develop the process for the treatment of COVID-19 plastic and textile waste based on thermochemical gasification in a high-temperature reduced environment to produce a valuable energy product, hydrogen-enriched synthetic gas. This gas could be further used for the production of synthetic fuels or directly in transport and other energy systems.

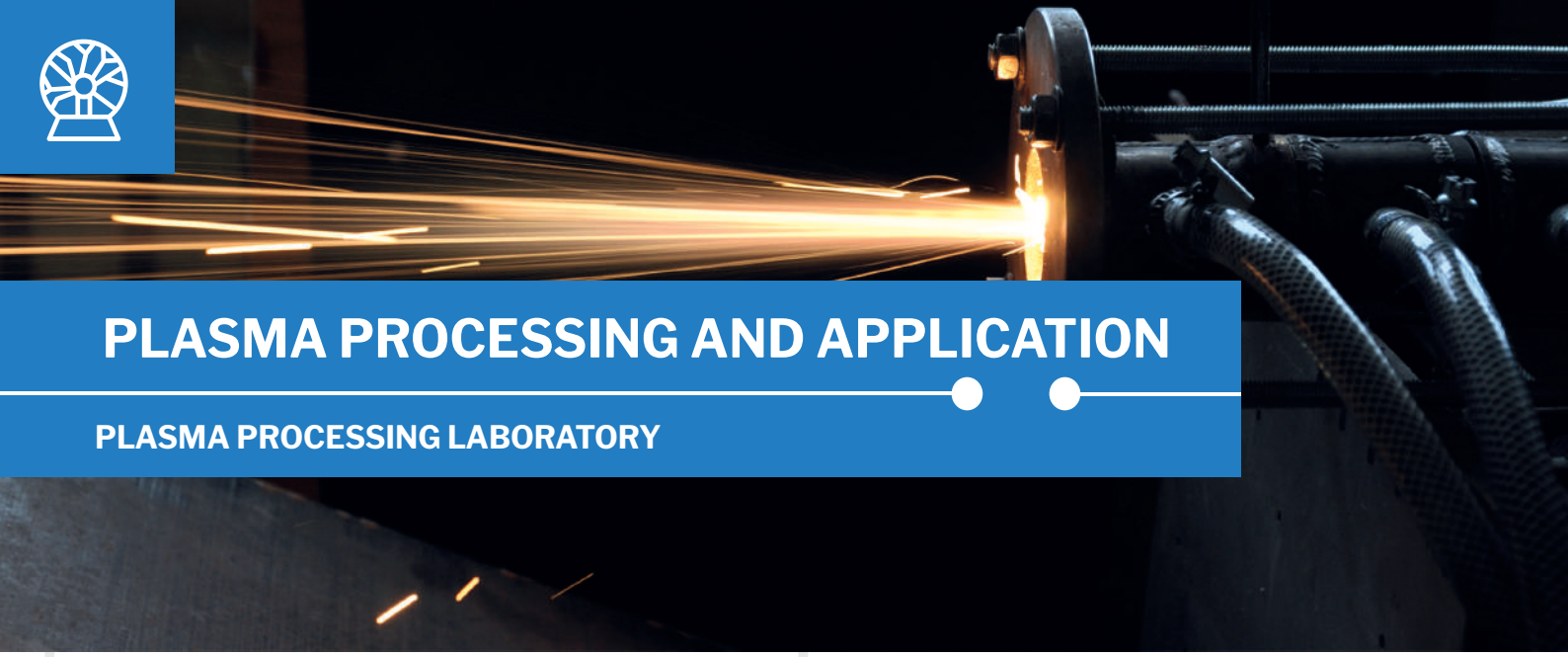
Following the main activities foreseen in the project, an innovative process concept for the production of H_2-enriched gases was developed and validated by the use of a new type of catalyst, which allowed to convert of almost all the hydrocarbons (CnHm), including the light hydrocarbons in syngas and the heavier ones in tar, into a gaseous product (conversion 99. 1 wt.%) containing mainly H_2, CO and CO_2, with a dry gas concentration of 60, 30 and 10 % by volume respectively.

An innovative H2 rich-syngas production concept based on thermochemical conversion of plastic waste was developed and tested :

- C_nH_m conversion – 99.1 wt%
- max H_2 in syngas - 60.1 vol%

Kuriame Lietuvos ateitį
2014–2020 metų Europos Sąjungos fondų investicijų veiksmų programa

Research Council of Lithuania



PLASMA PROCESSING AND APPLICATION

PLASMA PROCESSING LABORATORY

MAIN RESEARCH AREAS OF THE LABORATORY

- development and research of DC plasma sources for wide range of applications
- research of processes and phenomena taking place in discharge channels, exhaust plasma jets and flows
- diagnostics of plasma and high-temperature flow and development of diagnostic measures
- research on interaction of plasma jets and substances in various plasma-technological processes
- generation of water vapor plasma and its application for fuel conversion and neutralization of hazardous waste
- research and implementation of plasma neutralization process of hazardous substances
- synthesis of catalytic and tribological coatings in plasma ambient and analysis of their properties
- research of thermal and heterogeneous processes for reacting product flowing around catalytic surface
- formation and modification of constructional material surfaces in plasma
- synthesis of micro- and nano- dispersed granules and mineral fiber from hardly meltable materials and analysis of their properties

The plasma gasifier prototype dedicated to decomposing solid materials in an atmospheric pressure thermal plasma environment was developed in 2022

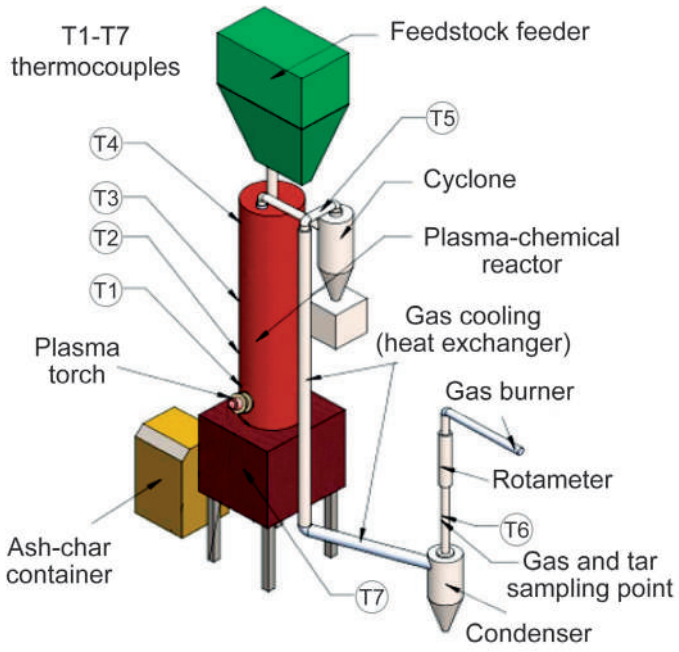


Fig. 1 The plasma-chemical gasification system

The plasma-chemical gasification reactor was used for the decomposition of the following substances:

- Biomass (wood pellets);
- Solid Recovered Fuel (SRF);
- COVID-19 face masks (FFP2).

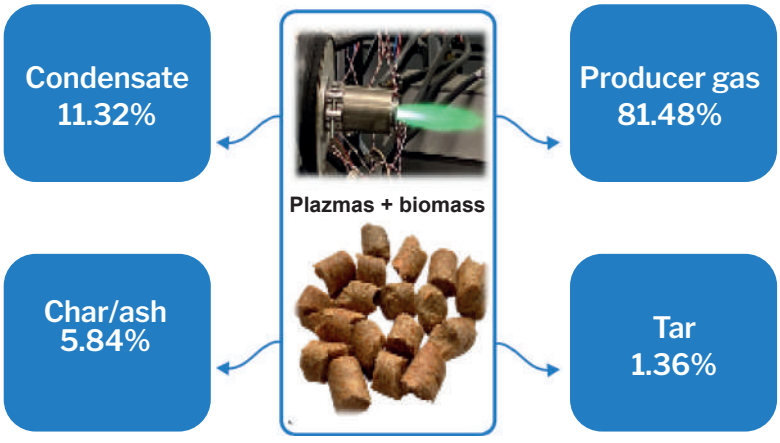


Fig. 2 Reaction products composition after the thermal plasma biomass (wood pellets) gasification

Significant research results were obtained during the gasification of wood pellets in the water vapor plasma environment.

The synthesis gas generated during the solid materials conversion process (in the case of wood pallets gasification: H_2=43.86%, CO= 30.93%) can be applied to produce electrical or thermal energy. Also, synthesis gas is a feedstock for synthesising methanol, methane, or liquid fuels (via Fischer-Tropsch synthesis).

MATERIALS RELIABILITY

LABORATORY OF MATERIALS RESEARCH AND TESTING

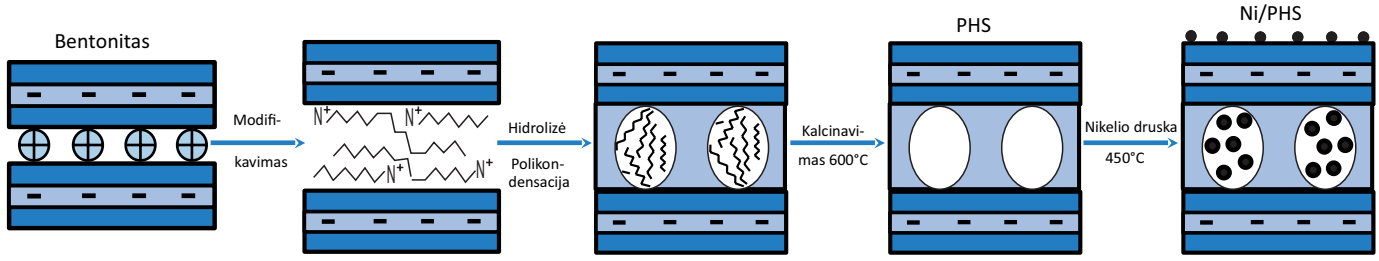
MAIN RESEARCH AREAS OF THE LABORATORY:

- Teliability of power plant facilities: research of metal aging processes and degradation of properties due to the impact of operational factors;
- Development and research of multifunctional materials and composites;
- Testing of materials, assessment and analysis of their qualitative indicators.

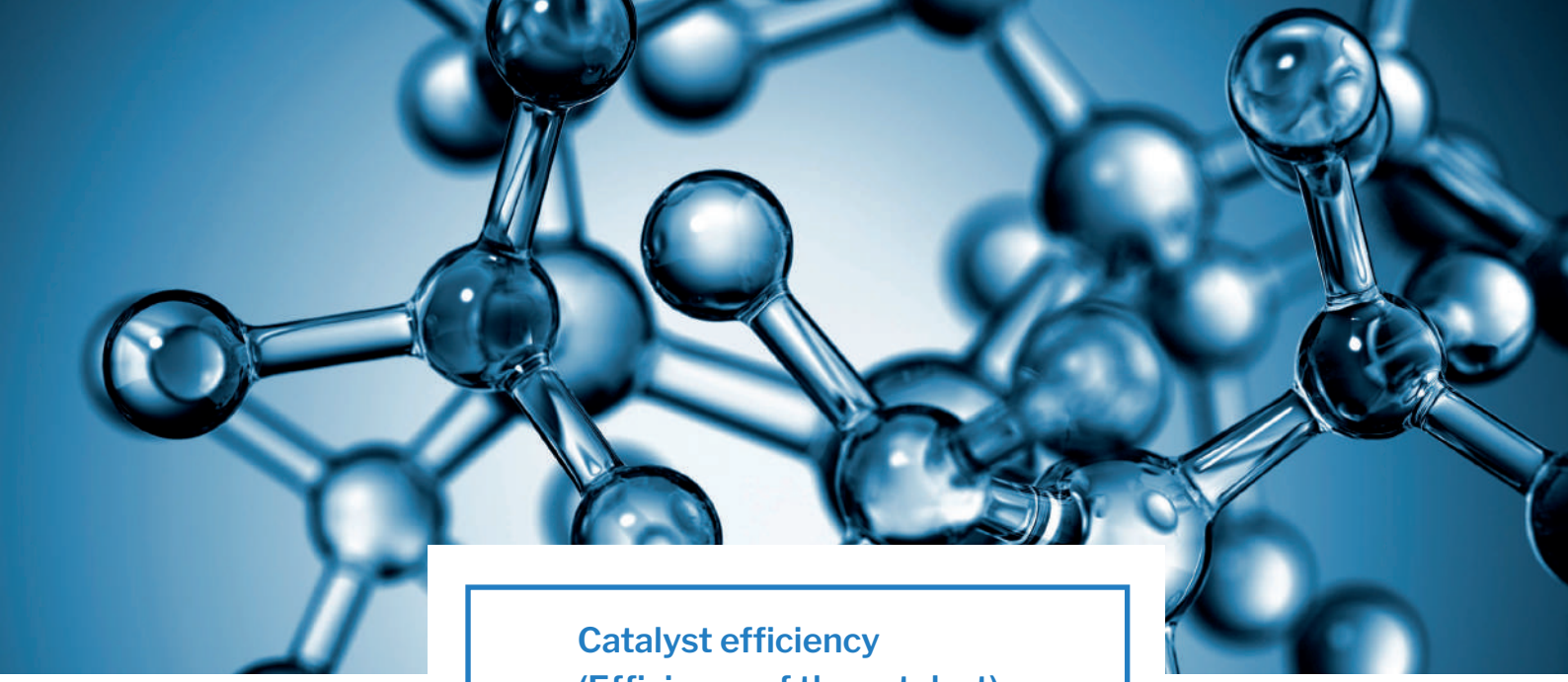
"A method for preparing a Ni-based methanation catalyst on a porous clay heterostructure support with a high specific surface area, and a Ni-based methanation catalyst thus obtained"

An European patent application has been submitted.

The invention relates to the synthesis methodology of a nickel (Ni) catalyst for the conversion of syngas to biomethane (methanation reaction). The essential feature of this catalyst is the support of a porous heterostructure (PHS) with a large specific surface area formed by chemical methods. The work was carried out in collaboration with scientists from the Combustion Processes and Plasma Technology laboratories, within the framework of the European Union Funds Investment Action Programme measure No 01.2.2-CPVA-K-703 "Promotion of the activities of Centres of Excellence and Centres of Innovation and Technology Transfer".

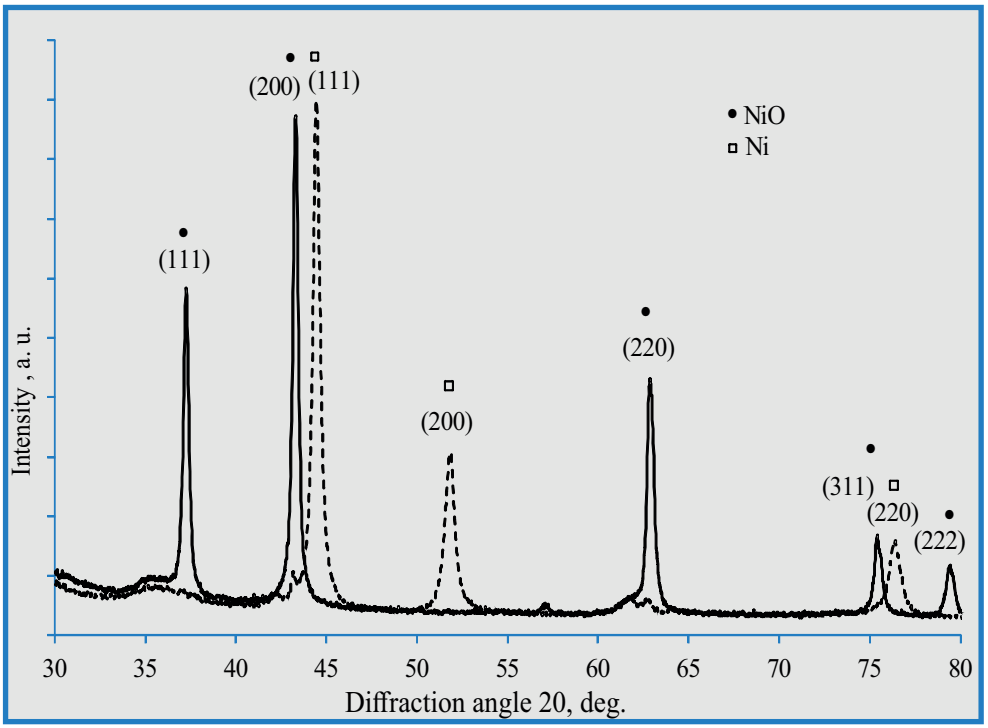


Scheme for the synthesis of a nickel catalyst formed on a porous heterostructure support (Ni/PHS)



Catalyst efficiency
(Efficiency of the catalyst)

CO_2 conversion – 94%,
Selectivity – 94%,
CH_4 yield – 88.6%



X-ray diffraction curves of Ni/PHS catalyst

Project 01.2.2-CPVA-K-703-03-008 “Performing R&D activities of the Centre of Excellence by developing and testing an innovative prototype for the production of gaseous biofuels”
(EPO patent application by scientists from 3 LEI departments).

FLUID DYNAMICS AND METROLOGY RESEARCH

LABORATORY OF HEAT-EQUIPMENT RESEARCH AND TESTING

MAIN RESEARCH AREAS OF THE LABORATORY

Processes and technologies for the efficient use of Renewable Energy Sources and reduction of environmental pollution:

- physical and thermal properties of solid biomass and recovered fuel
- fuel preparation methods and technologies
- thermal conversion processes (combustion, gasification) of solid fuel
- solid biofuel drying
- solid biofuel dynamics and thermal conversion on moving grate and in fluidized bed
- emission formation processes in heating appliances
- efficiency of low capacity boilers and heating appliances fired by solid fuel

Thermal physics, fluid mechanicsand metrology:

- flows mixing in chambers of limited dimensions and various geometry
- permeability of gas mixtures through membranes
- particulate emission reduction
- flow dynamics in elastic channels
- ultrasound propagation in flows
- heat and mass transfer by molecular dynamics
- maintenance of five national flow and pressure standards and assurance of measurement traceability

The Certification Department of the Thermal Equipment Research and Testing Laboratory of the Lithuanian Energy Institute is established.

In 2022 a certification department was established at the institute, which performs the certification of water and heat meters and measurement systems produced by Lithuanian and other countries' manufacturers, taking into account the new standards requirements, which allows to develop cooperation and participation in international projects in European metrology networks.

NATIONAL ACCREDITATION BUREAU

ACCREDITATION CERTIFICATE

No. LA.030-03 Valid until 19-12-2027

Lithuanian National Accreditation Bureau hereby certifies that

Certification Department of the Heat Equipment Research and Testing Laboratory of the Lithuanian Energy Institute
Breslaujos str. 3, 44403 Kaunas

complies with the requirements of LST EN ISO/IEC 17065:2012 and is accredited to perform

conformity assessment of water and thermal energy meters and measuring systems for liquids other than water according to Technical Regulation of Measuring Instruments approved by the Order of Minister of Economy of the Republic of Lithuania No. 4-699 „On Technical Regulation of Measuring Instruments" of 30 October 2015 which take over the Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 with amendments made by Commission delegated Directive 2015/13/EU

The scope of accreditation is listed in the Annex
Accreditation certificate issued 20-12-2022

Dalia Balčiūnė

Name of the product/product group	Conformity assessment procedure/module	Annex/Article of the Directive
Directive 2014/32/EU of the European Parliament and of the Council as amended by Commission Delegated Directive 2015/13/EU. Technical Regulation on Measuring Instruments, approved by Order of the Minister of Economy of the Republic of Lithuania No 4-699 of 30 October 2015 "On approval of the Technical Regulation on Measuring Instruments"		
Water Meters (Annex III MI-001)	EU type- examination	Annex II – Module B
Thermal Energy Meters (Annex VI MI-004): - thermal Energy meter complete; - flow sensor (sub-assembly); - temperature sensor pair (sub-assembly); - calculator (sub-assembly).	Conformity to type based on product verification Conformity to type based on quality assurance of the production process	Annex II – Module F Annex II – Module D
Measuring Systems for the Continuous and Dynamic Measurement of Quantities of Liquids other than Water (Annex VII MI-005)	Conformity to type based on product verification	Annex II – Module F

HYDROLOGY RESEARCH

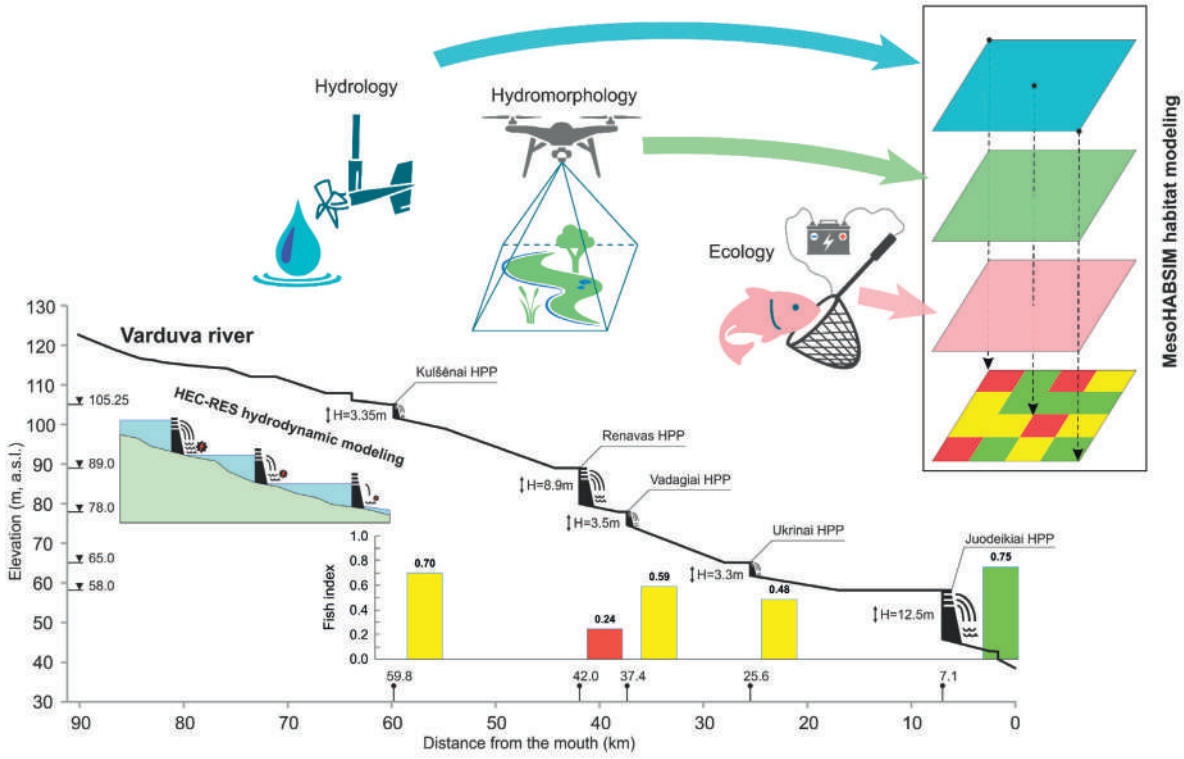
LABORATORY OF HYDROLOGY

MAIN RESEARCH AREAS OF THE LABORATORY OF HYDROLOGY

- Research of river runoff and hydrological extremes in the context of climate change;
- Research of wave, hydrodynamic, and sediment processes in water bodies;
- Research of environmental impact of energy and transport objects;
- Research of river hydromorphology by direct measurements and remote sensing methods.

Successful implementation of the project „Joint management of Latvian – Lithuanian transboundary river and lake water bodies“ (TRANSWAT) under Interreg V-A Latvian–Lithuanian cross-border cooperation programme

- A detailed study of hydropower plants cascade was carried out. The study involved the impact of mentioned technical structure on the hydrological regime of the river and the living conditions of fish;
- The ecological modelling was carried out below each of the five hydropower plants of Varduva River in order to obtain the changes in fish habitats due to the operation of hydropower plants cascade;
- According to the ecological modelling results, the ecological flow was estimated for each Varduva hydropower plant. The estimated values could replace the currently regulated environmental discharge;
- HEC-RES hydrodynamic modelling confirmed that all hydropower plants of Varduva River can operate in cascade mode, by releasing the estimated ecological flow;
- After summarizing the results of the project, recommendations were prepared for the documents of the Technical Regulation of Construction and the Typical Rules for the Use and Maintenance of Ponds.



Project manager at LEI: dr. Jūratė Kriaučiūnienė
Project period: 01.10.2020 – 30.09.2022
Project budget: 607 466.51 EUR

Project funding: Interreg V-A Latvian–Lithuanian cross-border cooperation Programme 2014–2020
Project website: https://www.lei.lt/en/transwat/

SAFETY AND RELIABILITY STUDIES OF ENERGY AND INDUSTRIAL FACILITIES

LABORATORY OF NUCLEAR INSTALLATION SAFETY

MAIN RESEARCH AREAS OF THE LABORATORY:

- Smart cities (integration of heat/electricity/hydrogen/RES/new technologies, district heating modernization, economic evaluation of alternatives, climate neutral/green deal, energy accumulation, digitization)
- Nuclear energy (small modular reactors, assessment of safety, risks and structural integrity of nuclear facilities, development of new nuclear technologies, decommissioning of nuclear facilities)
- Activities under the European Organization for Nuclear Research CERN (particles transport simulations, analysis of radiation processes, material activation calculations, nuclear and particle physics, participation in CERN Baltic Group activities)
- Thermonuclear fusion energy (development of new fusion technologies, international cooperation, experience in EUROfusion activities >9 yrs)
- Multiphase flows (thermal devices, efficiency, accidents, phase transitions, turbulence, flame propagation, gas explosions, water hammer)

3 new Horizon Europe program EURATOM-themed projects have been launched

Horizon Europe is 2021-2027 EU's key funding program for research and innovation.

EURATOM aims to pursue nuclear research and training activities with an emphasis on continually improving nuclear safety, security and radiation protection, notably to contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way. Laboratory scientists have been participating in these activities since 2004.

Funded by the European Union

HARMONISE (2022-2025)

Towards harmonisation in licensing of future nuclear power technologies in Europe

https://harmonise-project.eu/

The project is coordinated by LEI / lab staff

The objective - to prepare for the licensing of future nuclear energy technologies by assessing their specificities and potential shortcomings of licensing and regulatory requirements in various countries.

17 partners from 11 European countries.

SASPAM-SA (2022-2026)

Safety Analysis of SMR with PAssive Mitigation strategies – Severe Accident

https://cordis.europa.eu/project/id/101059853

LEI is a project participant

The objective - to transfer and adapt theoretical and practical knowledge of light water reactors (LWR) to iPWR, in view of the European SA and emergency planning zone analyses.

21 partners from European countries.

OperaHPC (2022-2027)

OPEn HPC theRmomechanical tools for the development of eAtf fuels

https://www.operahpc.eu/

LEI is a project participant

The objective – to develop open tools using High Performance Computing enabling a full 3D high-fidelity thermo-mechanical simulation of the fuel element.

14 partners from European countries.

NUCLEAR AND THERMAL ENGINEERING

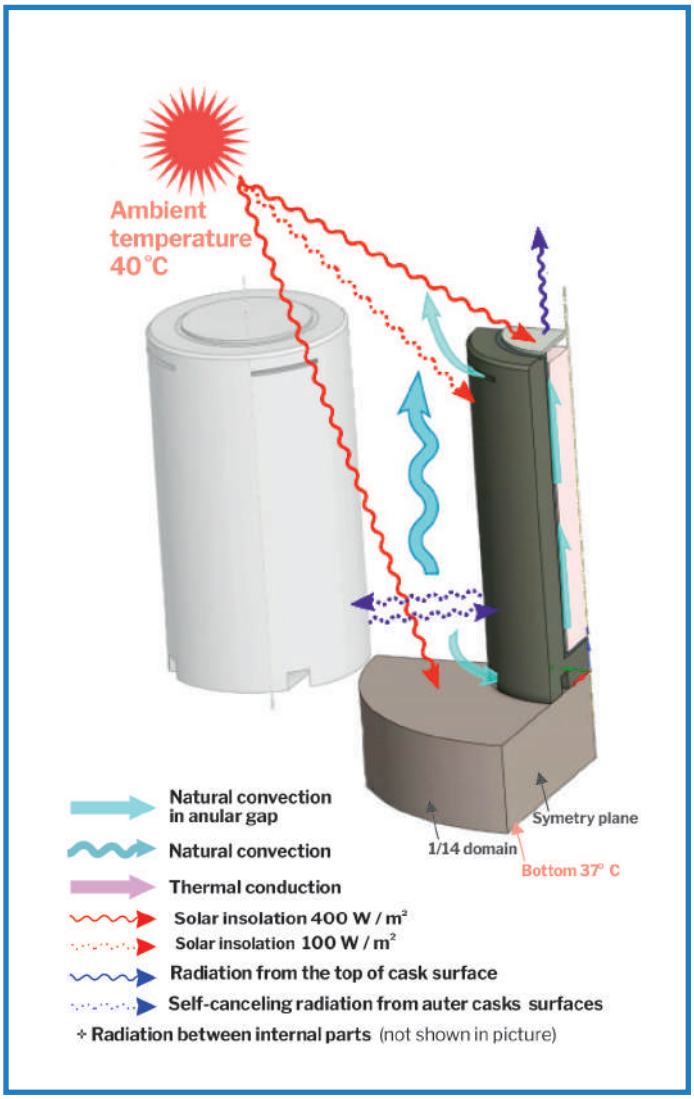
NUCLEAR ENGINEERING LABORATORY

MAIN RESEARCH AREAS OF THE LABORATORY

- Safety of spent nuclear fuel management
  - Interim storage
  - Disposal in deep geological repositories
- Safety of radioactive waste management
  - Treatment
  - Temporal and interim storage
  - Disposal in near-surface repositories
- Assessment of different factors related to decommissioning of nuclear facilities using DECRAD (LEI) software
  - Strategy selection
  - Safety assessment
  - Assessment of dose rates to workers and residents
  - Evaluation of radwaste qualities, labor cost, dismantling duration, etc.
- Waste heat recovery from flue gases during biofuel combustion and reduction of the amount of emissions from the exhaust
- Investigation of heat transfer and hydrodynamic processess in various systems and their components
- Fire safety investigation

Ignalina NPP has been implementing the Ignalina NPP megaproject—crucial and extremely significant as well as unique to Lithuania—and Nuclear Engineering Laboratory has been implementing the following related projects:

- "Environmental impact and safety assessments of the reconstruction and converting of the INPP Bituminised Waste Storage Facility into a repository"
- "Technical Support Organisation Assitance to INPP in respect of Safety Analysis and Repository Waste Acceptance Criteria"
- "Services of nuclear safety justification for the storage of unused nuclear fuel in the spent nuclear fuel interim storage facility"
- "Services for the determination of conditional uncontrolled levels of radioactivity of waste accumulated at the INPP industrial waste landfills"
- Research has also been carried out in two Horizon2020 programme projects, namely INNO4GRAPH (2020-2023) and HARPERS (2022–2025)

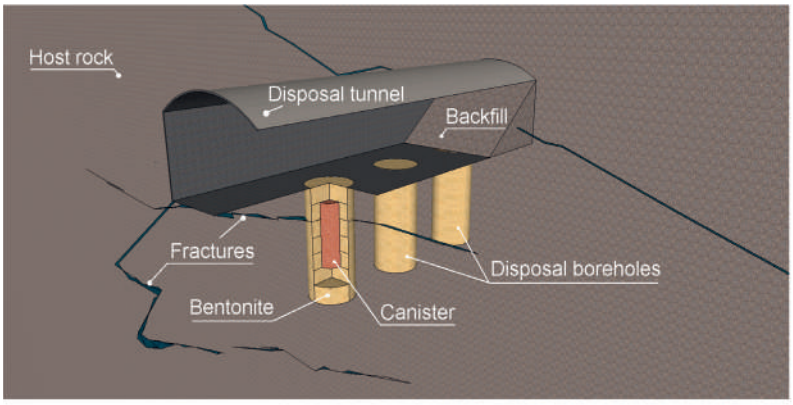


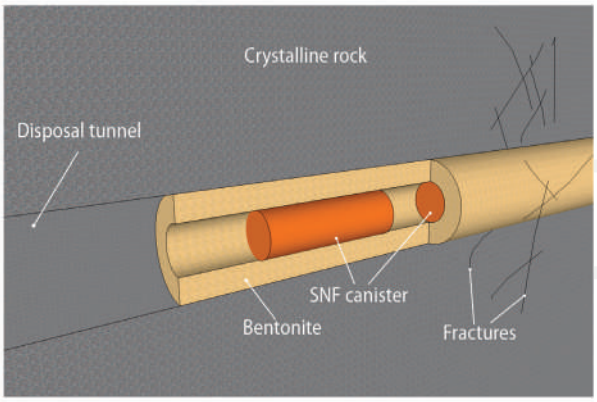
HARPERS

INNO4GRAPH

Ignalina NPP has been implementing a long-lasting deep geological radwaste repository megaproject in Lithuania. Together with foreign research companies, the Laboratory has been implementing the following projects:

- Socio-economic assessment of potential locations for the deep geological repository (Subcontractor to “IDOM”, Spain)
- Preparation of general safety criteria for deep geological repository construction in Lithuania (Subcontractor to “Posiva Solutions”, Finland)
- Research has also been carried out in two Horizon2020 programme projects, namely BEACON (2017–2022) and EURAD (2019–2024)





BEACON
Bentonite mechanical Evolution

eurad
European Joint Programme
on Radioactive Waste Management

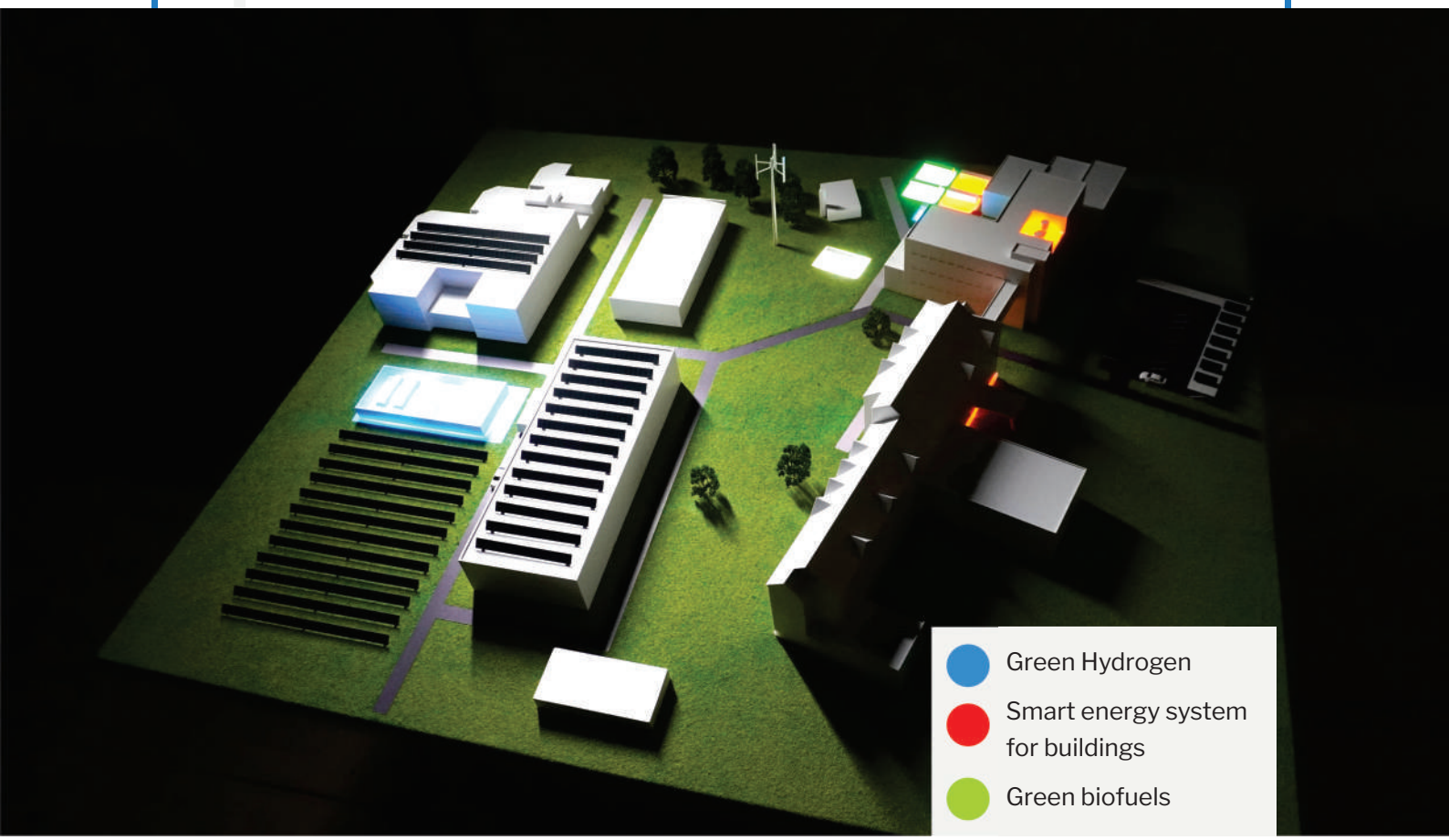
THE GREEN CAMPUS MODEL

LEI Green Campus is an exemplary model of an ecological smart town planned in the territory of the Lithuanian Energy Institute. The model incorporates and integrates technologies for the supply of renewable energy for hydrogen production and renovated buildings.

LEI's Green Campus vision resonates with the aims and objectives of the EU's mission „Climate-Neutral and Smart Cities" and with a goal set in Programme of the 18th Government of the Republic of the Lithuania – to establish a first climate-neutral and waste-free Lithuanian city by 2030.

This infrastructure would be used for the development, integration, and testing of green hydrogen production for transport and buildings, as well as for other energy storage and green fuel production technologies.

INFRASTRUCTURE CONSISTS OF THREE INTEGRATED ENERGY ECOSYSTEMS:



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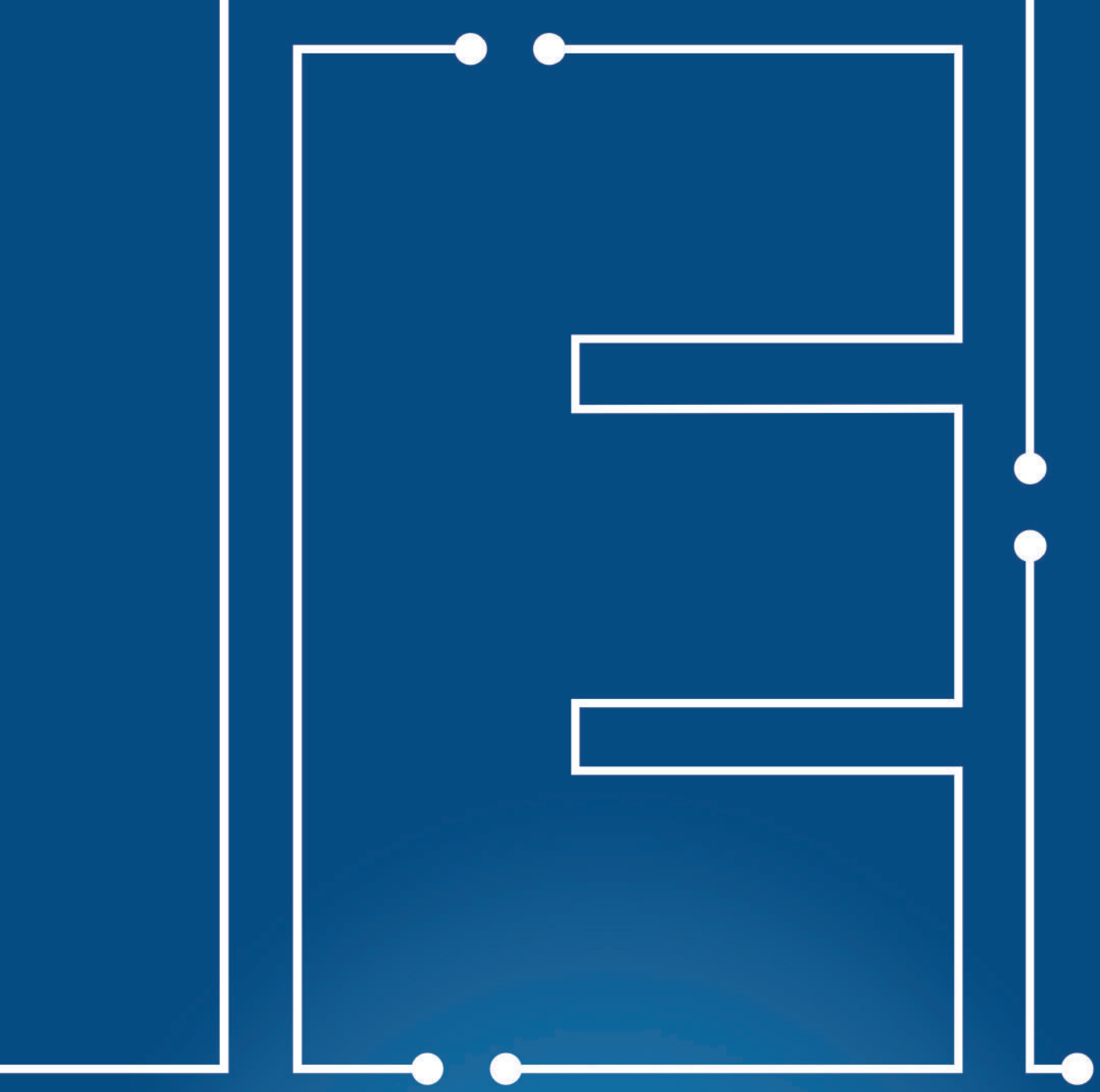

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