Science of Power and Electrical Engineering in Latvia

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A short history of power and electrical engineering science in Latvia

Well before the First World War, a number of prominent scientists were active in the field of power and electrical engineering at Riga Polytechnic Institute (RPI). Professor Engelbert Arnold made important contributions to the development of electric machines. Mikhail Dolivo-Dobrovolsky, a former RPI student, who invented the three-phase asynchronous squirrel-cage electric motor in 1889 and other electrical equipment, was also a major player in global electrification – he was the chief engineer for the world's first-three phase alternating current high voltage power transmission line, installed in Germany in 1891.

After the University of Latvia was founded in the autumn of 1919, its Faculty of Mechanics began to teach students in the field of electrical and power engineering.

Many pre-war period specialists, J. Demants, E. Šterns, J. Zābergs, I. Putniņš, K. Tabaks, Ē. Jankops, and others, worked at the Latvian State University (LSU) as it was reopened after the end of the Second World War. In order to improve their qualifications through their engagement in doctoral studies many lecturers were sent to higher education institutions in Moscow and Leningrad, later gradually introducing doctoral studies also in Latvia.

After the Latvian Academy of Sciences (LAS) was founded, Institute of Physical Energy (IPE) was set up where A. Kroģeris, V. Apsītis, V. Kucevalovs, and other young scientists started to carry out research in electrical engineering. Creation of a new power supply system for passenger carriages of trains was one of the first major tasks addressed by the newly created scientific institution. Hundreds of scientific publications, monographs, and patents were published during this period, as well as prototypes were created that went into production. Important monographs on self-excitation synchronous generators, design of electronic logic systems, semiconductor converters, and inductor machines were written.

At that time, scientific research in electrical and power engineering was carried out also at RPI, where doctoral studies had also been introduced – leading scientists from the LAS were invited to take part in this programme. Comprehensive and important research on the electric fields was carried out by Professor K. Tabaks, who gathered his own group of scientists in this field.

Most of the research in electrical engineering at RPI was carried out in cooperation with the LAS and Riga Electromechanical Factory. Under the guidance of docent L. Birznieks, a former student of A. Kroģeris, world-class scientific research was carried out between 1966 and 1969 – a thyristor-based speed control system for high-power electric traction drive was developed and installed in Baltic Railway Enterprise. Professor I. Raņķis later compiled theoretical and practical results in a monograph on the principles for creating and optimising such systems. Six electric trains were equipped with principally new speed regulators based on this design. The trains were successfully in operation in Latvia from 1969 until 1999 when the last train was taken out of service.

At the same time, research teams at the LAS and RPI also contributed to scientific advance in the fields of electrical heat power engineering, working on relay protection and automation systems, automation and optimisation of electricity generation, transmission and distribution processes – a number of scientific schools were created in these fields. Professor V. Fabrikants started to work in 1960 at the Faculty of Electrical Engineering (FEE) and the Laboratory for Scientific Problems of Semiconductor Relay Protection was then established, which was later recognised throughout the USSR – the use of semiconductor technologies in power system relay protection and automation was studied at this

laboratory. The laboratory made it possible to significantly expand the range of new engineers involved in scientific research and thus to train more highly qualified local specialists.

In 1986, the RPI FEE Scientific Laboratory of Electromechatronics was created and led by Prof. L. Ribickis. Several types of adjustable speed AC drives for centrifugal pumps were developed at this laboratory to be used in Riga water supply systems. Cooperation between J. Greivulis and L. Ribickis resulted in development of patents on more than 50 various inventions for industrial applications. Professor J. Greivulis was an especially active inventor – he had more than 200 patents to his credit.

Science in power and electrical engineering in Latvia in the 21st century

In terms of the amount of funding attracted by scientific research, the number of publications indexed in internationally recognised databases, as well as the rate of their citation, it is evident that Riga Technical University (RTU) (former RPI) is the most important centre in Latvia for scientific research in electrical and power engineering in the 21st century. Some research activities in these areas are carried out also at the Institute of Physical Energetics and the Latvia University of Life Sciences and Technologies (before 6 March 2018, titled Latvia University of Agriculture).

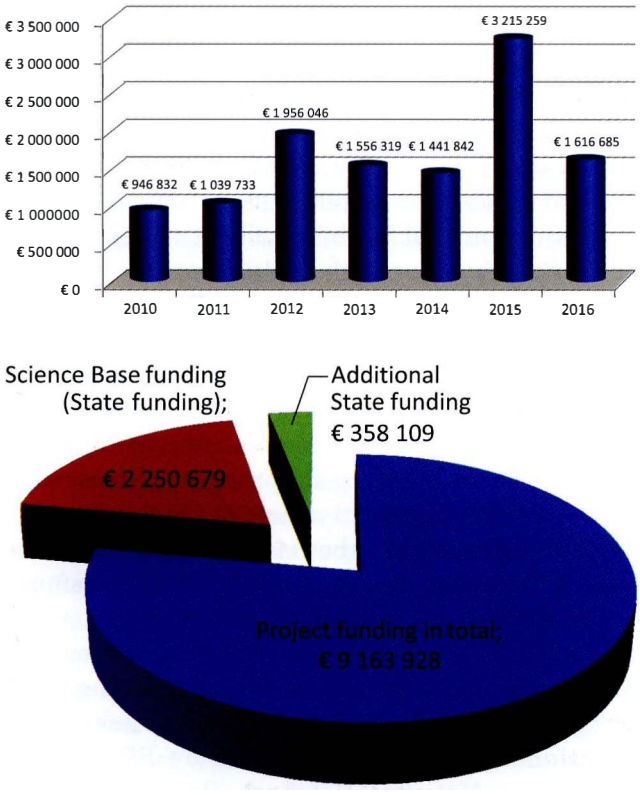

Fig. 1. Research funding obtained at the FPEE, 2010–2016

Science and technology transfer in the field of electrical and power engineering, as well as in environmental engineering in Latvia are mainly implemented at the Faculty of Power and Electrical Engineering (FPEE) of RTU. Three institutes of this faculty – the Institute of Industrial Electronics and Electrical Engineering, the Institute of Environmental Protection and Thermal Systems and the Institute of Energetics – have been the most successful institutes of the RTU for several years in terms of attracted funding, scientific publications and doctoral theses successfully defended. In the period from 2010 to 2016, 92 doctoral theses have been defended at the FPEE in the field of electrical and power engineering, which is a large number for Latvia. During this period, a substantial amount of funding has been attracted via fundamental research projects, as well as contract work, obtained by tender. Although it is difficult to predict the amount of future funding for research, since it depends on competitiveness of the applications and specifics of the funding programmes, FPEE of RTU shows a very positive tendency in attracting project funding (Fig. 1).

Besides FPEE, research on heat engineering is carried out at two other faculties of the RTU – Faculty of Civil Engineering (FCE) and Faculty of Mechanical Engineering, Transport and Aeronautics. Research in the field of energy – specifically studies on biomass conversion processes aiming at the production of liquid fuels, as well as research of the properties of transport fuels – is carried out at the Faculty of Materials Science and Applied Chemistry of RTU. Biofuel subjects are also considered at the RTU FCE Water Engineering and Technology Department, where research is carried out on innovative technologies for production of biofuels from waste. All research groups in the field of energy, electrical engineering, and environmental engineering within the RTU have for several years merged into a single "Energy and Environment" research platform with the aim of increasing the interdisciplinary elements of future research.

During the last decade, work at FPEE in the field of electrical engineering has been devoted to the development of technologies for increased energy efficiency and power electronics for electric drives, robotics, renewables and energy storage in various

mediums. Diagnostic methods for transformers and electric machines have been developed and various studies have been done on electromagnetic compatibility issues.

In the field of power engineering, FPEE has been investigating and developing diagnostic methods, management technologies, as well as instruments for stable and optimal operation of power supply systems. Assessment of critical infrastructures has been done, safety and risk evaluation of the Latvian power transmission and gas systems, have been carried out, including the mutual influence of the electricity transmission system, gas distribution network and correspondent communication systems.

Research in the field of heat power systems has been well integrated into environmental engineering over the last decade within FPEE. Research on various practical problems has been done introducing innovations and advanced technological solutions for various applications – raising energy efficiency in buildings, power plants, technological systems of industrial plants, district heating systems and other.

Science at the Faculty of Power and Electrical Engineering of RTU today

Since in comparison to other European Union (EU) member states the state funding for research in Latvia is very low, researchers of FPEE of RTU are very active in submitting project proposals within various EU funding programmes, as well as carrying out research contract work with enterprises, municipalities and public administration bodies.

Various international programme projects – in particular projects of EU framework programmes

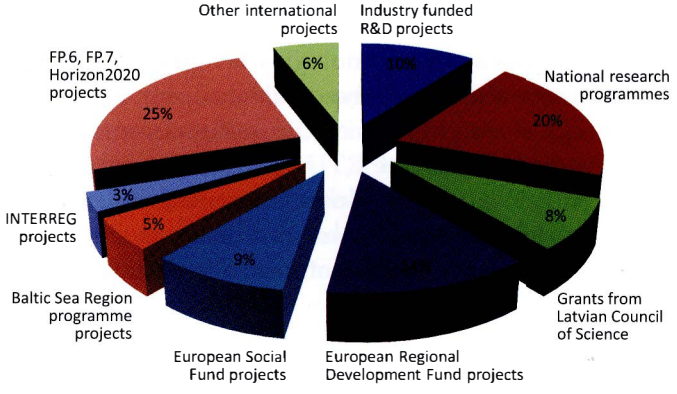

Fig. 2. Breakdown of funding sources of research projects at FPEE 2010–2016

"FP6", "FP7"and "Horizon 2020" – are considered to be the most significant scientific projects in the scientific community today. FPEE has participated and coordinated a significant number of projects within all of these programmes over the last decade (Fig. 2).

Among the most significant research projects implemented by the FPEE in the last decade the following should be mentioned:

- The recent FP7 project "AREUS" completed in 2017 was devoted to elaboration of a DC power supply system for future robotised automobile factories capable of delivering significant gains in energy efficiency. A prototype DC robot supply system was set up in *Daimler AG,* Germany within the project;
- Two "Horizon 2020" projects, "Sunshine" and "Accelerate Sunshine" currently coordinated by FPEE are devoted to developing third-party financing schemes for energy efficiency measures and the implementation of such schemes. The "Horizon 2020" project "RiBuild" devoted to raising the energy efficiency of historic buildings has gained wide acknowledgement as well;
- The ongoing "Horizon 2020" project "Real Value" has developed software for thermal modelling of distribution networks and individual households or buildings under conditions where partial electrification of heat supply has taken place with smart and centralised electric heat storage heaters;
- The FLEX4RES project, funded by the Nordic Energy Research programme, is dedicated to research of interconnection of electric energy and heat supply systems based on an analysis of the operational flexibility of heat supply systems in Scandinavia and the Baltic States;
- Altogether seven European Economic Area (EEA/Norway) programme funded projects have been implemented at FPEE – one of these projects considered a combined system consisting of solar collectors, storage tank and pellet heating boilers for provision of individual heat supply for multi-apartment buildings;
- Three projects have been implemented under the EU Baltic Sea Region (INTERREG) programme, particularly "Low Temp" project being devoted to fourth-generation district heating systems.

Among the local projects National Research Programme (NRP) "LATENERGI" has to be mentioned which is coordinated by FPEE since 2014. The National Research Programme is a form of state procurement of scientific research

in particular field of interest with an aim to foster development of this field. Research undertaken through NRP "LATENERGI" addresses the interaction between the complex and integrated Latvian energy sector and its limiting environmental factors. Practical solutions are offered for development of the Latvian energy sector, as it moves towards realising of the 20/20/20 priority objective set by the European Union.

Scientific research in the context of contractual work carried out at the FPEE has involved not only expertise, consulting, and development of technological equipment for companies active in the electrical and energy sectors, but also participation in drafting legislation and modelling development of the national energy sector. The following developments are among the most significant recent FPEE contracts:

- A prototype measurement system designed and commercialised resulted from a contract with "Daimler AG" for synchronous, multichannel electrical energy flow measurement in DC power supply systems in robotised automotive factories;
- Software packages "OptiBidus-HES" and "OptiBidus-TEC", which were developed for the JSC *Latvenergo*, are applicable for mode prediction and optimal control of hydro power plants on the river Daugava and for hourly thermal energy demand management of Riga district heating system. The software can be used to estimate the quantity and cost of electricity produced by Riga combined heat and power plants (CHPP-1 and CHPP-2) and for the preparation of price bids for energy exchange;
- Decision support software was developed for high voltage transmission system manager JSC *Augstsprieguma tīkls*, for optimal control of parameters for regulation of the power system, in order to ensure energy balance and uninterrupted supply. The developed software is one step towards increased use of Baltic energy resources for balancing the power system and to reduce the quantity of energy imported from Russia – an essential factor for integration of the Baltic energy systems into the European energy network and decoupling from the BRELL network;
- Sensitivity measurements and extended testing of smart electricity meters were carried out in a contract with electric energy distributor JSC *Sadales tīkls*, studying various factors influencing smart metering of electricity;

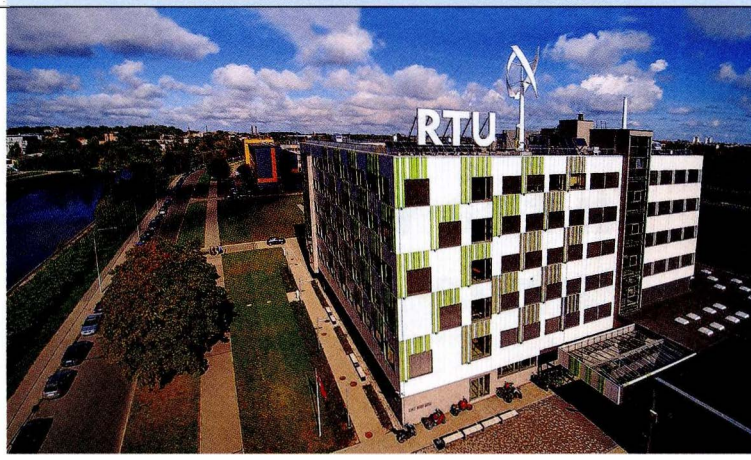

Fig. 3. The new building of the Faculty of Power and Electrical Engineering of RTU at Ķīpsala, Āzenes iela 12/1

- An energy and exergy analysis of industrial equipment was carried out for energy producers *Granul invest* Ltd and *Līvānu karbons* Ltd;
- Innovative thermal power equipment solutions were developed and patented for boiler manufacturers *Grandeg* Ltd and JSC *Komforts*;
- Technological solutions were developed for raising system efficiency and the training of engineering staff for suppliers of district heating, *Fortum Latvija* Ltd, JSC *Rīgas Siltums,* and *Jūrmalas Siltums* Ltd;
- A study was done for the Ministry of Economics, which included a model for operation of Riga CHPP in the electricity wholesale exchange *Nord Pool*, which allowed assessing both the possibilities for reducing state aid granted to Riga CHPP and changes in the price of electricity offered on exchanges under different scenarios. Results of the research were later used in elaboration of the 2017 conceptual report "Complex Measures for the Development of the Electricity Market".
- A System-dynamics model was developed for the Ministry of Economics to model the implementation process of the EU Energy Efficiency Directive in Latvia;
- A model of the impact of the energy sector on climate change was developed for the Ministry of Environmental Protection and Regional Development to model the progress of Latvia as an EU Member State towards reaching energy and climate targets for 2020 and 2030.

Another well-acknowledged measure, which is an important indicator of a successful scientific performance within the scientific community, is the number of internationally recognised scientific publications. Over the past five years, FPEE researchers have published more than 500 high-quality scientific publications indexed in the SCOPUS or Web of Science databases.

Translated by Eduards Bruno Deksnis