LITHUANIAN ENERGY INSTITUTE 2006 ANNUAL REPORT

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ENERGETIKOS INSTITUTAS



LITHUANIAN ENERGY INSTITUTE

is a state scientific research organization, created for carrying out the long-term scientific research projects important for Lithuanian economy, culture and international cooperation. The main activities of the Institute are R&D activities.

The Institute seeks to become the highest qualification expert on the issues of power engineering safety, energy economics, metrology, and engineering.

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Scientific activities in the Institute were carried out according to five research directions approved and financed by the Government of the Republic of Lithuania:

- . Development of energy economy planning methods, investigation of safety and reliability of power plants, their impact on the environment, efficient energy consumption and renewable energy sources.
- II. Investigations in the fields of thermal physics, fluid mechanics and metrology.
- III. Simulation of complex systems, development of their control methods and technologies.
- IV. Investigation of energy systems' construction elements aging and development of new multifunctioned materials.
- V. Investigations of combustion and plasma processes in the fields of fuel saving, reduction of environmental pollution and thermal decontamination of materials.

Distribution of researchers according research directions



Power Plant, SC *Lietuvos Energija*, SC *Lietuvos Dujos*, SC *Achema*, Klaipeda State Seaport, other). Some of the projects were implemented together with scientists and experts from Czech Republic, Estonia, France, Germany, Russia and United Kingdom.

LIANCE

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Year 2006 – the anniversary year for Lithuanian Energy Institute (50-year anniversary) and the closing year for the EU Sixth Framework Programme – was one of the most successful years in the history of the Institute.

Researchers of Lithuanian Energy Institute carried out 19 state funded research projects, six of which were successfully completed and defended in 2006, whereas other projects will be continued in the period of 2007–2008.

Researchers of the Institute successfully and productively co-operated with Lithuanian and international institutions and private companies. Projects worth of 11 million Litas were performed, out of them projects worth 7.7 million Litas – contracts from Lithuanian institutions and industrial enterprises (the Ministry of Economy and the Ministry of Environment of the Republic of Lithuania, State Nuclear Power Safety Inspectorate (VATESI), State Enterprise Radioactive Waste Management Agency (RATA), Ignalina Nuclear In 2006 one of the largest and most successful projects in the history of the Institute was completed: researchers of the Institute together with specialists of Ignalina NPP developed and implemented **Technology of nuclear fuel transporta-***tion from Ignalina NPP Unit 1 to Unit 2 for fuel reuse.* Lithuania undertaking its obligations, included in the Treaty of Accession to the European Union, in 2004 shutdown Ignalina NPP Unit 1. One of the specific features of RBMK-type reactors is that after the shutdown of Unit, fuel assemblies, which remain in the reactor, are applicable for further reuse.





Laureats of the Lithuanian Science Award 2006 – Benediktas Cesna, Petras Vaitiekunas and Leonas Vaidotas Asmantas. The award granted for the cycle of works of Fundamental and applied sciences research Intensification of heat and mass transfer and determination of

reguliarities in power devices (1975–2005)

Thus, after the shutdown of Ignalina NPP Unit 1, approximately 1000–1200 of fuel assemblies from Unit 1 are applicable for further reuse in Unit 2 reactor. Technicaleconomical calculations demonstrate that such reuse of fuel enables to save approximately 600 of fresh fuel assemblies, the price of which exceeds 100 million Litas. Besides this direct economical effect, the project implementation allows to reduce the amount of fuel to be transported from Unit 1 to a fuel storage facility, the amount of fuel to be imported to Lithuania, and the amount of radioactive waste to be stored. If we take into account the reduction of expenses, related to fuel storage, the economical effect due to fuel reuse in Unit 2 reactor increases up to a few hundred million Litas.

Developed set of equipment for nuclear fuel transportation is successfully operated at the Ignalina NPP. The first 6 fuel assemblies from Unit 1 to Unit 2 reactor were transported on the 1st of July 2006, whereas the first fuel assembly from Unit 1 reactor was loaded to Unit 2 reactor on the 9th of November 2006, on the eve of 50-year anniversary of the Institute. In total, during the year 2006 66 fuel assemblies were transported from Unit 1, 22 from them were loaded to Unit 2 core. Experts of Ignalina NPP mastered the technology of nuclear fuel transportation and at present this process has accelerated – at the end of January 2007, 96 fuel assemblies were transported from Unit 1, 62 of them loaded to Unit 2 core.

Researchers of the Institute actively participated in the EU financed programmes. Researchers of the Institute together with partners from different countries completed one project of the EU Fifth Framework Programme and three projects of *Intelligent Energy Europe*. Lithuanian Energy Institute implements three projects of INTERREG III, two projects of EUREKA, five projects of IAEA and COST, one project of the Leonardo da Vinci programme, several projects of PHARE and even seventeen projects of *Intelligent Energy Europe*.

Title of completed project financed from the state budget		Direction of scientific activity	Leading researcher	
Unertainty analysis of modeling result natural and social systems	ts of technical,	1	Dr. Habil. A. Kaliatka	
Analysis of Ignalina NPP Unit 1 decom management of radioactive waste	nmissioning and	1	Prof. Dr. Habil. P. Poskas	
Research of impact of air flow hydrod of measurement of standard and ope	lynamical characteristics on the accuracy rating air volume, flow velocity meters	11	Dr. Habil. A. Pedisius	
Research of impact of liquid physical characteristics on the accuracy of me	properties and flow hydrodynamic easurement of volume and flow meters	11	Dr. G. Zygmantas	
Hydroecological regime of use of Lith environmental protection assessment	uanian rivers and t	1	Prof. Dr. Habil. B. Gailiusis	
Synthesis of metal alloys designed fo applying ion-plasma methods	r hydrogen storage,	IV	Dr. D. Milcius	



These are excellent results. However, the integration of the institution into the most significant EU research programme -Sixth Framework Programme speaks of the true scientific potential and perspective of science and education institution. According to Agency for International Science and Technology Development Programmes, Lithuanian Energy Institute researchers submitted 51 projects proposals for the Sixth Framework Programme, out of which 15 projects received the EU funding (in total 574 thousand euros). In such way, a success rate of the submitted projects proposals of the institute for the Sixth Framework Programme is rather high - 29%. In comparison: Lithuanian science and education institutions for this programme submitted 1578 project proposals, out of which 330 received the funding, thus, their success indicator is 20.9%. In accordance with the number of implemented Sixth Framework Programme projects, Lithuanian Energy Institute is the unguestioned leader among Lithuanian science institutions and only Kaunas University of Technology and Vilnius University surpass Lithuanian Energy Institute.

Scientists of the Institute together with partners from best European research centres implement EU Sixth Framework Programme projects, devoted for the research of NPP severe accidents phenomenology (SARNET), extension of nuclear power plants operation time (NULIFE), hydrogen energy (NENNET, FET-EEU, HYTRAIN, NESSHY and HySIS), new and renewable energy sources (CEERES and COFITECK), and energy socialeconomical (NEEDS, EIFN, SOLID-DER and CASES) issues. It should be noted that Institute was the first Lithuanian science and education institution to join the EU Sixth Framework Programme thermonuclear synthesis research programme FUSION, the aim of which is to develop an operating industrial thermonuclear reactor. Currently researchers of the Institute successfully implement two

FUSION projects, devoted to the assessment of hydrogen release during the accident in experimental thermonuclear reactor ITER and for the research of properties of materials used for the production of thermonuclear reactors. In 2006 the Institute together with the European Commission's Directorate-General for Research signed EURATOM-LEI association contract, which enables Lithuanian science and industry institutions to get involved into EU thermonuclear projects. In EURATOM-LEI association, besides Lithuanian Energy Institute, Kaunas University of Technology, Vytautas







The most active young scientists and Ph.D Candidates of Lithuanian Energy Institute. Among them laureates of the Lithuanian Academy of Sciences – in the front – Dr. R. Alzbutas and Ph.D Candidate V. Matuzas (in the centre of second row)

Magnus University, and Institute of Theoretical Physics and Astronomy of Vilnius University represent Lithuania.

Aiming for high quality science and technical works, a close synergetic connection between fundamental research and applied science is required. Fundamental research results cannot be achieved without state-of-the-art measurement equipment and special software of the highest level. In 2006 Institute spent approximately half a million Litas for the expansion of the basis for scientific research. From these funds Laser Doppler anemometer equipment for the measurement of two components, impulse meter of controller UV-8, flow meter MAG1100, specialised software (e.g., Arc View v.91), and numerical data base of Lithuanian cosmic image map were purchased. However, state-of-the-art experimental equipment and software itself do not ensure significant research results. Therefore, considerable attention was given to the increase of qualification and competence of scientists and young researchers.

Lithuanian Energy Institute successfully participated in preparing tenders for applying for the EU Structural Funds and mastering them for the period 2004–2006.

Researchers of the Institute succeeded in implementing the project *Center for Hydrogen Energy Technologies*, financed by the Central Project Management Agency and Lithuanian Energy Institute, in which possibilities of implementation of infrastructure project (Center for Hydrogen Energy Technologies), which was planned to be submitted, were evaluated.

At present two projects of EU Structural Funds are being implemented by Institute: project **Organization of hydrogen energy technologies training** (partner Vytautas Magnus University), financed by the Ministry of Education and Science, the European Social Fund Agency and Lithuanian Energy Institute, and the project **Repair of heat transfer and nuclear facilities laboratory administrative building (10C 3/b) of Lithuanian Energy Institute**, financed by the Lithuanian

In 2006 Kaunas University of Technology together with Lithuanian Energy Institute conferred Doctor of Science degree for three researchers of the Institute:

- 13 June Stase Irena LUKOSIUTE for work Peelable methylolpolyamide coatings and their properties in the field of materials engineering;
- 19 December Virginijus RADZIUKYNAS for work Influence of power balance and frequency deviations on electric power system operation and their control in the field of power and thermal engineering;
- 19 December Aurimas TONKUNAS for work Modeling of the reactor control and protection system and its cooling circuit during dewatering process in the field of power and thermal engineering.



Variation of publications number (Author's contribution evaluated)

Business Support Agency and Lithuanian Energy Institute.

The Institute also participates in the EU Structural Funds project **Development** and implementation of postdoctoral traineeship system of natural sciences co-ordinated by the Lithuanian Science Council.

Successfully collaborating with SC Naujasis Kalcitas a new EU Structural Funds project Scientific research of development and application in manufacturing of high caloricity materials and waste gasification technology, which reduces fuel input, funded by the Lithuanian Business Support Agency and SC Naujasis Kalcitas, has been implemented since the beginning of 2007.

Currently research institutions as well as industrial enterprises cannot expect contracts without certificates from supervising institutions to implement a certain activity and without implementing quality management system in an institution, corresponding to the requirements of ISO 9000 series standards. Lithuanian Energy Institute was the first Lithuanian science and education institution to implement the Quality Management System, Lithuanian Standardization Department on the 17th of February 2004 issued a Certificate Institute's Quality Management System, which corresponds to the requirements of LST EN ISO 9001:2001. This system is constantly improved, each year audits of quality management system are carried out. To continue the validation of ISO 9001:2001 certificate, the repeated quality management audit has to be performed each year, and each third year – a comprehensive audit. In order to maintain ISO 9001:2001 certificate a repeated quality management audit had to be completed till the 17th of January 2007.

However in the Institute it was decided to assess not only in accordance with Quality Management System ISO 9001:2001, but also in accordance with the requirements of Environmental Management System. Mentioned audits of Quality Management System and Environment Management System were successfully carried out in November of 2006, whereas on the 15th of February 2007 Lithuanian Standardization Department issued certificates, which correspond to the requirements of LST EN ISO 9001:2001 and LST EN ISO 14000:2005.

As it has already been mentioned, 2006 was closing year for Sixth Framework Programme, During the period 2007–2013 the EU Seventh Framework Programme, the budget of which is much larger than that of the Sixth framework Programme, will take place, and one of its key instruments will be Technology Platforms. Seeking better participation in the Seventh Framework Programme the Institute together with other Lithuanian industry, research and education institutions took part in initiating a number of Technology Platforms – Hydrogen and fuel cells, Future manufacturing technologies, National heating energy, National biomass and biofuel manufacturing and consumption, and National biofuel technology platform.

PHD Studies

Since 1992 up to 1998 Lithuanian Energy Institute had an authority to award doctor's degree in the following science directions:

- Energetics and thermal technology (7D);
- Materials science (08T);
- Geography (hydrology) (2D).

Since 1998 after the change of the Regulation of Ph.D studies in the Republic of Lithuania, Lithuanian Energy Institute together with Kaunas University of Technology has had an authority to award doctor's degree in the field of technology sciences, energetics and thermal engineering direction (06T). Since 2003 Lithuanian Energy Institute has the integrated Ph.D studies together with Kaunas University of Technology in the following science directions:

- Economics(04S);
- Environmental engineering and regional management (04T);
- Power and thermal engineering (06T).



In the period 1992-2006 52 Ph.D

Candidates completed Ph.D studies,

doctoral theses were defended by 35.

Thus, performance of Ph.D studies – 67%.



Distribution of Lithuanian Energy Institute Ph.D Candidates according to the science directions

The presidium of the Lithuanian Academy of Sciences according to the results of young researchers scientific works competition 2006 The Award of the Academy of Sciences, awarded Dr. R. Alzbutas and Ph. D Candidate V. Matuzas for set of publications Assessment and control of reliability and risk of power systems. M. Lelis for his work Plasma interaction with polymers and research of their adhesive properties was granted the Award of the Academy of Sciences for university students.

Since 2004 the annual conference *Youth Energy* of Ph.D Candidates and young scientists has been organized. It is aimed at educating young researchers' ability to present their ideas and research results in public, defend them reasonably and discuss, listen to remarks and recommendations of other scientists, prepare articles and get acquainted with works of their colleagues. Ph.D Candidates of other universities and institutes are invited to participate in the conference. In 2006 the conference was attended by 24 Ph.D Candidates: 16 – Lithuanian Energy Institute 4 – Kaunas University of Technology, 1 – Vytautas Magnus University, 2 – Vilnius Gediminas Technical University, 1 – Siauliai University and 1 – Vilnius University.

Laureates of the conference "Youth Energy 2006"



LABORATORY OF HEAT-EQUIPMENT RESEARCH AND TESTING

Main directions of the Laboratory research:

- provision of metrological support to the Lithuanian energy sector in the field of fluid flow measurements, establishment and maintenance of state flow standards and ensuring measurement traceability to standards of European countries;
- research of influence of liquid physical properties and flow disturbances on the metrological characteristics of reference and working volume and flow rate meters, operating under different principals. Proving the reliability of metrological characteristics of meters calibrated by fluids-substitutes for measuring real flow of technical and nutritional liquids;
- scientific research in order to develop methodologies of liquid and gas flow measurement, to determine the impact of influence factors on measuring accuracy and forecast non-balances of energy supply and consumption.
- test of thermal equipment, gas appliances as well as liquid fuel, natural gas, water and heat meters carried out with the aim to determine its conformity to the requirements of Lithuanian and European normative documents.

Accredited services of the Laboratory:

- calibration of measuring instruments and facilities designed for its calibration/verification, tests of measuring instruments, water heating boilers and gas appliances in accordance with LST EN ISO/IEC 17025 standard;
- conformity assessment of measuring instrument and equipment mentioned above ir accordance with LST EN ISO/IEC 17025 standard (in this field the Laboratory is notified and granted the identification No 1621).

In 2006 work was initiated aiming at notification for measuring instrument type evaluation and conformity assessment.

Research of turbine gas meters in pulsating flow

In 2006 important results were obtained investigating the reaction of turbine meters to flow pulsations, which are evoked by uneven gas consumption or wrongly adjusted regulators. The relevance of this task is determined by the wide use of turbine meters in the country. Taking into account that approximately 3 billion m³ natural gas is con-



Turbine gas meters (flow rate up to 1000 m³/h) test facility

sumed in Lithuania, whereas its price constantly increases, significance of these activities is observed.

Experimental research carried out in facility, which is provided with contemporary measuring process control and data processing equipment, which enables changing pattern of flow pulsations increasing flow rate from 0 to 400 m³/h and vice versa reducing it from 400 m³/h to 0. It was determined that with the reduction of flow rate readings of meter stabilize slower than at flow rate increase. In case of flow rate reduction the results were summarized using analysis of dimensions, and regularities were determined when main parameters are three nondimensional complexes. One of these complexes is an analogue of Fourier's criterion, used for describing nonstationary heat conduction processes.

Dynamic error research methodology based on finite differences method was developed. Performed analysis of impact of flow pulsations revealed that when pulsation frequency is 1 Hz dynamic error reaches limitary value and further does not increase.

The biggest errors are obtained when flow pulsates according rectangular law and their value depends on the amplitude of



Dependence of dynamic error limitary values on flow pulsation variation law and relative amplitude: 1, 2 and 3 – rectangular, cosine and triangular laws, respectively

flow pulsations. Thus, in pulsating air and gas flows turbine meters may record a larger amount than flow through them realistically. When amplitude of pulsations reaches 10% from nominal flow rate value positive error already reaches 1%.

Research of air velocity measurement

In order to reliably evaluate uncertainty of measurements while investigating air ve-

locity it was inclined towards low air velocities measurements.

1 and 2 beam Laser-Doppler anemometer (LDA) was mastered. Preliminary research, measuring velocity in the limits from 0.5 to 30 m/s, revealed that uncertainty may be reduced up to three times, and the uncertainty at the moment in this field will comprise \pm (2.7–0.30)% and



Facility designed for investigation of liquid meters characteristics

will correspond to the level of the best measurement institutes of Europe.

At low velocities total uncertainty is mostly determined by flow instabilities. Measurement of low velocities is especially relevant for calibration of thermoanemometers, the lower measurement limit of which, declared by producers, comprises 0.05 m/s and which became almost the only instruments used in different fields to measure low velocities. It came up a possibility to precisely measure velocity distributions and their deformations when flow cross-section is blocked with obstacles or the measuring instrument itself. Thus employing LDA the will be aim to investigate and validate the method in air and water flows, which would enable, employing LDA, calibrate large diameter water meters in their operation place.

Research of liquid (water and oil products) volume measurements

In 2006, it was carried out research of the impact of physical properties of liquids and installation conditions of meters on the accuracy of measurement in newly developed facility, the construction of which is analogous to the construction of state standard facility and with high



Facility designed for air velocity measurements employing LDA

accuracy enables to perform measurements of volume and flow rate.

Measurement errors of electromagnetic flow meters (of different manufacturers, including Lithuanian) used for the accounting of nutritional liquids at different electric conductions and liquid temperature were assessed. It is determined that dependence of measurement error on liquid temperature is a few times bigger than it is declared by producers of these meters. A very important applied work was related with metrological validation of accounting unit (comprised of 11 measurement systems of oil products connected to common central computer) of newly installed oil products terminal of SC Mazeikiu Nafta. Each measurement system is comprised of density, temperature and volume measurement equipment, the elements of which are connected to corresponding electronic calculators-controllers, which control filling process and measurement results of volume and density. For this purpose methodology and working mobile reference standards - 5 m³ volume standard and positive displacement meters for flow rate up to 135 m³/h were equipped. This enabled to test operation of individual parts of accounting unit.and evaluate total measurement accuracy which does not exceed $\pm 0.5\%$ and satisfies conventional requirements.

International comparisons of standards

In 2006 international comparisons in the fields of oil products, water and gas to confirm the traceability of standards, developed at the Laboratory, with the standards of national measurement institutes of European countries as well as the competence level of personnel were completed.

Final comparison according EUROMET projects No 669, 862 and 863 were particularly important since only national laboratories of countries responsible for state standards participated.

Results of all comparisons were positive, i.e. measurement possibilities of standards of the Laboratory agreed with the average of European countries and cor-



Mobile facility with 5 m³ volume standard



Comparison results of gas meters in accordance with EUROMET project No 862



Comparison results of water meters in accordance with EUROMET project No 669

related very well with reference values, which were submitted by national laboratories which organized the comparisons.

Tests of boilers and gaseous appliances

In 2006 eight investigations and tests of gaseous appliances and boilers were carried out according contracts with Lithuanian organizations.

Modernization of testing and research facility of boilers and gaseous appliances and application for the investigation of biofuel combustion efficiency, according LST EN 303-5:2000 standard requirements, should be considered the most important accomplishment. Operation of facility was tested by investigating combustion of wood sawdust granules. In order to satisfy the needs of manufacturers of Lithuanian boilers, which burn biofuel, the Laboratory prepared for accreditation in this field and efficiency research. Measurement equipment was supplemented with analyser of unburnt hydrocarbons.

Other activity

Researchers of the Laboratory:

- participated in working group to prepare the new version of Metrology law and technical regulation of measurement instruments;
- prepared normative document Legal metrological regulation of measurement instruments;
- carried out 20 technical expertises by request of different Lithuanian organizations;
- participated in project No 2005/017-494-05-01 Strengthening measurement infrastructure in liquids and grain sectors provided by State Metrology Service and The Netherlands Measurement Institute;
- prepared thesis for doctor degree, which defended on February of 2007.

Researchers of the Laboratory prepared 1 article for publication included into the list of Institute of Scientific information, 7 articles in Lithuanian journals and 1 science popularization article.

Dr. Habil. Antanas PEDISIUS

Head of Laboratory of Heat-Equipment Research and Testing Tel.: +370 37 401863 E-mail: testlab@mail.lei.lt

LABORATORY OF COMBUSTION PROCESSES

Main directions of scientific activities:

- efficiency increase of combustion processes;
- design and development of burners;
- research of hydrogen separation from organic fuel;
- experimental research of solid waste utilization-gasification;
- numerical modelling of granular mediums;
- research of carbon nanostructures extraction optimization.

Utilization of glycerol fraction derived from biodiesel production

Scientific research of glycerol fraction utilization, which has been initiated since 2006 in Lithuanian Energy Institute, is carried out in two directions: *autothermal conversion of glycerol fraction* and *glycerol combustion*, seeking to develop a glycerol burner. After performing the analysis of main thermal decomposition processes (partial oxidation and autothermal decomposition) and initial experimental research, it was observed that glycerol is a potential raw material for hydrogen extraction, whereas biodiesel is a very attractive alternative for diesel. In the Directive 2003/30/EC of the European Parliament and of the Council it is promoted to use biodiesel for transport, pursued amount of consumed fuel is indicated. By the end of 2005 the amount of consumed biofuel should account for 2% of total fuel consumed for transport,



Experimental setup of glycerol fraction thermal decomposition: 1 – Rotameter; 2 – Air inlet nipple; 3 – Reaction chamber; 4 – Calibrated glycerol container; 5 – Glycerol injector;
6 – Reaction products; 7 – Gas burner; 8 – Heating chamber; 9 – Water cooled gas suction probe; 10 – Peltier cooler; 11 – Glass condensers; 12 – Silica gel absorber; 13 – Aspirator; 14 – Membrane pump; 15 – Flow regulator with rotameter; 16 – Temperature sensor; 17 – Volumeter; 18 – "Tedlar" gas bag

whereas by 2010 this amount should increase by 5.75%. Huge costs of biofuel production is one of restricting factors. Huge amounts of by-products, e. g. glycerol, should be utilized in such methods, which would contribute to economic extraction process of biofuel and thus it would be possible to implement the EU objectives.

Developing a glycerol burner in the beginning all attention was paid to the research of characteristics of glycerol atomization and suitable selection of burning process for further designing of burner. Due to universal applicability the most simple glycerol atomization method employing atomizer was chosen.

Seeking to present many effective glycerol fraction utilization solutions, international consortium of different expertise, qualification and experience, comprised of different science institutions, universities and industrial enterprises, was developed. Main objective of this consortium was to develop economically efficient technological processes for the utilization of glycerol fraction. In this project Lithuania was represented by two partners: JSC *Taurages Silumos Tinklai* and Lithuanian Energy Institute. The Institute during EUREKA implementation foresees the following scientific works:

- scientific research of glycerol combustion and develop a burner designed for burning glycerol fraction;
- scientific research of glycerol phase thermal decomposition to develop autothermal glycerol conversion process for hydrogen separation.

Glycerol, taken from one of the largest biodiesel factories in Lithuania JSC *Rapsoila*, was used for experiments. Research setup was designed to perform thermal decomposition of glycerol fraction.

Decompositing glycerol by thermal method, the most attractive hydrogen extraction technologies are *partial glycerol oxidation* or *autothermal conversion*. In ideal cases of these processes it may be seen that the maximum hydrogen concentration is reached in thermoneutral $(\Delta H_{r,298} = 0)$ points of these processes and respectively account for ~ 30% and ~57% of volume. However, practically the concentration should be smaller since additional amount of heat would be necessary to heat up a reactor and reaction products up to 800–1450 °C. It is determined that hydrogen concentration in gaseous reaction products with the decrease of air surplus coefficient from 0.6 to 0.16 increased from 7.8 to 11% according volume. In order to obtain larger hydrogen concentration in final reaction products, optimal conditions must be determined at which the minimum amount of hydrocarbons would be formed.

With experiments it is also determined that H_2 concentration in gas mixture increases at reduction of air surplus coefficient, at temperature 1200– 1400 °C. Most part of hydrogen is formed during rapid exothermal partial fuel oxidation (in the primary part of reactor approximately 70–90% from total H_2), whereas the other part is formed during endothermal CO conversion into water vapour.

Aerodynamic calculations of KT1/1 furnace smoke system and reconstruction solutions

The objective of the project is to find aerodynamic solutions for turbulent flow in large spaces, when sources, which evoke flow function, operate in parallel and consistently. Solutions are sought by calculations of differential equations, which have been performed by Lithuanian Energy Institute. The work is planned to be expanded and specified by more generalized direction and prepare scientific publication *Management of currents flowing in large spaces*.

Systems of differential equations are solved using FLUENT code, the obtained results are generalized to form a simple

9.75e+01
9.27e+01
8.78e+01
8.30e+01
7.81e+01
7.32e+01
6.84e+01
6.35e+01
5.87e+01
5.38e+01
4.90e+01
4.41e+01
3.93e+01
3.44e+01
2.96e+01
2.47e+01
1.99e+01
1.50e+01
1.02e+01
5.30e+00
4.52e -01

Velocity Vectors Colored By Velocity Magnitude (m/s)



Dec 07, 2006 FLUENT 6.1 (2d, dp, segregated, ske)

Regulated air supply to the burner

empirical methodology to manage flow directions As an example specific applied task solution can be analysed.

Air necessary for the combustion has to be supplied to the burner evenly, i.e. velocity vectors are distributed evenly around the opening. In uncontrolled channel velocity vectors are not distributed evenly and differ around the perimeter of the opening. Introducing additional plates which direct flow, the flow in the air supply channel may be distributed evenly and





New constructions of burners for the burning of carbonic monoxides: on the left – fuel oil burner for waste furnaces; on the right – gaseous fuel burner for wood boiler

flowing evenly covers the burner. As it can be seen from presented modelling result, the flow outflows the burner and while hitting the end channel wall rotates, whereas in the end part of burner local velocity maximum is formed. This drawback may be eliminated by additional directing plate. Such an example reveals how with simple technical means the flow distribution is solved towards desirable direction.

The obtained results were used improving chimney flues of KT furnaces of SC Mazeikiu Nafta. Smoke of six furnaces. which heat oil are cooled in two operating utilization boilers and is removed through chimney. Since capacities of furnaces 601 and 602 are increased, and their convective surfaces foul, thus, total system of smoke channels requires doubly increased draught as it was designed in the project. Calculation model of smoke tract was developed, operation of consistent and parallel channel connection of flows was solved. In the contracting work it was decided how to make bypasses in furnaces 601 and 602, how to escape contamination, reach the parameters of initial project and use natural draught of chimney while repairing boilers utilizators.

Research of carbon nanostructures

In the last decade carbon nanostructures, particularly carbon nanotubes, were of great interest for many researchers due to their unique properties. In the research





Carbon nanotubes

of carbon nanostructures main attention is given to the growth of carbon nanotubes, research of their structure and properties, preparation methodology of catalysts and general definition of growing model.

In the initial stage the simplest method of carbon nanostructures growth was selected - chemical catalytic vapour deposition on the catalyst. Nichrome was chosen as a catalyst since it is a heat resistant material and it does not loose strength properties in the temperatures interval necessary for the experiment. The obtained carbon nanostructures were investigated with the scanning electronic microscope. Diameter of obtained structures from 50 to 100 nm, length up to 100 microns, optimum growing conditions were determined: gas structure, temperature, and reaction time. Due to the obtained results growing model was created, defining the effect of gas and temperature on the formation of carbon

nanostructures. Growing of nanostructures occurs in the non-inertic environment, oxygen significance for growing process was determined. Changing the environment conditions temperature, time and combustion rate diameter and length of the produced structures are controlled, also a sudden diameter jump in the same carbon structure is possible.

At present chemical vapour deposition equipment is constructed. Main component of this rig is chemical vapour deposition furnace, where it will be possible to quite precisely regulate temperature and supplied amount of gas. Using chemical methods the catalyst is formed, with which the selected surface will be covered, and then in the furnace, supplying hydrocarbons gas mixtures, carbon nanostructures will be synthesized. A dense layer of nanotubes is planned to be grown on polished silicon, ceramics, and noninert surfaces (metal) as well.



Scheme of chemical vapour deposition rig: 1 – Rotameter; 2 – Manometer; 3 – Valve; 4 – Reductor; 5 – Special reductor; 6 – Flexible connector; 7 – Protection from explosion; 8 – Pressure regulating device; 9 – Interception valve; 14 – Collector



The most active fourth year Ph.D Candidate Simas Rackauskas at the conference "Youth Energy 2006"

Numerical modelling of combustion, mixture and segregation of granular materials

Solid waste (tires, granular domestic waste, etc.) are complex materials, chemical composition and physical properties of which are very different, thus cannot be precisely defined as other types of solid fuel. Transport of powdery waste on the moving grate is one of the most important processes, which influences waste combustion, whereas average time of particles' movement on the moving grate is one of significant parameters, which defines the quality of waste combustion. Up to now only several scientific investigations, designed for average movement duration of particles and mixture of powdery material, since there is no satisfactory theory to describe the motion of granular materials, have been carried out. At present many models are used, the most precise of which is the discrete element method (DEM). This method due to a large number of particles is very receptive to computer memory and processor time. Analyzed efficiency tasks of numerical possibilities of discrete element method, such as selection of programming language, parallelism in multiprocessor computers and vectoring

of material particles data were and by 30% speeded up calculations.

Models of differential particles combustion were tested by numerically modelling particles combustion on the moving grate. At present an integral model, which simulates such stages of particles combustion as heating, desiccation, pyrolisis and flaming, carbon burning, is developed. Thermodynamic and chemical processes, which occur in the gaseous environment of particles, thermal radiation of walls, heat transfer among particles are included into the model.

To explain the mechanisms, which determine segregation at different mechanical properties and process conditions, statistical analysis of data, which would enable to exclude processes in different size particles subsytems, is carried out: energy redistribution among different size particles during the process, collective motion of different size particles, convection and condensation.

In 2006 researchers of the Laboratory published nine articles in scientific journals, presented one paper in international and three papers in Lithuanian scientific conferences.

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LABORATORY OF NUCLEAR ENGINEERING

Main research areas of the Laboratory:

- experimental investigation of convective heat transfer regularities in singlephase flows: forced and mixed convection; turbulent and transition flow regimes; influence of channel geometry, variable physical properties, roughness, centrifugal forces and transients effect;
- numerical modelling of heat transfer and turbulent transport in single-phase flows in various channels and geological structures;
- management of spent nuclear fuel: safety and environmental impact assessment of storage and disposal facilities; modelling of fuel characteristics; normative and legislative base;
- management of radioactive waste: strategy; safety and environmental impact assessments of treatment technologies and storage and disposal facilities; normative and legislative base;
- evaluation of different factors related to decommissioning of nuclear power plants: planning and cost of decommissioning and dismantling; radiological assessment of territory, buildings, systems and facilities; safety and environmental impact assessment; normative and legislative base;
- fire hazard analysis of nuclear power plants and other large facilities.

Experimental and numerical heat transfer and turbulent transport investigation in channels and geological structures

The Laboratory has a comprehensive experience of 30 years in investigations of heat transfer and flow hydrodynamics in different energy facilities, whereas in the recent years in geological structures and shafts as well. It is observed that in many power facilities the impact of thermogravitational forces is important in cases of laminar and turbulent flows. Under certain conditions the impact evoked by thermogravitational forces on heat transfer usually becomes a reason for accidents in different facilities. Thus, the research on mixed convection (originally in pipes, later in flat channels as well) has been initiated since 1985 in the Laboratory.



Velocity isolines and heat transfer in stabilised vertical part of flat channel in case of twosided heating (Re = 2000): 1, 2 – experimental data; 3 – heat transfer at turbulent forced convection; 4 – heat transfer at laminar forced convection

In 2006 the analysis of the results on experimental and numerical investigations in vertical flat channel in transitional flow zone for opposing flows was continued, experimental and numerical investigations were carried out for aiding flows. Data of the investigations show that in the vortex zone a significant difference of heat transfer among channel walls is possible. However, a reasonably good correlation of the numerical and experimental results is obtained.

Numerical modelling in the channels is carried out using FLUENT code. This code is also used performing heat transfer modelling in geological repositories for spent nuclear fuel in the international project coordinated by International Atomic Energy Agency (IAEA).

Management of spent nuclear fuel

Specialists of the Laboratory for a number of years have been performing research related to the management and disposal of spent nuclear fuel (further SNF). The dry interim storage facility for SNF at Ignalina NPP with CASTOR RBMK-1500 and CONSTOR RBMK-1500 type casks was commissioned in 1999. The Laboratory has been performing studies related to the safety assessment of SNF storage. The Laboratory carried out assessments of radioactive nuclides activity variation during the interim storage period, criticality and radiation doses on the cask surface and at the specific distance from it, and temperatures of the cask under normal operational and accident conditions.

In the frame of the research programme (The Programme of Assessment of Possibilities of the Disposal of Spent Nuclear Fuel and Long-lived Radioactive

Waste in Lithuania) (2003–2007), the Laboratory experts with the assistance of Swedish experts, proposed the generic concepts of deep geological repository in clay and in crystal rocks in Lithuania. Analysing the possibility of SNF disposal in Lithuania, the cost estimation of geological repository was performed, and the generic safety assessment has been started. The scenarios of repository evolution under present conditions and under changed conditions in case of one defected disposal container were analysed.

In 2006 main attention was devoted to the investigation of radionuclides migration



Ph.D Candidate A. Brazauskaite at SNF repository copper container model during TopSeal 2006 conference in Olkiluoto (Finland)

from geological repository. Most important processes, determining and influencing radionuclides migration (SNF matrix dissociation, radionuclides release from SNF matrix, radionuclides solubility, sorption, diffusion, migration by advection through engineering and natural barriers) were analysed. When SNF disposal container becomes leaky main parameters, which influence the processes of SNF matrix change/degradation are as follows: SNF specific area, activity, yield of radiolysis products, temperature, concentration of iron, hydrogen and carbonates, initial degree of SNF matrix oxidation, etc. Further migration of radionuclides occurs by diffusion and advection, some radionuclides interact with the surface of pores of engineering and natural barriers materials and may be sorbed.

Models of radionuclides migration from repository's near and far fields were developed and improved. COMPULINK, CHAN3D, PREBAT-BATEMAN (Sweden), AMBER (UK) codes were applied for the assessment of radionuclides migration. In 2006 the Laboratory together with GNS-RWE NUKEM GmbH (Germany) consortium continued the project - The Interim Storage Facility for RBMK Spent Nuclear Fuel Assemblies from Ignalina NPP Units 1 and 2 Supply and Installation (B1) (2005-2009). The Laboratory is preparing environment impact assessment and safety analysis reports of this SNF storage facility (operational time no less than 50 years) and supports in licensing the storage facility. In 2006 the Laboratory experts prepared *Environmental Impact Assessment Report* and *Preliminary Safety Analysis Report*.

Radioactive waste management

Since 1994 the Laboratory has been actively involved in the analysis of the radioactive waste management issues at Ignalina NPP. Laboratory experts carried out a number of projects, including longterm safety assessment of existing radioactive waste storage facilities at Ignalina NPP and Maisiagala, and analysing the possibilities to transform these storage facilities into repositories. In 2001–2004 the Laboratory together with Framatome ANP GmbH (Germany) participated in performing environment impact assessment and safety analysis for Ignalina NPP cement solidification facility and an interim solidified radioactive waste storage facility. Some projects were performed together with Sweden Company SKB International. The Laboratory constantly participates in IAEA coordinated research programmes, among them -Application of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities (ASAM) (2002-2005), Improvement of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities (ISAM) (2005-2006).



Representatives of consortium Thales Engineering and Consulting – ANDRA – LEI – FI at Maiçiagala storage facility during final meeting, implementing PHARE project

In the recent years a significant attention was paid to site selection for a near surface repository in Lithuania, also to the investigations related to radionuclides migration from radioactive waste repositories and their influence on safety. The Laboratory specialists with the assistance of Swedish experts prepared the set of criteria for choosing a near surface repository site, updated the concept of a near surface repository, and prepared the implementation programme.

In 2006 the Laboratory specialists analysed the effect of *heterogeneous* waste activity distribution on radionuclides migration from simulated surface repository. Heterogeneity of waste was analysed in two cases: the first one, *when radionuclides migration is determined by sorption process*, and the second one, *when sorption and diffusion processes define radionuclides transfer*.

After performing parameters sensitivity analysis the effect of uncertainty of parameters, which define sorption and diffusion processes, – distribution and diffusion coefficients – on the assessments of radionuclides migration from the repository was determined. The results of analysis revealed that sorption process has a bigger influence. Thus, in the analysis of radionuclides migration more attention should be given to the uncertainties of distribution coefficients. Comparing modelling results of radionuclides migration for homogeneous and heterogeneous waste activity distribution, conclusions regarding the influence of disposed waste heterogeneity on the safety of near surface repositories were presented. DUST, GENII, GWSCREEN (USA), AMBER codes were used for investigations.

In 2006 the Laboratory specialists completed the project - Preparation of Preliminary Waste Acceptability Criteria for a Landfill-Type Repository. Data on very low activity radioactive waste, planned to be disposed of in a landfill-type repository, amount and their radiological, physical-chemical properties were analysed and summarized. The preliminary acceptance criteria were defined for radioactive waste intended to be disposed of in repository. The information concerning environmental conditions of proposed alternative sites for repository has been analysed also. The degree of compliance with waste acceptance criteria is assessed. The more favourable site, i. e. site with higher level of correspondence to waste acceptance criteria, has been recommended.

In 2006 the Laboratory together with French Companies *Thales Engineering and Consulting* and *ANDRA* as well as Institute of Physics completed PHARE project – *Safety Assessment and Upgrading of Maisiagala Repository in* *Lithuania* (2004–2006). The Laboratory specialists participated in preparing *Safety Analysis Report*, developed the database containing all information on the radioactive waste inventory, which is being stored in the Maisiagala repository, and performed a comprehensive nuclide composition analysis.

Continuing the research funded by Science and Study fund specialists of the Laboratory together with the Institute of Physics in 2006 prepared report -Research and application of radioactive waste formation, its dispersion and impact on the environment and man. Numerical models and results on RBMK reactor construction material neutron activation and radionuclides accumulation in technologic process chains were presented. Model of radionuclides migration from near surface repository to biosphere and physical-chemical dispersion parameters assessment results were presented as well.

In 2006 the Laboratory together with NUKEM GmbH (Germany) started to implement the project – *New solid waste management and storage facilities at Ignalina NPP (B2/3/4)* (2006–2008), where the Laboratory experts are involved into environmental impact and safety analyses.

In 2006 specialists of the Laboratory started to implement another project – *Transformation of Ignalina NPP bitumen radioactive waste storage facility (building 158) into repository*, where assessment of environmental impact of repository will be carried out. To ensure long-term safety it is recommended to transform existing Ignalina NPP bitumen radioactive waste storage facility into repository by installing additional surface engineering barriers over storage facility.

Evaluation of different factors related to decommissioning of nuclear power plants and fire hazard assessment

In 1998 the Laboratory specialists started a new activity related to the decommissioning of Ignalina NPP. Our experts participated in PHARE project preparing *Preliminary Ignalina NPP Decommissioning Plan.* An extensive database describing the characteristics of the elements of different systems and DECOM software was developed. This software enables to estimate the amount of radio-



Radioactivity levels and its variation for RBMK-1500 reactor components

active waste, which will be accumulated at Ignalina NPP, and also financial expenses for carrying out the presumable operations. In the course of preparing Final Ignalina NPP Decommissioning **Plan**, this code was further developed at the Laboratory and information on radiological and technical data on Ignalina NPP systems was updated. In order to evaluate radioactive contamination level of the most contaminated systems, LLWAA-DECOM (TRACTEBEL, Belgium) code adjusted to RBMK reactors was used. In 2004 the Laboratory specialists prepared the drafts on The Ignalina NPP **Decommissioning Programme and the** Plan of Means of its Implementation for the period 2005-2009 for the Ministry of Economy.

In 2002–2004 the Laboratory specialists with the assistance of Swedish experts performed *the fire hazard analysis for Ignalina NPP Unit 1 and Unit 2.* In 2005 fire hazard assessment of some renewed Ignalina NPP rooms was carried out. *Fire hazard assessment of newly designed Ignalina NPP SNF and radioactive waste storage facilities* was carried out as well.

In 2002–2006 the Laboratory has been participating in IAEA coordinated research project – *Disposal Aspects of Low and Intermediate Level Decommissioning Waste*. During 2002–2005 the Laboratory

prepared methodology of radioactive deposits formation analysis and its activity assessment at final Ignalina NPP shutdown, also analysed the expected amounts of the radioactive waste.

In 2006 two assessment models of reactor construction materials neutron activation were developed: when reactor operation history is taken conservatively and another when real Ignalina NPP Unit 1 reactor operation history is considered. Activation analysis according both these models was carried out for reactor graphite components (blocks and rings) and metal components (fuel channels and protective and supportive panels). Results of this analysis revealed that fuel channels have the biggest specific activity during all simulated cooling period of 150 years, and immediately after final reactor shutdown steel constructions of reactor have bigger specific activity than graphite components, however, approximately after 20 years of cooling activity drops down to the level of active zone graphite blocks and specific activities of rings.

It was also determined that bigger specific activities are obtained for metal constructions of all main radionuclides in conservative assessment case than in the case when real reactor operation history is considered. Whereas for graphite blocks and rings specific activity of some radionuclides is somehow bigger in the case when real reactor operation history is considered. SCALE (USA) code was used for the modelling.

In 2006 together with Institute of Physics the Laboratory completed the project -Development of radiological characterization programme for equipment and installations at INPP (2005-2006), General Programme of Radiological Survey was prepared and presented, and after accumulating and analysing data about Ignalina NPP site Historical Assessment Report of Radiological Situation at INPP was prepared. Programmes of detail radiological characterization of individual Ignalina NPP blocks (V1, G1, 117/1) were developed as well. These programmes and collected and analysed data regarding radiological situation at Ignalina NPP are necessary for the preparation of Ignalina NPP dismantling project.

Main results

In 2006 the Laboratory completed state funded research project and carried out 12 applied projects and earned more than one and a half million Litas. Researchers of the Laboratory actively participated in different training programmes, coordinating meetings, presented 15 papers at international conferences (Australia, Austria, Croatia, Finland, Germany and Greece), and published 29 scientific articles in Lithuanian and international journals.

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LABORATORY OF MATERIALS RESEARCH AND TESTING

Main research areas of the Laboratory:

- testing of materials, assessment and analysis of their quantitative indicators;
- investigations in the field of hydrogen energy;
- hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium-based alloys;
- investigation of degradation of heat carrier pipes;
- research and development of arc-plasma reactors, diagnostics of plasma jets and flows;
- neutralization of hazardous waste;
- synthesis and characterization of catalytic, tribological coatings and plasma polymers.

Research in the field of hydrogen energy

Hydrogen storage

After completing activity IEA Hydrogen Implementing Agreement Task 17: *Solid and Liquid State Hydrogen Storage Materials*, researchers of the Laboratory continued research in another group (22) *Fundamental and applied development for hydrogen storage materials*.

In 2006 state funded project **Synthesis of** *metal alloys designed for hydrogen storage, employing ion-plasma methods* was completed. The originality of this work is related with the employment of nonequilibrium plasma technologies for the hydriding of nanocrystallite materials. During interaction with plasma, the sur-

face becomes unstable, surface potential increases, absorbtion-desorbtion kinetics changes and hydriding efficiency increases. Mg, Mg₂Ni, Mg₂Al₂ thin nanocrystalline films were obtained employing physical vapour deposition methods. During hydriding of nanocrystalline materials the hydrogen may be stored not only in chemical compounds, but in grain boundaries, which significantly increases the amount of stored hydrogen. In this work the impact of grain boundaries on the hydriding of materials is analysed in detail. Results of the project were presented at seminars of IEA Hydrogen Implementing Agreement Task 17 and 22, in Japan, Norway, UK and USA.

In 2006 researchers of the Laboratory continued EU Sixth Framework Prog-



Hydrogen energy technologies training. Lecture is given by Prof. R. Vaisnys (Yale University, USA)



Formation of hydriding cluster on the top of crack in the zone of thermal impact of welding seam in TMO-2 fuel channel sample hydrided in the Laboratory

ramme projects NENNET and HYTRAIN. The ultimate goal of *NENNET* - sustainable, application driven high-level research network on national level contributing effectively to ERA activities.

Further continued FET – EEU project, the objective of which is to carry out activities which will contribute to the integration of the research and technology development groups in new Members States and Associated Candidate Countries and old Members States in the area of future energy technologies. Doctoral studies are carried out in HYTRAIN project together with JRC Institute for Energy (the Netherlands) and Vytautas Magnus University (Lithuania).

In accordance with contract No. 312 of the Minister of Education and Science of the Republic of Lithuania, Lithuanian Energy Institute was granted a support of 365000 Lt for the purchase of vacuum thin film synthesis system. PVD-75 system (Kurt J. Lesker Company, USA) was purchased, which is used performing synthesis works of nanocrystalline thin films.

Successfully continued EU Structural funds project Organization of hydrogen energy technologies training. Project duration 36 months, it is implemented by Lithuanian Energy Institute and Vytautas Magnus University. The main aim of the project: to raise the qualification of scientists and researchers as well as prepare new specialists in the field of hydrogen energy technologies so that the quality of performed scientific research in Lithuania would satisfy the needs of the concerned society groups (business, education, etc.), and performed research would be competitive at the EU level. During project implementation participants actively participate in lectures and

seminars, perform laboratory works in Lithuanian Energy Institute and in the laboratories of project partners. In 2006 three project participants were on training in France, two participated in summer school on materials for hydrogen economy in Iceland. Methods of different nanomaterials chemical structure and surface morphology analysis were acquired theoretically and practically during these trainings. Project activities and obtained results in more detail are given on the web site: www.hydrogen.lt.

Researchers of the Laboratory actively participated in establishing *Lithuanian Hydrogen Energy Association and Lithuanian Hydrogen and fuel cell technology platform.* They also participated in the Ministry of Economy funded project **Development of hydrogen and fuel cell technologies, business and science research in Lithuania**. Development strategy of hydrogen and fuel cell technology platform, the feasibility study and strategic research agenda were prepared during the project, web site for platform was created: www.h2lt.org.

Research of hydrogen impact on properties of zirconium-based alloys

The laboratory since 1999 has continued research of hydrogen and hydrides degradation impact on mechanical and physical properties of zirconium-based alloys. The laboratory works together with Ignalina NPP. The Laboratory participates in IAEA coordinated project Slow hydrogen-induced cracking of fuel cell zirconium-based alloy. The objective of the project is to develop recurrent experimental procedures which will enable to assess velocity of slow hydrogeninduced cracking in zirconium-based alloy fuel cell tubes. Conditions of hydrogeninduced cracking and its fragmentation are investigated under different conditions

employing specific geometric samples and devices.

Justification of rods resource of Ignalina NPP Unit 1 control and protection system

In the project, which was initiated in 2005, Laboratory of Materials Research and Testing and Laboratory of Nuclear Installation Safety participated. Condition of rods of Ignalina NPP Unit 1 control and protection system was investigated evaluating the impact of corrosion and ionizing irradiation on the functioning of constructional elements and materials. Justification of rods resource continuation of control system was carried out in accordance with obtained results.

Research of nanocrystalline zirconium electroceramics used for the hydrogen fuel cells systems

After evaluating merits and demerits of different powder manufacture methods as well as basis for powder synthesis, chemical analytically pure powder retraction method was chosen for the synthesis general precipitation of components out of saline deliguescent in water. It was determined that powder was comprised of 10-20 μ m aggregated powder. After burning powder at temperature 800–1000 °C, crystalline YSZ powder was retrieved, which comprised of monoclinic, tetragonal and cubic crystalline mixture. The impact of combustion temperature on the retrieved raw material and its ceramic properties were investigated. The possibility to form coatings, prepared by plasma spray technologies out of synthetic YSZ powder was analyzed. Comparing coatings' structure with the coatings of mechanically granulated YSZ powder, coatings retrieved from synthetic raw material were less porous.





YSZ powder synthesized by chemical method. Combustion temperature 800 °C

Research of operational properties of high-temperature ceramics

With the support of Lithuanian State Science and Studies Foundation, cooperating with the Institute of Materials Science Problems of Ukraine, the Laboratory acquired new thermal conduction methodology in accordance with LST EN 993-15 standard, thus increasing hightemperature materials thermal conduction measurements up to 15-20 W/mK. Cooperating with Lithuanian and Ukraine laboratories, the material of stable properties at high temperature (up to 1000 °C). thermal conduction of which 1.25 W/mK. was created. Works were initiated investigating materials, thermal conduction of which varies from 0.3 to 1 W/mK. Material of such properties could be a high-temperature thermo isolation material standard for the verification of thermal conduction equipment.

Long-term materials for artificial joints, performed in the frame of COST 533. In

the memorandum of program COST 533 significance of ceramic coatings in creating long-term and resistant to attrition materials for artificial joints is mentioned. Laboratory of Materials Research and Testing joined the second work group of COST 533. The main research direction of this work group is research of resistant to attrition solid coatings for artificial joints. In 2006 due to the support of Lithuanian State Science and Studies Foundation the technology of bioinert titanium oxide coating formation on the titanium steel trays was mastered. Research was carried out by plasma spray method forming resistant to attrition and long-term bioinert zirconium oxide coatings of tetragonic structure on the titanium steel trays for the development of artificial joints. Structure and properties of coatings were investigated.

Experiments of materials and assessment of their qualitative indicators

In 2006 the Laboratory successfully approved its accreditation in carrying out tests of plastic and insulated pipes, building mortars, polymer bitumen sheeting, thermal insulating products, refractory materials and products. Constant renewable of technical investigations basis enables to carry out building products testing in accordance with the requirements of international European standards.



Head of Material sector, Dr. J. Cesniene introduces the activity of the Laboratory to Dr. S. Rencys the Director of Lithuanian State Science and Studies Foundation

The following activities are carried out in the division of plasma technologies:

- development and research of constant current plasma sources;
- research of processes and phenomena taking place in reaction arc zone and low-temperature plasma;
- research of dynamics and heat-mass transfer processes of hightemperarature gas flows in atmosphere and reduced pressure environments;
- plasma and high-temperature flows diagnostics and development of diagnostics measures;
- research of plasma pyrolisis and plasma process of hazardous materials neutralization and assessment of its lifetime cycle;
- research and employment of plasma spray pyrolisis process;
- synthesis of catalytic and tribologic coatings and properties analysis;
- research of thermal and heterogenic processess when reacting combustion products outflow the catalytic surface.

Development of high-temperature gas flow, its dynamics, heat transfer in channels of different form and dimensions and in models of heat cariier elements were analysed. Operation regimes of linear electric arc gas heaters and reactors, their operational characteristics were investigated, conditions of increasing work duration were determined, methods of arc turbulization and other new energy use in palsma facilities were investigated. Employing contact method, thermal nonequilibrium conditions of atmosphere pressure plasma current were investigated. Regularities of distribution of velocities, temperatures and their pulsations in high-tempearture cuurent were determined.

Seeking to obtain high-temperature ultra thin fibre, reprocess hazardous materials, different coatings, synthesize new materials, the interaction of electric arc and plasma jet with amorphous and dispersed materials was investigated, physcial, chemical and mechanical properties of obtained materials and coatings were determined.

New technologies. Reactor was created to burn hazardous materials, which complies with the environment protection requirements and conditions (neutralized materials are kept longer than 2 s at temperature higher than 1200 °C), its technical characteristics were determined. New plasma technology equipment created for the synthesis of solid coatings. Active aluminum oxide, carbon compounds, diamond-like carbon and various catalytic coatings, the specific surface of which reaches 100 m²/g, were received. The mechanisms which generated combustion products jet of permanent characteristics as well as a new methodology for the investigation of catalytic properties

of coatings and mass transfer processes near the active wall surface were created. Regularities of heat and mass transfer processes in oxide catalytic reactor channels were analyzed in order to improve catalytic properties of coatings, determine gas velocities, temperature distribution in catalytic reactor, jet and wall heat-mass transfer coefficients. Results of the research may be employed in creating, designing and calculating catalytic reactor oxidizing CO.

In 2006 Laboratory personnel participated in the following international programmes:

- The COST Action 525 Advanced Electronic Ceramics: Grain Boundary Engineering, with the participation of 16 European countries. The main objective of the COST Action is to understand the role played by grain boundaries in controlling the manufacture, microstructure and properties of electronic ceramics. For this purpose LEI formed yttrium stabilized zirconium oxide coatings, and investigated their structure and properties. Dependence of obtained coatings' structure, phase structure and crystallites size from plasma process parameters and thermal treatment conditions was determined. The activity coordinated by Manchester University, U.K.
- The COST Action 527 *Plasma Polymers and Related Materials*, with the participation of researchers from 18 countries. The objective of the Action is to improve the knowledge of the plasma polymerisation process in relation to the desired physical and chemical properties of resulting plasma polymers with special regard to the understanding and following suppression of ageing processes of plasma polymers at ambient and extreme conditions. Facility and plasma polymers deposition method in atmospheric and reduced pressure plasma jet was created in Plasma Technologies sector.
- The COST Action 530 Life Cycle Inventories for Environmentally Conscious Manufacturing Processes, with the participation of 17 European countries. In Plasma Technologies sector implementing the activity programme, the investigation of thermal neutralization process life cycle of hazardous materials was initiated.
- The COST Action 532 Triboscience and Tribotechnology: Superior Friction and Wear Control in Engines and Transmissions, with the participation of 17 countries. Participating in the programme, personnel of Plasma Technologies sector performs project Research of surface processes during the stainless steel nitriding in atmospheric and reduced pressure plasma jet.
- The COST Action 538 *High Temperature Plant Liftime Extension*, with the participation of 16 European countries. The main objective of the Action is to develop an innovative integrated toolbox of predictive methods/models and targeted invasive and non-invasive measurement techniques, improving the means for European industries to reliably quantify the condition and remaining life of plant components in all types of conventional fossil, biomass and waste-fired power plant. Participating in the Action personnel of Laboratory performs project *X-ray diffraction analysis of carbide phase in heat resistant steels*.
- The COST Action 542 *High performance energy storages for mobile and* stationary applications. The main objective is the development of high performance energy storage systems and their implementation in mobile and stacionary applications in transportation and energy technologies.
- Cooperation programme between Lithuania and Ukraine 2002-2008 Development of plasma-technological methods, designed for the formation of coatings of desirable properties from nanodispersive materials.
- Cooperation programme between Lithuania and Ukraine 2002-2008 Development of scientific basis of manufacturing technologicy of catalytic neutralizers developed by plasma method for complex cleaning of motor exhaust gas.
- Eureka project. E!3539 State-of-the-art manufacturing methods of mineral splint from local raw materials and waste, when Laboratory personnel together with researchers and manufactureres from Italy and Poland try to determine possibilities of alloy granulation of Si, Mg, Ca and Al oxides and their compounds in plasmachemical reactor.

In 2006 research results were published in articles, included into the list of Institute of Scientific Information – 7, articles in journals, listed into international databases of Lithuanian scientific council – 12, papers at international conferences – 11, papers at Lithuanian conferences – 9, and popularisation articles – 8.

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LABORATORY OF NUCLEAR INSTALLATION SAFETY

Main research areas of the the Laboratory:

- thermal-hydraulic analysis of accidents and operational transients;
- thermal-hydraulic assessment of Ignalina NPP Accident Localization System and other compartments;
- simulation of radionuclides and aerosols transport in the compartments;
- assessment of RBMK-1500 reactor core modifications and analysis of postulated reactivity accidents;
- nuclear safety justification calculations;
- safety analysis of thermonuclear synthesis reactors;
- analysis of new generation nuclear reactors;
- Level 1 and Level 2 Probabilistic Safety Assessment of Ignalina NPP;
- assessment and prognosis of the graphite stack-fuel channel gap closure dynamics;
- structural analysis of plant components, piping and other parts of Main Circulation Circuit;
- single failure analysis and engineering assessment for complex technical systems;
- risk and hazard analysis of industrial sites;
- safety and reliability assessment analysis of network systems (pipes, power supply network, means of communication)
- sensitivity and uncertainty analysis of modelling parameters and results;
- fundamental investigations in thermo-physics.

In 2006 researchers of the Laboratory together with Lithuanian and international partners implemented **35** projects:

- 3 state funded scientific research projects;
- **3** priority Lithuanian R&D projects funded by Lithuanian State Science and Studies Foundation
- **15** projects with Lithuanian partners;
- 14 international projects (among them 3 EU Sixth Framework Programme projects, 4 international scientific research programmes financed from own resources).

Uncertainty analysis of modelling results

Budget work report Uncertainty analysis of modelling results of technical, natural and social systems was prepared and successfully defended. The aim of the work, performed together with LEI Laboratory of Energy Systems Research and Laboratory of Hydrology, was the expansion of applicability of uncertainty analysis methodology for 2D and 3D equation systems, solving tasks of technological sciences, also carrying out numerical investigations in the fields of physical (hydrology) and social (energy economy) sciences. Final conclusions were prepared regarding the employment of methodology of sensitivity and uncertainty analysis of individual parameters and results for 3D models of reactor neutronic kinetics processes. forecast of Lithuanian electricity energy demands in economy branches and input parameters of Kaunas Hydropower Plant reservoir hydrodynamic model.

Research of condensation implosion

In the field of thermal physics Research of condensation impact on the gas/ liquid interface stability was begun. This two-phase flow study aims at determining and comparing the impact of condensation on interphase friction and on the stability of interphase surface. The obtained results are expected to be employed creating passive (driven by condensation implosions) cycle of energy and mass transfer, opposite to the natural circulation. In the first stage a numerical research of two-phase flow in the inclined channel was carried out and modelling results were compared with experimental data. Single-phase flow velocity profile variation at different roughness of the wall was determined and pressure loss in single-phase and two-phase flow was compared. The analysis of obtained results revealed the drawbacks of experimental facility, helped to decide on the constructions of experimental facility

and further improvements of measurement equipment and methodology.

Safety and reliability assessment of energy supply

The aim of the work **Development of** methodology for security and reliability of energy supply to Lithuania is to create an instrument with the help of which it would be possible to reveal insecure fields of energy supply and most hazardous scenarios, and evaluate probabilities of its occurrence. Most of attention is given to the discussion and development of energy supply safety criterion, taking into account the experience of Western Europe, USA and Japan. Presented energy supply safety criterion encompasses most significant technical, economical, environmental and political questions of energy supply. In the report energy supply safety applied in Lithuania, where the topic of supply safety became especially relevant after the shutdown of Ignalina NPP Unit 1 and where primary energy resource is obtained only from one country, is analysed.

In accordance with agreements with SC *Lietuvos Energija* and SC *Kauno Energija* reliability and safety assessment works of electricity and heat transfer nets were carried out. Software NETRPAS, designed for the assessment of reliability level of electricity transmission grid, planning of reconstructions and calculation of possible losses, was further improved. User interface for substations' modelling was improved, calculation algorithm of reliability of transmission grid and structure of database were corrected.

Experience gained in earlier scientific research was applied implementing agreement with SC Kauno Energija Preparation of Kaunas heat transmission network reliability assessment methodologies and primary reliability analysis of main network. Reliability and thermal hydraulic models of Kaunas city main thermal network and strength model of main network were developed, reliability assessment methodology of thermal networks was prepared. Initial reliability analysis of main network of city centre was carried out. In the future, after carrying out reliability analysis, it will be possible quantitatively evaluate parameters of energy supply system and forecast frequency and consequences of possible accidents, and identify most hazardous places of system.



Meeting of EURATOM-LEI association in the field of thermonuclear synthesis (15 November 2006)

Hazard and risk assessment of industrial objects

In 2006 scientists of the Laboratory continued the participation in the activities of **BEQUAR** (Benchmark Exercise in Quantitative Area Risk Assessment) project. The **BEQUAR** is coordinated by the European Commission Joint Research Center Institute for Protection and Security of Citizens. The main objective of BEQUAR is to introduce new EU member states with the requirements of Seveso II Directive 96/ 82/EC to ensure safety of hazardous industrial enterprises. During the project participants perform technical expertise of risk study of selected hazardous industrial object (factory in Hungary). BEQUAR participants are trained to use APIRAR software, which is used for risk based land planning (one of Seveso II requirements). In 2006 the project was completed and final project report was published.

Safety analysis of thermonuclear synthesis reactors

A perspective and innovative field of activity is **thermonuclear energy programme FUSION**, to which the EU pays a considerable attention. According to experts, in the second part of this millennium thermonuclear energy could serve in the production of ecologically pure energy. It was decided to construct an experimental thermonuclear reactor ITER in Cadarache (France). Scientists of the Laboratory have accumulated experience in safety justification of nuclear power plants. The analogous safety justification works are relevant in developing thermonuclear synthesis equipment. In 2006 the works were continued in accordance with the agreement with EURATOM for the implementation of the project Cost-Sharing action: Hydrogen deflagration/detonation analyses in ITER HNB- and DNB-boxes and cryopumps following a loss of *vacuum accident.* This is the first project in Lithuania in the frame of thermonuclear synthesis programme. Information on ITER compartments was collected, models of these compartments were developed and calculations were carried out.

At the end of 2006 the European Commission and LEI signed the contract of association to carry out jointly the research programme in the field of fusion energy. The contract came into force on the 1st of January of 2007.

Projects of development of new generation nuclear reactors

During 2006 in **IRIS** (International Reactor Innovative and Secure) project scientific research was restricted to participation in the activity of probabilistic risk analysis group and IRIS NPP risk assessment analysis. Taking into account documents, which regulate NPP works and safety analysis documentation of new reactors, assessment criteria and analysis methodology of external events hazardous to IRIS power plant were improved. After performing preliminary IRIS external events analysis, external events hazardous for power plant were chosen for further risk assessment. Risk analysis of individual external events (extreme winds, airplane crash) was renewed, evaluating probability of these events and analyzing the impact on IRIS power plant. Implemented works were related to IAEA coordinated research programs.



One of such IAEA coordinated programs Review of economical benefit of evacuation zone and safety measures around nuclear power plants with innovative small and medium capacity reactors in the regions, where reactors are used for electricity and heat generation. In this work valid Lithuanian standardization documents related with determination and assessment of Ignalina NPP evacuation zone, taking into account demographic data, were surveyed, in addition meteorological and other data related with radiation impact and risk analysis on Ignalina NPP site, were renewed. According to this contract, economical effect of evacuation zone reduction or elimination is determined if reactor was used for the production of electricity and heat. In such a case, NPP could be constructed nearby cities and used for electricity production as well as for district heating. The obtained results revealed that in such case efficiency of new NPP would increase significantly.

International scientific research projects concerning nuclear reactors under operation

Researchers of the Laboratory actively participated in EU initiated SARNET and NULIFE competence networks under the Sixth Framework Programme and Fifth Framework Programme NESC III.



SARNET Network of Excellence. Contract on Network of Excellence for severe accident research and management (SARNET) was continued in 2006. 49 European R&D organizations, including LEI, have participated in this project. In 2006 the laboratory personnel participated in activities and workgroups meetings for ASTEC, CONTAINMENT, COCOSYS and PSA-2. Models of RBMK-1500 confinement were developed and processes in confinement were simulated using ASTEC and COCOSYS codes. In the CONTAINMENT workgroup the benchmark of the codes is performed with the objective to investigate the influence of water sprays on the destruction of atmosphere stratification. The analysis is performed by different organizations, participating in SARNET Network of Excellence. The results of calculations are compared with parameters, measured during experiments. Specialists of LEI use COCOSYS code for calculations.

Scientific research in the field of systems' probabilistic dynamic simulation and analysis is also part of SARNET. Applying probabilistic dynamics, the theory and methods of level-2 probabilistic safety analysis were improved. Assimilating new theoretical base, the modelling and analysing methodology of rare events (severe accidents) based on stimulated dynamics modelling was initiated. Software, which in the future should be connected with codes of severe accidents (for example, ASTEC) and systems of uncertainty analysis (for example, SimLAB), is created for the comparison of theory and solution of practical tasks. Pilot model of severe accident (hydrogen explosion and reactor containment rupture) research task was analysed together with participants of the project (close cooperation with scientists from Consejo de Seguridad Nuclear and Universite Libre de Bruxelles).

In 2006 LEI together with partners initiated works of **NULIFE** Network of Excellence. One of the main tasks is to establish an integral organizational structure – virtual institute capable of performing scientific research of durability assessment in European nuclear facilities industry. **NULIFE** Network of Excellence will enable to coordinate scientific research, carried out in Europe, in the fields which require interaction among different ageing processes, environmental impacts and loadings, taking into account safety level of different nuclear facilities. Executers of the project are gathered into consortium (coordinator – VTT Technical Research Centre of Finland), which is comprised of partners from ten organizations and their partners from 27 European organizations, including LEI. Researchers of the Laboratory participate in three working groups:

- IA-1 mapping of partner RTD expertise and competences.
- IA-2-2 integrity assessment.
- IA-2-4 safety, risk information and reliability.

Actively participating with partners, experience is gained in the fields of ageing assessment of nuclear power plants, research of components strength, on research methodologies applied in other countries. It is planned that **NULIFE** Network of Excellence is to be performed for five years.

In the field of structural integrity analysis the researchers of the Laboratory participated in **NESC III** work group activity according EU Fifth Framework Programme. This programme is designed for verification of structural assessment processes, coordination of national standardization documents, improvement of codes and standards used for structural integrity analysis. Using methodology of finite elements, dimensions of acceptable cracks in a weld of pipe were determined, and rates of cracks growth and mechanics characteristics of dissociation were calculated.

In 2006 researchers of the Laboratory continued research in **PHEBUS FP programme.** PHEBUS-FP programme comprises five integral experiments on reactor severe accidents dealing with fuel degradation, hydrogen generation, fission product release, transport and behaviour in the containment. In 1988 the programme was initiated and coordinated by IRSN. Representatives from the EU countries, USA, Japan, and South Korea participate in its activity. LEI uses RELAP/SCDAPSIM code for simulation of the fuel melting processes during experiments that were Containment of PHEBUS experimental facility



performed in PHEBUS test facility. Phenomena occurring in PHEBUS containment are simulated using COCOSYS code.

At the end of 2006 LEI signed contract with Inspecta Nuclear AB (Sweden) LEI support in review of PULS 03 project. Documentation regarding Sweden nuclear power plant (Oskarshamn) capacity increase is prepared in project PULS 03. Thermal hydraulic and strength calculations comprise main part of documentation prepared in the project. In thermal hydraulic calculations the increase of NPP capacity is taken into account, and loadings, which influence pipes and other components in case of postulated accidents, are determined. The structural integrity of piping and other components is justified by structural analysis. The task of researchers of the Laboratory who participate in the project is to perform review of modification design calculations. Researchers who have experience in the fields of thermal hydraulics and structural strength analysis are involved in the project. On December of 2006 the first review of obtained reports for the calculation of loadings in pipes was carried out.

Projects for Ignalina NPP safety assessment and improvement

In 2006 technology of Ignalina NPP nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor for further fuel reuse was successfully implemented. During the project *Fuel reuse of Ignalina NPP Unit 1 in Unit 2 reactor* on-site transport container for spent fuel transportation, its transporter, guide shielding shafts, moving biological shielding, grab and other equipment, ensuring safe and reliable nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor, were developed, designed and manufactured.

Creating a technology of fuel transportation, performing its efficiency and safety justification, a number of scientific and experimental investigations were carried out, namely:

- development of technology of nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor for further reuse, covering the development of all technological process operations and new equipment, necessary for safe and reliable performance of these operations;
- modelling of reactor core at different variants of fuel assemblies loading was carried out, parameters determining nuclear and radiation safety were assessed, acceptability of these parameters was evaluated;
- solved optimisation tasks, as a result of which, sequence of optimal fuel assemblies loading in Unit 2 reactor depending on fuel burnup of assemblies and optimal arrangement of loaded fuel assemblies in reactor core, were determined;
- safety analysis, in accordance with the international requirements, which revealed that the created technology ensures a necessary safety level, was carried out;
- experimental research was carried out besides analytical calculations, using original experimental setups and models-prototypes of tested equipment, which confirmed the reliability of created equipment and used calculation models.



Tracker and transporter with set of in-site transport container are ready for fuel transportation

A multidimensional review was performed for the design documentation of the developed set of equipment and technical safety justification, in which specialists of Ignalina NPP and VATESI (State Nuclear Power Safety Inspectorate) and qualified experts of Lithuanian science institutions (Institute of Physics, Vilnius Gediminas Technical University, and Kaunas University of Technology) participated very actively.

In 2006 the comments of VATESI review for the Technical safety justification report and Basic design documentation of new equipment, as well as buildings and support systems modifications were considered. In the technical safety justification report all issues relevant to NPP safety analyses were considered: description of set of equipment, engineering assessment, development of accidents list, analysis of failures and accidents, etc. In the safety justification report it was proven that the set of equipment, which was developed, will perform its functions and ensure the required safety level.

As it was mentioned in LEI activity report of 2005, main fuel transportation equipment was manufactured in 2005. At he beginning of 2006 all equipment, which had been developed and manufactured during the project, was supplied to Ignalina NPP. After delivering equipment to Ignalina NPP, necessary works of equipment installation were carried out on NPP site

<image>

Container is turned from horizontal to vertical position

as well as "cold" and "hot" tests of all equipment. With "cold" test all technological process operations were simulated, however, instead of nuclear fuel the simulators of fuel assemblies, weight and geometry characteristics of which correspond to the parameters of fuel assemblies, were used. After "cold" tests, when it was clear that fuel equipment performs its functions as it was forecasted in the technological process and Basic design documentation, "hot" tests were carried out, during which 24 fuel assemblies were transported. Performed experiments confirmed that technological as well as radiation parameters correspond to design data. Thus fuel transportation equipment was timely and successfully prepared for operation.

Technology and equipment of Ignalina NPP nuclear fuel transportation for reuse developed during the project have no analogues - for the first time in the history of nuclear reactors operation such a technology has been developed and implemented. Innovative technology of nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor for fuel reuse is legitimated by the patent No LR5326 **Operation method of channel uranium**graphite reactor of the Republic of Lithuania.

The project received recognition at exposition Kaunas 2006, where for the work Development of technology of nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor for fuel reuse Lithuanian Energy Institute was granted a nomination Implementation in business of the best scientific decision, developed in Kaunas.

In 2006 three R&D projects funded by Lithuanian State Science and Studies Foundation were continued. Continuing project Development of beyond design basis accidents methodology for Ignalina NPP Unit 1 and 2 methodology was prepared covering possible accidents in operating Ignalina NPP Unit 2, shutdown Unit 1 and spent nuclear fuel pools. Lists of beyond design basis accidents are presented in the methodology, phenomena possible during beyond design basis accidents are described, selection of initial condition of analysed objects and codes designed for performing analysis of accidents are described. Researchers are planning to perform a thorough analysis of chosen accident scenarios and assess consequences of accidents.

Continuing project Impact of external events on the safety of Ignalina NPP and other nuclear objects, earlier prepared methodology, which is necessary for the selection of hazardous external events and for the assessment of frequencies and impact on the safety of Ignalina NPP and other nuclear equipment, was applied. After evaluating frequency and forecasting of most significant events, the mathematical models, which summarize statistical, meteorological, technical and other data, related with analysed external events, were developed and used in the work. The following main tasks are solved in this work: data analysis and probabilistic assessment of selected hazardous external events, preparation of software and assessment of events frequencies and impact, development of methodology for sensitivity and uncertainty analysis of models, probabilistic assessment of airplane crash on nuclear objects, analysis of the impact of airplane crash on Ignalina NPP Unit 2, assessment of earthquakes frequency and research of seismic loading. Taking into account individual external events, the integrated assessment of safety level due to hazardous external events was carried out.

In the project *Investigation of RBMK fuel* channels ageing process and determination of safe operation criteria participated two Lithuanian organizations (LEI Laboratory of Nuclear Installation Safety and Laboratory of Materials Research and Testing, KTU Faculty of Mechanical Engineering and Mechatronics and Prof. K. Barsauskas Ultrasound Research Institute). In 2006 in the Laboratory of Nuclear Installation Safety modelling of fracture parameters (stress intensity factor and J-integral) was performed using finite elements methodology (ABAQUS software). 2D and 3D models were used for the modelling of parameters. The obtained results were compared to experimental research results. The hydrogen concentration was evaluated in the modelling of the fracture parameters. Analysis of variation of thermohydraulic parameters in fuel channels at normal operation and accident conditions was performed using Ignalina NPP model by RELAP5 code. The critical cracks sizes were calculated at normal operation and hydraulic test conditions. Experimentally determined mechanical characteristics and loadings were used in the analysis of cracks. Employing conception *leak-before break*, deterministic analysis of RBMK fuel channel TMO - 2 was carried out. The results of experimental investigations and deterministic analyses have confirmed that the fuel channel (TMO-2) fulfil the LBB requirements.

In 2006 new PHARE project Support to VATESI in solving significant Ignalina

KOS INSTITUTAS

Nomination "Implementation of best scientific decision, developed in Kaunas, in buisiness", at exposition "Kaunas 2006"



NPP licensing tasks, the objective of which is to give support and its TSOs in assessment of beyond design basis accidents for RMBK-1500 reactors. This project is carried out together with Institute of Physics, GRS mbH (Germany) and IRSN (France).

In 2006 fuel element models were developed by FEMAXI and TESPA–ROD codes, reactor and cooling circuit by RELAP/SCDAPSIM and ASTEC codes, and models of spent fuel pools were developed by ATHLET–CD code. Engineering manuals were created for the calculation of nuclide structure of nuclear fuel and the above models. First calculations of beyond design basis accidents were carried as well. The project is to be completed in 2007.

In 2006 the project *Preparation of* manual on the management of Ignalina NPP beyond design basis accidents was completed. It was implemented together with Jacobsen Engineering Ltd (UK), Volian Enterprises and SCIENTECH (USA) companies. During implementation of the project, specific manual for management of beyond design basis accidents at Ignalina NPP was developed taking into account the peculiarities of a channel type reactor. The specialists determined the weak places of Ignalina NPP and gave suggestions how to mitigate the severe accidents more effectively. After implemention of this manual at Ignalina NPP the whole spectrum of accidents, beginning with design basis events. finishing with severe accidents during which nuclear fuel could melt, will be covered.

10-year cooperation with GRS company was continued in 2006, when the project regarding the performance of the *Analysis* of accident localisation system (further *ALS*) of Ignalina NPP was completed. During the project it was analysed how effectively radionuclides are confined in ALS compartments and what is the hydrogen distribution during beyond design basis accident. This project is the first integrated analysis of radionuclides release to the environment, including not only ALS, but the release of radionuclides from fuel to the compartments as well.

Comprehensive Fuel Data Report for RBMK 1500 Fuel Assemblies used at INPP was prepared according the contract with German company Gesellschaft für Nuclear-Service mbH (GNS), where data is systemised regarding characteristics of Ignalina NPP spent fuel assemblies. This database encompasses all types of fuel used in Ignalina NPP, including 2.8% of uranium-erbium and 2% of regenerated uranium fuel. Radiation characteristics (integral radiation, decay heat, g-radiation, neutron terms, gaseous product contents) of spent and maximally burnt fuel are given in the report for the period of 3-50 years after removing fuel assembly from reactor. In the future this information will be useful performing designing of transportation containers, analysis of long-term storage fuel ponds, accounting of fission materials and other studies of spent fuel.

Implementing the project Technical support in licensing of Ignalina NPP operations reactor core integrity surveillance, LEI together with Institute of Physics consult international experts and carry out main calculations. During the project Serco Assurance company (UK) must develop modern method for generating 2-group data for the whole core reactor physics model for RBMK-1500 type reactor at Ignalina NPP and present corresponding software to VATESI. In 2006 the first verification calculations aiming at assurance of relevance of sequence of the development of macroscopic cross-sections were carried out. The project will be continued in 2007.

Replacement of flowmeters due to the diagnostic results in Unit 2 in 2006. In each technological channel of RBMK-1500 reactor coolant flowmeters are installed. When the flowmeter fails, the operation of appropriate technological channel is interrupted until the next shutdown of the reactor, when the broken flowmeter is replaced with a new one. Flowmeter diagnostics is being carried out before annual maintenance in order to avoid failures. In 2006 in the continued work analysis of diagnostic measures results was carried out and it was determined that 509 flowmeters had to be replaced in Ignalina NPP Unit 2 in order to guarantee a reliable operation of Unit 2 until the next planned maintenance.

The residual graphite-fuel channel gas gap probabilistic analysis and forecast at Ignalina NPP Unit 2 was carried out in 2006. Statistical analysis was performed based on reactor measurements, completed in 2005. The residual graphitefuel channel gas gap closure probability until the next planned preventive maintenance period in 2007 and 2008 was estimated and compliance to VATESI requirements was demonstrated. In the work 30 technological channels were indicated for which gap calculations should be carried out during planned maintenance in 2007.

In 2006 in continued work *Improvement* of *RBMK* – 1500 reactor fuel channel *linear protection coefficient computational algorithm* was aimed at improvement of RMBK-1500 reactor fuel channel linear protection coefficient computational algorithm in order to avoid frequent value fluctuations due to purely computational reasons. Corresponding recommendations were developed for the modification of special mathematical tasks NZ15 and NZ07. At the moment developed algorithm of algorithm improvement is tested in Ignalina NPP. The work is to be completed in 2007.

Investigation of the parameters of delayed hydride cracking and preparation of the realization of the analysis of conception "leak-before break" for the pipings of fuel channel TMO-2. Two laboratories of LEI, i.e. Laboratory of Nuclear Installation Safety and Laboratory of Materials Research and Testing have been participating in the project since 2005. The object of this project is to define the parameters of hydride cracking and to carry out evaluation of the fulfilment of conception *leak-before break* for the fuel channel TMO-2. After evaluating the impact of neutrons on mechanical characteristics of zirconium alloy and fracture parameters it is determined that depths of allowable cracks are larger than cracks, which are determined in accordance with regulations for in-service inspection of fuel channels of Ignalina NPP. The function of crack growth in case delayed hydride cracking was calculated in the period from the moment of crack detection till reactor shutdown. In this analysis the impact of neutrons on the hydride cracking growth rate was evaluated. Deterministic analysis of RBMK TMO-2 irradiated fuel channel in normal and emergency cases of reactor shutdown according the requirements of conception leak-before break was carried out. It was determined that the length of crack (at delayed hydride cracking) may reach 39 mm in emergency case of reactor shutdown. This length is more than two times shorter than the length of critical crack (95 mm). According obtained results it may be stated that irradiated fuel

channels fulfil the requirements of conception *leak-before break*.

Implementing the project **Development of** set of equipment designed for picking spent fuel fallings in the hot cells of Ignalina NPP a set of equipment designed for picking spent fuel fallings was developed. Works of implementation of the set in the hot cells of Ignalina NPP will be completed in 2007. In 2006 technical safety justification and design documentation of existing equipment and systems modifications were prepared, most part of new equipment necessary for project implementation was delivered to Ignalina NPP.

In 2006 Contract of material collection on beyond design basis accidents. preparation of training material and training of specialists concerning training of personnel of the power plant how to use the manual of beyond design basis accidents management, which was developed in cooperation with Jacobsen Engineering Ltd, Scientech and Volian Enterprises companies, was singed with Ignalina NPP. Implementing this project the material on phenomena occurring during beyond design basis accidents in power plant was systematized, training material was prepared and training of personnel of Ignalina NPP training centre was performed. Following the presented material, the trained personnel will be able to prepare a training programme for operators of power plant and personnel of technical support centre.

In order to reliably and qualitatively determine fuel assemblies, which are not leaktight and unsuitable for use, cooperating with JSC "Designing of new technologies" the project *Control system of leaktightness of irradiated fuel elements after long storage* was carried out, during which control system developed, justified and implemented at Ignalina NPP. This system will be used for monitoring of leaktightness of irradiated fuel assemblies, which are reloaded in the reactor INPP of Unit 2.

In 2006 the activities of *Ignalina NPP safety probabilistic analysis* were initiated. Different improvements of model and additional research will be carried out to ensure adequacy of probabilistic model of Ignalina NPP. Renewed probabilistic safety analysis of Ignalina NPP will be published. Activities are to be completed in 2007.

In 2006 two new interrelated contracts Research of the impact of linear power criteria violation on fuel element during transients in the reactor core and Analysis of the impact of uncertainty and sensitivity parameters on the modelling results of transients were concluded. The objective of the first project is to assess the impact of linear power criteria overrun on further operation of fuel elements. In the first stage employing QUABOX/ CUBBOX – HYCA code model of RBMK-1500 reactor core and engineering book were prepared, and verification of the model was carried out. In the second project uncertainty and sensitivity analysis of modelling results is to be carried out modelling continuous withdrawal a group of rods, erroneous fuel assembly reloading and control and protection system cooling circuit voiding accidents.

In Analysis of radiological consequences of design basis accidents in the Ignalina NPP Unit 2 reactor, loaded with uranium-erbium fuel with 2.8% enrichment variation of thermohydraulic parameters in RBMK-1500 reactor cooling circuit and compartments surrounding it, and transfer of radionuclides in Ignalina NPP compartments during design basis accidents were calculated. The analysis was carried out taking into account 2.6% and 2.8% enrichment fuel with uraniumerbium properties for all fuel combustion range. The obtained results enabled to assess radiological consequences of design basis accidents. In 2006 final work report was published.

In 2006 continuing activities of contract *Preparation of safety justification of Ignalina NPP Unit 2 diverse shutdown system servodrives* final safety justification of Ignalina NPP second diverse shutdown system servodrives was completed and it was submitted to VATESI experts for assessment. Activities are to be completed in 2007.

Laboratory of Nuclear Installation Safety is one of the technical support organizations, which for a number of years has been closely cooperating with VATESI. Performing agreement *Expertise of INPP* documents, submitted to VATESI, related with changes of reactor core configuration, physical characteristics and control, and other issues of reactor physics and nuclear fuel storage and management, Ignalina NPP documents were analyzed in order to justify modifications of composition of RBMK-1500 reactor core (implementation of uraniumerbium fuel, rods of new design), control of compliance of reactor passport characteristics for the determined limits. Independent calculations were carried out, on the basis of which conclusion were drawn on the reliability and expedience of presented safety justifications.

In 2006 the Doctoral dissertation was defended in the field of thermal engineering; research results were presented in reports, two monographs and fifty scientific articles (among them, 10 in publications, included in the list of Institute of Scientific information): 47 papers were presented in scientific conferences. It should be noted that researchers of the laboratory participated and presented papers in all basic international conferences, where safe operation of nuclear power plants and physical phenomena in them were analyzed. They also participated in different training programmes, many IAEA technical committees meetings, and coordination meetings. The fact that researchers of the laboratory are invited to participate in various meetings as independent experts and consultants, speaks of their high competence.

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LABORATORY OF ENERGY SYSTEMS RESEARCH

Main research areas of the Laboratory:

- scenarios analysis of macroeconomic development, modelling and forecasting of energy demands;
- analysis of medium- and long-term energy supply scenarios using widely approved optimization models;
- environmental impacts of the energy sector, analysis of pollution reduction technologies and implementation of environment protection policies;
- energy management and marketing research;
- generalization of energy restructuring and liberalization experience in the European Union and Central and Eastern European countries and application implementing reforms in the Lithuanian energy sector;
- development of energy information system, collection of statistical data on the energy sector development in Lithuania and worldwide.

In 2006 the Laboratory performed research significant for the Lithuanian energy sector, the analysis of specific energy systems development, forecasting of energy demands, formation of optimization methodology and software of the energy sector development, and renewal of necessary statistical data basis.

State funded science research work Uncertainty analysis of modelling results of technical, natural and social systems, which was carried out together with the laboratory of Nuclear Installation Safety and the Laboratory of Hydrology, was completed. Methodology of uncertainties analysis and application possibilities of software SUSA, created by German GRS company, for preparing forecasts of energy demands in branches of the Lithuanian economy, analysis of obtained results and perspective energy development were analyzed in the above project.

In 2006 new state funded scientific work **Research of distributed energy** generation development in which common overview (benefits and drawbacks) of the distributed generation, level of distributed energy generation in the EU countries, characteristics of the distributed electricity generation in Lithuania (its input in the balance of electricity production, analysis of existent law base), problems of joining the marker and connection to the networks are presented.

In 2006 long-term cooperation with the Ministry of Economy of the Republic of Lithuania was successfully continued. The laboratory won the tender and carried out the following four applied works:

- The comparative analysis and public publication of Lithuanian energy sector branches development trend for 1990-2005 and main economic and energy indicators of other EU countries (based on analysis and generalization of information presented by Lithuanian Department of Statistics, SC Lietuvos Energija and international publications, the publication "Energy in Lithuania-2005" was prepared.
- Analysis and forecasts of energy sector development trends till 2025. The analysis of trends of the Lithuanian energy sector development, energy consumption changes and energy intensity change in the Baltic, Central and Eastern European countries and other factors which have an important impact on energy demands is presented in the work. Research carried out in this work and presented recommendations assisted the organizers of National Energy Strategy in substantiating strategic provisions of the energy sector development.
- The comparison of projects for storage of natural gas resources (geologic information was analysed, material of finding places for potential gas storages

Primary energy intensity for 2005, GDP evaluating by purchasing power standards (PPS)

In 2006 continuing the cooperation with SC Lietuvos Energija scientific work Improvement of long-term planning energy system model was carried out, which will assist to specialists of the company in solving tasks of power system perspective planning. Issues of calibration of model for planning of the Lithuanian electricity network are analysed in this work; modelling principles of wind power plants modelling and gas supply for power plants are improved introducing restrictions for seasonal supply fluctuations and forecasting possibilities of underground gas storage, methodology of expenditure income calculation in Lithuanian power plants is implemented; processing means of results are modified and pilot calculations of Lithuanian power system perspective development are presented.

In other scientific work Lithuanian tracking system for electricity technical conditions of implementation of electricity origin identification system are analysed: system of management institutions is proposed; registered production features are defined; possibilities of data collection taking into account its availability are analysed; minimal requirements raised for data collection are defined.

In 2006 EU Fifth Framework Programme project Analysis of policy instruments and identification of tools for the implementation of rational energy use and increased use of renewable energy sources in the EU candidate countries was completed. Experience accumulated in preparing the following EU Sixth Framework Programme projects will be very valuable for raising the qualification of Laboratory personnel: New Energy Externalities Development for Sustainability (NEEDS), Coordination action to consolidate RTD activities for large-scale integration of DER into the European electricity market (SOLID-**DER)** and **Cost** assessment of sustainable energy systems (CASES).

Relevant questions regarding the Lithuanian energy sector development, including aspects of wider usage of renewable energy sources are analysed in the following international projects of Intelligent Energy Europe: European tracking system for electricity (E-TRACK), Assessment and optimization of renewable support schemes in the European electricity market (OPTRES), Deriving a future European policy for renewable electricity (FUTURES-e), Sustainable energy systems in new buildings – market introduction of feasibility studies under the Directive on energy performance in buildings (SENTRO), REFUND + project, Analysis of the degree of achievement of 2010 national and Community targets under Directive 2001/77/EC (PROGRESS).

Climate change mitigation tools applied in Lithuania and different possible international climate change mitigation policy regimes were analysed in IAEA coordinated research project Scenarios of greenhouse gas emissions mitigation strategy and energy development.

Dr. Dalia Streimikiene contributed to preparing scientific popularization publication Climate change policy outline and implementing **INTERREG-IIIC project** Redirecting urban areas development towards sustainable energy (RUSE).



terminal construction is presented); Analysis of scenarios of the energy sector development and preparation of project NES implementation measures for the period 2007-2012 (based on provisions presented in NES project, measures for strategy implementation by individual energy sectors are analysed; initial assessment of measures, which were submitted to the Ministry of Economy by Lithuanian energy companies, other ministries, departments and municipalities, is presented).

accumulated by Lithuanian Geology Office and assessment for storing natural gas of potentially relevant structure in Lithuania is presented; possibilities of use of existent and perspective Latvian underground gas storages are analysed; assessment of technical-economical indicators of liquid gas import



Final energy intensity for 2004, GDP evaluating by purchasing power parity (PPP)

Accumulated experience of the Laboratory was used at international level in preparing:

- Baltic energy strategy project (Dr. Arvydas Galinis);
- Power sector models of Mongolia, Serbia and Montenegro, and Poland including analysis of their development scenarios (Dr. Arvydas Galinis);
- Intergovernmental panel on climate change fourth assessment report Climate change 2007: mitigation (Dr. Inga Konstantinaviciute);
- Sustainable development strategy for Kazakhstan (Dr. Dalia Streimikiene);
- Study *Energy and climate change* prepared according World Energy Council plan (Dr. Dalia Streimikiene);
- Research funded by Center for International Energy and Environmental Policy, carried out together with experts from Central and Eastern European countries (Dr. Habil. Vaclovas Miskinis).

Dr. Arvydas Galinis in Slovakia and Iran participated in IAEA organized training courses as expert delegated by this agency, responsible for use of the MESSAGE model seeking to solve tasks of perspective energy planning. Dr. Inga Konstantinaviciute raised her qualification in Slovakia, participated in IAEA training courses.

Researchers of the Laboratory participated in conferences in Austria, Belgium, Latvia, Poland, Germany, where more than 20 papers were presented. In 2006, Laboratory researchers published 35 scientific articles in Lithuanian and international journals and proceedings of international conferences.

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LABORATORY OF REGIONAL ENERGY DEVELOPMENT

Main research areas of the Laboratory:

- analysis and modelling of energy sector development of municipalities, which enable to forecast in short and medium periods;
- analysis of activity indicators of heat sector companies, taking into account economical and social factors and impact of regulation measures;
- integration of local and renewable energy sources into regional energy development programmes;
- development of data basis for energy sector development of municipalities and macroeconomic analysis of issues at regional level.

State-funded research

Research project *Investigation and mathematical modelling of factors, having impact to municipal heat sector regulation measures* was continued. It is designed to develop monitoring and regular development forecasting system for municipal heat sector. This work is oriented towards the research of factors, which have impact to the activity of heat sector and regulation measures via applying macroeconomic and microeconomic modelling. Macroeconomic model developed in 2006 enables comprehensive analysis of heat sector development issues:

- the impact of different tools of economic policy on the indicators of heat sector development;
- market trends of district heating supply in local economics;
 acquisition of existent technical/energy forest/rural economy biomass reserves and develop planning tools for bioenergy investments, which enable to better evaluate economical possibilities of local fuel use in heat sector.

Seeking to include wind energy into regional energy development, principles of formation of wind energy cluster and technological platforms were used and strategic municipal methodology was considered. Expanded competitive ability in heat supply network enables to evaluate efficiency improvement options of noneconomic district heating systems (optimization and renovation of pipeline segments, disconnection of detrimental consumers or their groups, changes of network configuration, decomposition of supply systems into smaller ones, etc.).

Contracts for scientific applied research

Within contract with SC Klaipedos Kartonas performed feasibility study for energy sector development revealed that in accordance with electricity and gas prices scenarios, presented by the company, construction of the new CHP plant is feasible, increasing prices of gas do not evoke huge risk for project feasibility since in this case steam generation costs in the boiler-house will increase, whereas bigger risk is evoked by rates the growth of electricity tariffs from power supply company VST. If this price does not increase more than 180 Lt/ MWh, the project will not be feasible. SC Klaipedos Kartonas seeking to reduce total energy costs should start to implement CHP plant investment project and search for its most favourable financing sources. In tender on purchasing facilities, main attention should be paid to the efficiency of such power plant and scope of operational and maintenance costs since if there is no competition in this field they may be increased gratuitously.

Economical analysis and recalculation of financial feasibility indicators of waste thermal utilization is carried out within the contract with SC Klaipedos Energija, continuing Feasibility study for construction of combustible waste utilization CHP plant in Klaipeda city. It is determined that cost price of one tone waste utilization in cogeneration comprises 502 Lt/t, whereas in heat production boiler - 392 Lt/t. This is the least cost price of thermal waste treatment. Here only expenses of waste utilization are evaluated, neglecting possible income from heat and electricity sales. Present results of economical and financial analysis reveal that the project is not commercially profitable and appropriate fund support and political decisions regarding waste

utilization taxes are required. Existent data enable to expect better project indicators applying state-of-the-art technologies, however, this data should be verified thoroughly.

Analysis of options for renovation of heat generating sources of Utena DH company and selection of the best technical solution was carried out within the contract with JSC Utenos Silumos Tinklai. In accordance with existent information scenarios of heat demands should be elaborated, boiler renovation options analysed, taking into account natural gas price forecasts, prices of purchased electricity, existent heat demands, fuel resources and its price, use of existent boilers, operation costs, scope of investments, etc. Risk factors, related with commercial conditions and regulation of promotion of high-efficient cogeneration, biomass and other local fuel, performed by Lithuanian governmental institutions, should be taken into account as well.

International projects

International **RUSE** project – *Redirecting urban areas development towards sustainable energy* (under INTERREG-IIIC programme) was continued. The aim of the project is to support new EU countries in directing energy policy towards sustainable development, using the structural funds. This support is provided at urban development level, by rendering the experience of 15 old EU members in various aspects of energy sector. The task assigned to Lithuanian Energy Institute in the project is to coordinate the development of implementation strategy of joint projects objectives. On the 31st of March of 2006 local seminar for municipalities was organized in Lithuanian Energy Institute *Reorientation* of urban development towards sustainable energy using contribution from Structural Funds.

In accordance with one of project components as foreseen in the programme, researchers of the laboratory on the $21^{st} - 24^{th}$ of February of 2006 visited Tamper town (Finland) and had a possibility to see practically implemented examples of projects and obtain information on Finland experience in the field of sustainable energy development. On the $26^{th} - 28^{th}$ of September of 2006 Kirkl and Lester towns in UK were visited (topic *Consideration of energy and environment: What government and energy agencies can do on their own and with the help of the society.*



RUSE project participants together with Kirklees Energy Team representatives (UK)



Meeting of RUSE project participants in Brussels (Belgium)

International SEIPLED project **Sustainable** energy investments for consistent urban environmental management, the objective of which is at local level to demonstrate that sustainable energy investment plans may be implemented thoroughly by designing technical, economical and financial indicators. Specific project tasks are as follows:

- demonstrate viability of integrated projects when sustainable energy enhances aspects of local development (new working places, new enterprises, added value for farmers, etc.);
- spread this methodology in all EU agencies, small and medium enterprises.

Six pilot project plans are to be prepared in two fields of local development policy: 1) development of industries regions and innovations in small and medium enterprises; 2) decentralized energy supply and its efficient consumption.

SEIPLED project seminar in LEI, Kaunas



Final result of the project – new methods will be elaborated on successful integration of energy into local development policy. Italy (coordinator), Germany, Austria, UK, Lithuania, Greece and Bulgaria take part in the project.



International BBN project **Baltic Biomass Network** (under INTERREG III B programme) is partially financed by the European Commission. The objective of the project is to contribute to implementing the EU objectives in energy sector pursuing that share of renewable energy sources in region and total EU energy balance would satisfy the tasks, which are foreseen in the directives and other regulating documents. Lithuania, Latvia, Estonia, Germany, Finland and Poland take part in the project.

In 2006 data of agricultural production and forest management of several years were collected. On the basis of this data assessment models of biomass energy potential was be determined and territorial planning data basis for biomass energy will be prepared. Assessment data was presented in two publications: What is energy biomass? and Assessment of biomass resources and use in territorial planning of Kaunas County. International conference GIS methods for biomass modelling at regions level of the Baltic countries material of conference papers was published (papers of LEI participants F. Dzenajaviciene and S. Vrubliauskas are also included).

On the $6^{th} - 8^{th}$ of October participants of BBN project demonstrated the stand at Lithuanian exhibition-fair *Agropanorama* 2006, whereas for the participants of exhibition organized the seminar, which was awarded by three diplomas. During international cooperation the conference

Wood for Energy (Koli, Finland) and forestry exhibition-fair (Silva, Finland), also the biggest bioethanol factory Schwedt in Europe, innovative biogas factories Frieddersdorf and Dogelin, and biodiesel factory Kleisthöhe (Germany) were visited.





6th Framework Programme EIFN (Energy Innovation Financing Network) in the framework of INNOVA programme was continued. A wide network of energy enterprises and institutions as well as financial agencies, which will help to implement the EU innovations and energy policy, offering financial services in energy sector, making practical and effective decisions, which would enable the access of innovation agencies to financing



Rig in exposition-fair "Agropanorama 2006"



Publications on energy saving designed for energetic planning of biomass resources and habitants

sources in energy sector, is to be created. During the project LEI participants organized the network of participants of energy and financial activity in Lithuania, which will be included into common EU INNOVA network space. Several descriptions of innovative projects in Lithuania were prepared for the project newspaper, the objective of which is to share the experience of implementation and financing of innovative energy projects.



International ISEES project **Improvement** of social dialogue seeking for energy efficiency in social dwelling-houses is carried out in the framework of programme *Intelligent Energy Europe*. The project is designed for the improvement of energy efficiency of social dwellinghouses. It is expected that the project will enable to show possibilities of efficient energy consumption and start dialogue with habitants seeking to improve energy consumption efficiency. With the help of ISEES project there is a need to initiate *social dialogue* among consumers, housing associations, energy enterprises (DH and electricity supply companies) and municipalities, seeking to determine issues, related with energy consumption in social buildings, present technical solutions, which would enable to optimize energy consumption, evaluate the quality of services supplied by municipal enterprises and heat companies. Austria (coordinator), UK, Czech Republic, Slovakia, Bulgaria and Lithuania take part in the project.

EU-project **BALANCE** – *Balance globally*, evaluate locally is carried out within the framework of programme Intelligent energy for Europe. Partners form eight countries - Ireland, Germany, Austria, Italy, Czech Republic, Holland, Switzerland, and Lithuania participate in the project. The aim of the project is to prepare methodology, which would enable to evaluate the impact of implementation of energy efficient measures on the amount of CO₂ emissions. Taking into account certification and quality management system, which is currently applied by about 320 municipalities, questioner and indicators, which enable to carry out energy and environmental assessments, will be prepared. Prepared measures will be tested carrying out assessments in one

chosen municipality of each country participant. In Lithuania, Kaunas town municipality is selected for this purpose.

Researchers of the laboratory presented six papers at international and four papers at national conferences. Three scientific publications are included into reviewed journals and four publications in international conferences material.

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LABORATORY OF RENEWABLE ENERGY

Main research areas of the Laboratory:

- research of solid biomass usage for energy production;
- research of wind power parameters' change as well as wind power plants modelling taking into account local conditions;
- analysis of up-to-date technologies application using local and renewable energy sources (RES), – technical economical assessment of their usage, research of environmental issues;
- preparation of accredited training courses, formation of data basis, services and consultations for users.

In 2006 research of biomass, biogas, solar and wind energy was carried out in the Laboratory. Resources of these energy sources are investigated, measurement methodologies of their usage efficiency are created, and recommendations of pilot project implementation are prepared aiming for more efficient use of RES. Electricity production from these sources in Lithuania comprises approximately 3.4% total electricity energy consumed in the country, whereas RES comprises approximately 8.2% in the primary energy balance. In order to implement the requirements of the EU Directive 2001/77/EC (to produce 7% of the consumed electricity energy from RES in 2010) it is necessary to use various types of RES at a large scale.

Research of solid biomass usage for energy production

At the Laboratory research related with rational biomass resources use in biofuel production and solid biofuel use to produce heat and electricity energy is carried out. Data on biomass sources and their use in biofuel production, covering all cycle from raw material collection, preparation, reproduction into solid biofuel and burning in furnace of different types of boilers, are accumulated and analysed. Wood comprises the biggest part of solid biomass in Lithuania. At the moment according to existent valuations approximately 80% of wood fuel sources are consumed for energy production. With the increase of boiler-houses and CHP, which consume wood fuel, the demand for wood increases and its shortage in the future will restrain the development of energy

sector. Thus cultivation of energy plantations (it has just begun), which may significantly increase biofuel production raw material sources, promote decisions in regard to environmental issues and economical development in rural areas. The Laboratory aims at evaluating the perspectives of plantations cultivation in Lithuania. Keeping the objective in mind data on the experience of other countries are collected and analysed, particular attention giving to the economical vitality of plantations.

Laboratory personnel actively participate in the activity of the 71st Technical Committee **Solid Biofuel**, translating into Lithuanian the EU standards and validating them at the national level.

Research of possibilities of solar energy use

Continuing research of solar energy use for the preparation of hot water, possible capacity of solar hot water preparation systems under Lithuanian conditions is estimated. The amounts of hot water produced in solar collectors during different periods of the year and its percentage in the annual hot water balance are analysed. Efficiency of plates and vacuum collectors was analysed, the price of hot water prepared in solar systems at different values of collector conversion and heat loss was calculated. Payback time of solar hot water preparation systems depending on the types of collectors and their surface areas was evaluated. Possibilities study of passive heat systems using solar energy for heating industrial and domestic



Solar collector on the roof of the Institute

premises is carried out. The experience of foreign countries using photomodules for electricity production is analysed.

Economical and environmental efficiency research of biogas and biofuel production and use

Biogas. Anaerobic treatment technologies are one of the most effective organic waste utilization measures, which are directly related to the reduction of environment pollution. Without these technologies it is almost impossible to implement the environment protection requirements for the manure treatment, in accordance with order No D1-367/3D-342 of the Ministry of Environment of the Republic of Lithua-

nia, July 14, 2005. Therefore, the Laboratory performs the applied research of this trend. In the Laboratory methodological recommendations are prepared for state farmers and enterprises, implementing efficient technologies of energy production from organic waste, which meet the most important environmental requirements. Thus pollutants of organic origin may be most effectively utilized and it is possible to contribute to the performance of the responsibilities of the Republic of Lithuania and the requirements of the EU Directives.

Biofuel. With the increase of the number of cars the consumption of biofuel increases as well; as a result, pollution of

the environment with hazardous combustion products, inducing greenhouse effect in the atmosphere, increases, Lithuanian transport depends on the import of raw material for fuel, therefore it is very important to use them economically or search for alternative fuel, produced from local renewable resources. Biofuel, produced from vegetable origin biomass, are most appropriate under Lithuanian conditions: rapes – designed for biodiesel production and other cultures (sugar beetroots, triticales) - bioethanol production. Dehydrated ethanol and rapes methyl ester are already manufactured in Lithuania, however in state transport they are not widely used since potential consumers do not have detailed information on the issues of biofuel consumption. Main characteristics of biofuel - its stability, impact on nonmetal fuel supply system parts and impact on motor technical-economical characteristics are not thoroughly investigated under Lithuanian conditions. Experimental research works are carried out at the Laboratory to solve the problems mentioned above.

In 2006 the overview of ecological biofuel standards was carried out at the Laboratory, biofuel stability, possible impact on the parts of cars were investigated experimentally, research of balancing possibilities of biofuel production and use were carried out. Cooperating with Motor transport department of Vilnius Gediminas Technical University research of technical-economical characteristics of motor biofuel with bioethanol additives is carried out.



Diagnostics of REANAULT9 motor power at computerized case using biofuel

Research, modelling and forecast of onshore wind variations at the Lithuanian Baltic Sea cost

Data analysis of wind velocity and direction measurements is carried out in the Laboratory, wind power prediction model is being developed, wind energy resources in Lithuanian territory are estimated.

Analysis of wind energy parameters is carried out using annual observation data of Lithuanian meteorological stations and wind velocity and direction measuring data in Klaipeda region. The measurements were carried out for the period 1995–2003 in Giruliai, employing state-of-the-art wind parameters measurement equipment *Wicom-C*.

In order to investigate the impact of the air flow crossing the constructional elements of wind power plant (further WPP) on its operation, numerical modelling of flow over different wind turbine blade's airfoils, employing FLUENT software, was carried out. Distribution of pressure, air flow velocity, kinetic turbulent energy around airfoils at different air flow attack angles is calculated.

Cooperating with Wind Energy Department of Risoe National Laboratory (Denmark) detailed wind resources analyses and WPP siting methodologies using WAsP software were mastered.Wind power prediction methodology, based on numerical weather prediction data from Lithuanian Hydrometeorological Service, was analysed. According to this metho-



Flow over the wind turbine blade's airfoil at the angle of attack 15°

dology wind power prediction model, which is able to forecast WPP operation two days in advance, is being developed.

Analysis and research of development possibilities of renewable energy resources use for electricity energy production in Lithuania

Till 2004 electricity energy using RES was produced only in hydro power plants. Development of this sector is restricted by environmental requirements in Lithuania. Thus other RES are searched for energy production. Particular attention is given to wind energy, also biomass and biogas use in cogeneration facilities.



In 2006 wind energy resources assessment was carried out, existent wind energy parameter measurement data were generalized and new measurements were performed. On the basis of obtained results, Lithuanian Wind Atlas was formed, which enables to optimally select WPP construction site. Specialists of the Laboratory also determined selection criteria of WPP construction sites, prepared methodology of power plants deployment and calculation of territory occupied by WPP park, carried out technical-economical analysis of WPP installation. Such research is important while developing common constructional plans of WPP. regulations of safe work and forecasting perspectives of wind energy development.



Windwheel wing profile polars: experimental data and calculation results

The following international projects and programmes related to RES use were carried out in the Laboratory in 2006:

- Large-scale integration of RES-E and co-generation into energy supplies in the New EU Member States – EU 6th Framework Programme (2005– 2006).
- Extend Accredited Renewables Training for Heating (EARTH). EU programme Intelligent Energy Europe (2003–2006);
- Service Buildings Keep Cool-Promotion of "sustainable cooling" in the service Building sector (Keep Cool). EU programme Intelligent Energy Europe (2003–2007);
- Monitoring and control of energy consumption in municipal public buildings over the internet (2006). EU programme Intelligent Energy Europe (2003–2007);
- Baltic biomass network. EU INTERREG III B programme (2005–2007).
- Development of constructive solutions of new generation wind power plants. Project implemented in accordance with the bilateral collaboration scientific research programme (2005–2006) between the Republic of Lithuania and Ukraine;
- Investigation of possibilities of technical-economical and cost price reduction of motoring ecological fuels with bioethanol additives. Project implemented in accordance with the bilateral collaboration scientific research programme (2005–2006) between the Republic of Lithuania and Ukraine.

Implementing common projects together with the institutions of other EU countries, research of biomass, biogas, wind, biofuels and other RES and implementation of new technologies was carried out, including research of cogeneration power plants integration processes into the country's energy sector, covering analysis of possibilities of local and renewable energy sources usage in co-generative power plants' development as well as implementation of the requirements of the European Parliament and Council Directives 2001/77/EU and 2004/8/EC. Cooperating with research centres of Germany, Denmark, Poland and other countries, research of bioenergy development perspectives in European regions was performed. Project Baltic Biomass **Network**, implemented in accordance with INTERREG III B programme, was continued.

Accredited training courses for specialists of RES use for heating are prepared in the Laboratory, possibilities of solar energy use in contemporary buildings are analysed. Different measures, promoting the implementation of cooling technologies in new buildings, are analysed. Energy demands for cooling buildings of different EU countries are analysed and passive measures of their reduction are forecasted. The impact of buildings of different forms on cooling input is analysed, regularities of energy variation of buildings cooling are determined depending on different size of heat transfer coefficient of windows.

Cooperating with Ukraine science research centres, constructive elements of WPP are improved. Methodology of numerical modelling of air flow over wind turbine blade's airfoil was developed. According to the methodology aerodynamic characteritiscs, which define efficiency of wind flow energy conversion into mechanical energy, are determined. After performing research, constructive decisions for new generation WPP development were presented. Information was summarized in the fields of biogas production and consumption aiming at more efficient use of alternative energy resources.

Spread of information on RES and their use for energy production

The Laboratory together with Kaunas Schoolchildren Environmental Research Centre in 2006–2007 implement the ecological education project **Renewable** *energy – future energy*. The project is funded by the British Embassy. The aim of the project is to improve the informal education activity of schoolchildren and teachers of natural sciences, pursue ecological education of teachers and schoolchildren. During project activities environmental issues and up to date news regarding RES, experience of their use worldwide and situation in Lithuania are presented. Seminars, discussions, excursions to objects using RES are organized for teachers of natural sciences and schoolchildren, consultations are given on efficient energy consumption.

In 2006 Laboratory researchers published five articles in science journals and four articles in other science publications, two articles in popular publications. They also participated in seven international and twelve Lithuanian science conferences.

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ENERY EFFICIENCY RESEARCH AND INFORMATION CENTER

Main activities of the Center:

- to compile, analyse and provide to experts and society the experience of efficient energy consumption in Lithuania and worldwide;
 - projects for the realisation of National Energy Efficiency Programme;
- participation in international projects, organization of conferences and training courses.

Implementing its research programme, according to the determined basic science work directions, the center implements the following programme objectives:

- compiles and analyses information concerning energy sources, efficient generation of various kinds of energy, energy distribution and consumption, provides information and consults on these subjects;
- investigates utilisation possibilities of renewable and waste energy sources and propagates their significance in Lithuanian economy sector;
- executes energy audits in energy enterprises, industrial enterprises and buildings; assists in implementing means, which enhance energy consumption efficiency;
- participates in preparation and implementation of the National Energy Efficiency Programme, prepares energy saving legal acts and standard specifications;
- takes part in international projects related to the development of energy sector efficiency;
- arranges seminars, conferences and courses on efficient energy consumption, develops publishing activity related to efficient energy consumption and promotion of new energy technologies.

Energy saving and efficient use of energy sources, promotion of manufacturers and consumers to efficiently consume local, renewable and waste energy sources is one of the most important energy objectives defined in main strategic documents of the Republic of Lithuania, which regulate the development and perspective of Lithuanian energy sector.

At present in Lithuania, after the structure of final energy consumption has changed, industry and buildings cover almost two thirds of total final energy consumption. In these sectors the potential of increasing energy consumption efficiency is the biggest. It could be acquired by implementing up-to-date energy management systems, energy efficient technique and technologies, and by improving organizational legal measures.

State funded programme **Research of** *increasing energy consumption efficiency in sectors of industry and buildings* was initiated in 2006. The main objective of this work is to perform the analysis of industry structural changes and energy consumption in industry for the period 2005–2007. Also in more detail analyze the largest branch of industry – the manufacture of food products and beverages, consuming approximately the third of energy input of industry.

One of the assessment indicators of energy consumption efficiency in industry is the comparison of energy input for manufacturing a production unit with analogous input in Western countries. It is foreseen to collect energy consumption efficiency data in selected enterprises of manufacture of food and beverages and using the comparative methodology of the results of Western countries, compare this data with analogous enterprises in Western countries. On the basis of obtained results recommendations regarding possibilities and perspective of increasing energy consumption efficiency in chosen branch of industry will be presented. It is foreseen to present energy management implementation model for small and middle size enterprises, prepare computerized energy management "E-learning" system.

Taking into account Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market, it is planned to perform technical economical substantiation of possibilities of implementing low capacity (30– 250 kW) microturbines (one of cogeneration technologies) in industry and buildings.

In the sector of buildings the following is foreseen: to evaluate possibilities of electricity energy consumption efficiency increase in the sector of dwelling-houses; collect statistical data on electricity consuming facilities in dwelling-houses, electricity consumption efficiency and possibilities of increasing it, existent facility replacing by new technologies. Obtained data is planned to be compared with analogous data of Western countries, evaluate legal base, barriers which prevent from increasing electricity consumption efficiency in dwelling-houses and propose measures for improving the situation.

Results of the implemented scientific work for 2006:

- collected data of fuel and energy consumption in industry in 2005, analysis of it carried out;
- overview material of Energy management applied in industry sector of other countries is presented and energy management model relevant for the implementation in Lithuanian small and middle size enterprises is proposed.
 - collected and generalized information regarding microturbines, manufactured by foreign companies, designed for the manufacturing of electricity energy and heat, possibilities of its application are explained;
- the overview of existent situation of electricity energy consumption in dwelling-houses is carried out, collected initial statistical data on electricity energy consumption and domestic appliances consuming electricity energy.





Variations of final fuel and energy needs of Lithuanian industry

Final energy demands in industry in 2005 comparing with 2004 increased from 1477 to 1574 ktne (\sim 6.5%) and comprised 30% of total final energy input of 2005.

Discussing the issues of Energy management application in industrial enterprises it should be noted that enterprises during the first year of implementation of energy management by energy management measures may reduce its energy input by approximately 5 - 15%.

Energy management model was begun to be implemented in Lithuanian small and middle size industrial enterprises. Measures, necessary to organize qualitative energy management in industrial enterprises, were presented. Main elements of energy management implementation model were described. International internet sites www.bess-project.info, Elearning measures (available in native language), providing main information of energy management implementation, have been created.







Countries participating in the implementation of Energy management in small and medium-sized industrial enterprises

Energy management is not designed exceptionally for industrial branches receptive to energy. Industrial enterprises of different braches may save energy and money, attributing energy consumption to the management tasks. Systems of Quality Management (ISO 9001) and Environmental Management (ISO 14001) are already widely used in Lithuanian industrial enterprises. Enterprises, which have implemented Environmental and Quality Management Systems, profiting from the proposed suggestions, without big efforts will be able to combine energy management system with already existent Management Systems. The industries, which have not implemented Environmental and Quality management systems yet, may first of all implement Energy management system, improve it and in the future connect it to other management system. The main value of energy management is constantly presented flow of possibilities. The most important idea of this process is that energy management in long-term perspective is more efficient than random actions. The main objective of energy management is to concentrate attention on energy consumption efficiency.

On the 6th of April 2006 the first working seminar – meeting of the representatives from industrial enterprises of manufacture of food products and beverages and Lithuanian project coordination group took place at Lithuanian Energy Institute, in which the overview of forecasted actions was presented, main objectives and tasks to be pursued were revealed, significance and milestones of energy management in industrial enterprises were described, tasks, responsibilities and awaited results were discussed.

On the 18th of September of 2006 in Athens (Greece) the accomplishments of the countries (including Lithuania) participating in the project in implementing



International comparison of energy input in small and medium-sized industrial enterprises

Energy management model in small and middle size industrial enterprises and performing the comparison of energy data were discussed.



Target of energy management E-learning

Discussing other results of scientific research work it should be noted that centralized (separated and combined) and decentralized (distributed cogeneration) electricity energy and heat production is overviewed, indicating in which field in the context of cogeneration facilities microturbines are used. Collected thorough information regarding microturbines of 250 kW electric power manufactured by foreign enterprises (Capstone Turbine Corporation, Bowman Power Systems, Elliot Energy Systems, Turbec AB, Ingersoll - Rand Energy Systems, Honeywell Power Systems. Presented material regarding Dutch OPRA gas turbines (1.6-2.0 MW) used in distributed cogeneration power plants and Russian turbogenerator (1.25 MW) manufactured at Завод им. В. Я. Климова and material regarding turbines, which operate according Organic Renkin cycle, is presented.

Presented material foresees wide possibilities of microturbines application using different types of fuel and mastering smoke heat from other facilities. Technical characteristics of microturbines are presented, possibilities of its application, necessary investments and operational costs are revealed. Data are compared with other technologies used in cogeneration power plants. It is revealed that the most efficient and perspective variant of electricity energy production is a set of microturbines and turbines, the planned electric efficiency of which accounts for 70%. Implementing national energy consumption efficiency increase programme the following was carried out:

 Study Possibilities of use of local, renewable and waste energy sources in Lithuania and Rokiçkis region prepared under the order of JSC Germeda;

 Experimental assessments of operated boiler-houses of Smalininkai L.Meskaityte secondary school and Erzvilkas primary health care centre and calculations of prices of centralized supplied heat in accordance with the requirements of National Control Commission for Prices and Energy are carried out;

 Economically substantiated boiling-house reconstruction operated by JSC Anyksciu Siluma, Kavarskas town, applying it for burning biofuel (firewood);

- Existent condition of heat economy and buildings operated by children sanatorium of Palanga town is evaluated and economically substantiated possible reconstructions and determined expected economical effect.



Comparison of technologies used for electricity production: 1 – Stirling engine, 2 – Organic Renkin cycle technologies, 3 – steam engine, 4 – gas turbines, 5 – steam cycle power plant, 6 – combined cycle power plant, 7 – internal combustion engines, 8 – microturbines, 9 – fuel cells

In 2006 the following international projects were carried out:

- Data comparison and Energy management schemes in small and middle size enterprises. The project was implemented in accordance with EU programme Intelligent Energy Europe together with partners from 11 countries (Austria, Bulgaria, Ireland, Finland, Greece, The Netherlands, Norway, Slovenia, Spain and Sweden), it will be continued for 28 months. The main objective of the project – develop and promote energy management use in small and middle size industrial enterprises, improving energy consumption efficiency and orienting towards manufacture of food products and beverages. It is expected to form innovative decisions ensuring continuous connection of small and middle size enterprises with energy management and efficient energy consumption. It is expected that measures will help to reduce cost price of production, increase energy consumption efficiency and implement environmental obligations under the Kyoto Protocol.
- Integration of electricity production from renewable energy sources to the EU network with least expenses. Project was implemented in accordance with EU programme Intelligent Energy Europe together with partners from 19 European countries. Perspective of electricity production from renewable energy sources in Lithuania up to year 2020 was evaluated.
- Dissemination and application of the Motor challenge programme. Project implemented in accordance with EU programme Intelligent Energy Europe together with partners from 15 European countries. Efficiency of electric motors utilization in water supply enterprises was analysed. Measures were proposed for the reduction of electric energy consumption in the enterprises.

Research results of 2006 were published in six scientific articles. Three papers were presented at international and Lithuanian conferences. Four seminars on efficient energy consumption, with the participation of representatives from Germany, Austria, Sweden and other countries, were organised.

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LABORATORY OF SYSTEMS CONTROL AND AUTOMATION

Main research areas of the Laboratory:

- mathematical modelling of power systems and network, investigation of control issues;
- information-control systems of power systems modelling and optimization research.

Quality of control of national power systems and electricity networks is very relevant from safety, reliability and efficiency points of view. The better control leads to reduced risk of disturbances in a power system, localisation of disturbances within a system, and to prevention of their spreading across the interconnected power systems. European Commission, Council of European Energy Regulators (CEER), EUROELECTRIC and other international organizations analyse and compare the development trends of systems and networks of individual countries, the emergency rates and reliability indicators, the tariffs of transmission and distribution services. Modelling of critical situations in European national systems and regions is considered to be the most significant scientific research task in the power system sector.

To assure quality of control, the complex investigations covering the expert analysis, modelling and application of new approaches and methods shall be carried out. Preparing for the new research tasks, in 2006 the Laboratory purchased the specialized software tools MATHLAB and SIMULINK.

In 2006 the Laboratory started the statefunded project *Efficient use of national* balance control resources in Lithuanian and Baltic power systems. This project is in accordance with the Institute's research direction Simulation of complex systems, development of their control methods and technologies. In interim report the features of power balance control of Lithuanian and Baltic power systems were analysed with regard to specificity of Baltic power system, existing control resources, influence of dynamic frequency response characteristics, and occurrence of disturbances in dependence on precedent operation states. Therein a new approach on balancing of

national and Baltic power systems has been proposed based on the idea that reserves of one kind, according to situation, shall take over the functions specific to reserves of another kind.

In 2006 in accordance with contract with the Ministry of Economy of the Republic of Lithuania the Laboratory carried out the applied research work *Technical-econo*mical analysis of reliability level of electricity supply, preparation of recommendations on legal regulation of electricity supply reliability taking into account experience of EU countries. The scope of this work was the services provided by electricity networks - quality of electricity transmission and distribution. The objective of the work was to analyze whether the legal framework of reliability regulation in Lithuania is due and fair, how this framework performs, what is actual reliability level in Lithuania. Special attention was given to reliability categories of consumers since the reliability differentiation among consumer groups as applied in Lithuania is a unique phenomenon in the European Union.

The review of reliability regulation methods in EU countries was carried out and reliability indicators across various countries were analysed. In parallel, consistency and coherence of Lithuanian framework of reliability issues were analysed. An extensive amount of data concerning breakdown of Lithuanian consumers to reliability categories was collected, as well as reliability implementation problems were analysed. The analysis covered networks and consumers of major network operators - SC Lietuvos Energija, SC Rytu Skirstomieji Tinklai and SC VST. Taking into account the current approaches to reliability increase in EU countries, the electricity supply recommendations were prepared on how to improve the reliability in Lithuania.



V. Radziukynas defends his doctoral dissertation "Influence of power balance and frequency deviations on electric power system operation and their control" (scientific supervisor – Prof. Dr. Habil. Antanas Nemura)

Accordingly, it was recommended to preserve the existent reliability categories of consumers and apply them as means to improve reliability of electricity supply. It is proposed to improve categories by supplementing them with some new parameters (at the moment a category includes only one reliability standard duration of a single unplanned long interruption of supply due to reasons related to responsibility of network operator). Another recommended guideline is to determine minimum network reliability standards for network operators: SAIDI. SAIFI for a average customer of distribution network and END, AIT indicators for transmission networks (since 2008). The operators are recommended within 5 years in distribution networks to install automatic recorders of number and duration of interruptions for consumers of higher reliability categories (I and II). It was determined as how to correct the discrepancies and inconsistencies of legal acts.

In 2006 the junior research associate V. Radziukynas defended Doctoral dissertation *Influence of power balance and frequency deviations on electric power system operation and their control* (scientific supervisor Prof. Dr. Habil. Antanas Nemura). This scientific work is a huge input to the increase of scientific competence of the Laboratory and to the strengthening of its competitiveness on research market. In dissertation V. Radziukynas reviewed the mathematical models of power systems, control methods and algorithms as related to frequency and power balance deviations, being applied in various power systems. Possible frequency deviations in Lithuanian power system were analysed, as well as the efficiency of 300 MW generation unit in Lithuanian Power Plant at regulation regime in dependence on its load variation range and system frequency was evaluated.

Using dynamic chains specific to automatic regulation theory, V. Radziukynas developed mathematical models of Interconnected power system (covering Baltic power system-, Belarus, Moscow and Saint Petersburg) and isolated Baltic power system- and assessed random variation of system load due to frequency variation. He developed mathematical models of wind power plants and wind velocity variation, which are equivalent to models based on physical dependencies but proved to be simpler and more convenient for practical calculations. Since input data (real changes of power and frequency ΔP , Δf) is important for modeling, a lot of efforts was given to parametric identification of measured data of power systems. Specific methodology based on parametric identification and spectrum analysis, which enables to assess parameters of frequency response characteristics, was proposed. Also the automated generation control algorithms were proposed in the dissertation for the needs of Lithuanian power system. Specifically, the secondary frequency and power controller of *fuzzy* type regulator was developed, with higher regulation capacity, as it was also acknowledged by the specialists of SC Lietuvos Energija (according to calculation results).

Contrary to other *fuzzy* regulators, it is designed for isolated Baltic power system, but can be used in the Interconnected power system as well. It — consists of 2 *fuzzy* regulators, each of them having one input and one output signal. One of them is designed for frequency regulation, another – for intersystem flow regulation.

The Laboratory aims at cooperating with international energy organizations. In 2006 under EUROLECTRIC request the researcher of the Laboratory, Arturas Klementavicius, presented a lecture at workshop of ERMINE project (in the framework of EU FP6) in Warsaw.

Researchers of the Laboratory presented six papers at international conferences and three papers at national conferences. Nine scientific publications were published, three of them in the proceedings of international conferences and one in the journal *Energetika*.

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LABORATORY OF HYDROLOGY

Main directions of research activities:

- investigations on safety and reliability of power plants and transport objects and their impact on water environment;
- analysis of climate change and rivers runoff variation;
- collection of data on Lithuania water bodies.

In 2006 researchers of the Laboratory implemented fundamental and applied research in the field of environment engineering.

environment and justification of environment protection measures is solved.

Research objects and tasks

The investigation of Lithuanian water bodies has been performed using numerous hydrographic, hydrologic, morphologic and other data collected in the Laboratory of Hydrology since 1961. Employing the state-of-the-art modules of modelling system MIKE 21 of Danish Hydraulic Institute the main task of environment protection – assessment of the impact of economical activity on the Most significant research objects of the Laboratory are as follows: the Kaunas Hydro Power Plant Reservoir and the Curonian Lagoon, the Baltic Sea, the Druksiai lake, the river Nemunas and other Lithuanian rivers. These water bodies are under extreme nature expressions (storms, excess rainfalls, and draughts) and are affected by human activities.

Using collected database and modelling system MIKE 21 the following tasks are solved:

- the assessment of environmental impact of human activities in water bodies and justification of environment protection means;
- hazard and risk analysis of hydrotechnical constructions;
- protection and management of the Baltic Sea coasts;
- investigation of quays interaction with water flow and selection of optimal constructions;
- determination of nature protection conditions using water bodies for different objectives;
- numerical assessment of mixing and dispersion of contamination under critical pollution conditions in water bodies;
- exploitation of Seaport and water ways maintaining secure depth for navigation;
- sensitivity and uncertainty analysis of input parameters of two-dimentional hydrodynamic model.



Flow variations of the Klaipeda Strait due to construction of seaport quaies

Seaport quai in the Klaipeda Strait



Distribution of annual rivers' run-off trends of the Baltic countries in the period of 1961–2003 (a positive trend – increase of rivers' run-off, a negative trend – decrease)

Research of surface water sources

Good state of Lithuanian water bodies is closely related with hydrographic, hydrologic, water economy and environmental research. Only after evaluating properties of water bodies of different physical geographical regions, sustainable development of water ecosystems is possible.

In accordance with the decision of the Government of the Republic of Lithuania the Laboratory of Hydrology is confirmed to be the supplier of cadastral data of Lithuanian rivers and lakes. Laboratory is responsible for collecting data on rivers hydrography and hydrotechnical constructions.

The safety analysis of the Kaunas Hydro Power Plant water body was carried out. Managing hydroenergetic system optimal decision is searched taking into account the assessment of run-off across embankment, inflow to reservoir, risk related with dam break and useful water volume of reservoir. Results of this analysis are related with extreme, larger than millennium floods. Created flood management model enables to make safe decisions. Sensitivity and uncertainty analysis of input parameters of hydrodynamic model was carried out for the Kaunas Hydro Power Plant Reservoir, which is under influence of operation of Kaunas Hydro Power Plant and Kruonis Pumped Storage Plant. For the analysis SUSA code developed by GRS mbh company (Germany) was used.

International cooperation

In 2005 the joint project with Northern countries Climate and **Energy** was launched. The project is funded by Nordic Energy Research. Researchers from Norway, Sweden, Finland, Denmark, Iceland, Lithuania, Latvia and Estonia take part in this project. The main objective of it is to assess the impact of climate change on energy sector. Research groups of climate change scenarios, statistical analysis and hydrological modelling were created to implement this objective. Scientists of laboratory participate in the activity of statistical analysis group. The task of this group is to evaluate the impact of climate

change on rivers run-off. Analysis of annual, seasonal and flood discharge trends of Lithuanian rivers for the periods of 1920–2003, 1941–2003 and 1960– 2003 was carried out in 2006. The obtained results were compared with the analogous research carried out by Northern countries. Common tendencies were determined: rivers winter run-off increases, spring floods occur earlier, maximum flood discharges reduce.

Cooperation with state and science institutions

The Laboratory of Hydrology closely cooperates with the Institute of Environmental Engineering of Kaunas University of Technology, have joint doctoral studies, since 1995 have been publishing scientific journal Environmental Research, Engineering and Management. The Laboratory together with Institute of Geology and Geography, Institute of Botany and Institute of Ecology of Vilnius University carry out complex environmental research. The most important tasks of the Laboratory of Hydrology is joint PhD studies and theses preparation and research of relevant Lithuanian water management problems. In accordance with agreements between the Ministry of Environment of the Republic of Lithuania and Lithuanian Energy Institute expertises of plans, programmes and projects are prepared at the Laboratory.

Applied research works

In the Laboratory's applied works are carried out and according agreements with enterprises and organizations hydrotechnics constructions projects are prepared:

- in the frame of the project with Klaipeda State Seaport Authority environmental impact assessment report of reconstructed quays, in which environment favourable quays variants and suggestions to select their construction were analysed, was prepared.
- in the frame of the project with Klaipeda State Seaport Authority environmental impact assessment reports of Malku Bay deepening and Klaipeda harbour northern part seaway widening were prepared.
- in the frame of the project with the Ministry of Environment deepening and cleaning environmental conditions of inland water bodies, the objective of which is to regulate navigation seaway supervision works, were prepared.
 in the frame of the project with Klaipeda State Seaport Authority impacts of
- Klaipeda deep-sea seaport on the environment were analysed.
- in the frame of the project with design enterprises JSC *Uostamiescio Projektas*, JSC *Pamario Projektai* and JSC *Hidroprojektas* studies on the Druksiai lake potential employment at Ignalina NPP, relevance of the Dane river valley for dwelling building and marina in Smelte peninsula, were prepared.

Laboratory personnel participated in three international conferences and published 8 scientific articles in Lithuanian and international journals.

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FINANCIAL HIGHLIGHTS

The financial sources of the Institute consist of:

LTL '000

- State budget subsidies;
- financing for research programmes and education of specialists;
- financing received from Lithuanian and foreign enterprises and organizations for contract works, realization of products and services;
- funds received from various international research programmes and funding organizations;
- subsidies, received from enterprises and associations for participation in joint activities and training of specialists.

Structure of Income and Total Expenses (LTL'000)

	2002	2003	2004	2005	2006
Income:					
State Budget Subsidies	4630	4473.2	6415.2	5454.7	6703.9
Contracts	7080	6074.0	6833.0	8230.9	10433.7
Other Income	1202	1128.0	1356.0	1048.7	1320.4
Total:	12912	11675.2	14604.2	14734.3	18458
Expenses:					
Salaries (soc. ins. incl.)	7181	7783.0	8667.0	9345.5	10709,1
Operating Expenses	2842	3572.2	3699.7	3559.0	4696.6
Capital Funds	1887	571.0	1564.3	1548.4	1185.5
Total:	11910	11926.2	13931.0	14452.9	16591.2
Long-term Projects Assets	1956	1705.0	2378.2	2878.0	4744.8

Variation of Financial Structure





SELECTED PUBLICATIONS

Books, monographs

- Augutis J., Ušpuras E. Technologijų rizika: monograph // Kaunas: Lietuvos energetikos institutas, Vytauto Didžiojo universitetas, 2006. 248 p. ISBN 9986-492-89-0.
- Jaunoji energetika 2006: Konferencijos pranešimų medžiaga. ISBN 9986-492-91-2 // Lietuvos energetikos institutas, 2006 m. birželio 8. / Kaunas, LEI, 2006.
- V. Klevas, D. Štreimikienė. Lietuvos energetikos ekonomikos pagrindai // Kaunas: Lietuvos energetikos institutas, 2006. 404 p. ISBN 9986-492-96-3.
- Lietuvos energetikos institutas 50. ISSN 132-4044, IBSN 9986-795-46-X // VĮ Mokslotyros institutas, 2006. Lietuvos mokslas. 61 knyga. 520 p.
- Pranevičius L. Physical vapour deposition of nanostructured thin films for hydrogen storage // Kaunas: Vytautas Magnus University, Lithuanian Energy Institute, 2005. 89 p. ISBN 9986-492-85-8.
- Pranevičius L. Characterization of thin films materials used for hydrogen storage // Kaunas: Vytautas Magnus University, Lithuanian Energy Institute, 2005. 119 p. ISBN 9986-492-90-4.
- Šilumos energetika ir technologijos: Konferencijos pranešimų medžiaga. ISBN 9986-492-92-0 // Lietuvos energetikos institutas, Kauno technologijos universitetas, 2006 m. vasario 2, 3. / Kaunas, LEI, 2006. 318 p.
- Ušpuras E., Kaliatka A. Accident and transient processes at NPPs with channel-type reactors: monography // Kaunas: Lithuanian Energy Institute, 2006. Thermophysics: 28. 298 p. ISBN 9986-492-87-4.

Articles in the journals included in the list of ISI

- Akdogan E., Cokeliler D., Marcinauskas L., Valatkevičius P., Valinčius V., Mehmet M. A new method for immunosensor preparation: Atmospheric plasma torch // Surface & coatings technology. ISSN 0257-8972. 2006. Vol. 201, Iss.6, p. 2540-2546.
- Almenas K., Pabarčius R., Šeporaitis M. Design and tests of a device for the generation of controlled condensation implosion events // Heat transfer engineering. ISSN 0145-7632. 2006. Vol. 27, Iss. 3, p. 32-41.
- Augutis J., Krikštolaitis R., Urbonas R., Ušpuras E. Hazard distribution and risk assessment in the network systems // Stochastic environmental research and risk assessment. ISSN 1436-3240. 2006. Vol. 21, No. 1, p. 51-61.
- Babilas E., Urbonavičius E., Rimkevičius S. Modeling of the TOSQAN test facility with the lumped parameter code COCOSYS // Kerntechnik. ISSN 0932-3902. 2006. Vol. 71, No. 5-6, p. 258-263.
- Balevičius R., Džiugys A., Kačianauskas R., Maknickas A., Vislavičius K. Investigation of performance of programming approaches and languages used for numerical simulation of granular material by the discrete element method // Computer physics communications. ISSN 0010-4655. 2006. Vol. 175, Iss. 6 p. 404-415.

- Dundulis G., Karalevičius R., Rimkevičius S., Kulak R., Marchertas A. Strength evaluation of a steam distribution device in the Ignalina NPP accident localisation system // Nuclear engineering and design. ISSN 0029-5493. 2006. Vol. 236, Iss. 2, p. 201-210.
- Džiugys A., Peters A., Husinger H., Krebs L. Evaluation of the residence time of a moving fuel bed on a forward acting grate // Granular matter. ISSN 1434-7636. 2006. Vol. 8, No. 3-4, p. 125-135.
- Girdauskas V., Kazragytė R., Bertašienė A., Dement'ev A. Cascaded compression of the first and second Stokes pulses during forward transient stimulated Raman amplification // Optics communications. ISSN 0030-4018. 2006. Vol. 265, Iss. 2, p. 664-671.
- Kaliatka A. Rimkevičius S., Ušpuras E., Urbonavičius E. Analyses of severe accident scenarios in RBMK-1500 // Kerntechnik. ISSN 0932-3902 / 2006. Vol.71, No. 4, p. 228-237.
- Kaliatka A., Ušpuras E., Vaišnoras M. Uncertainty and sensitivity analysis of parameters affecting water hammer pressure wave behaviour // Kerntechnik. ISSN 0932-3902. 2006. Vol. 71, Vol. 5-6, p. 270-278.
- Katinas V., Markevičius A. Promotional policy and perspectives of usage renewable energy in Lithuania // Energy policy. ISSN 0301-4215. 2006. Vol. 34, Iss. 7, p. 771-780.
- Klimašauskas A., Alzbutas R., Kopustinskas V., Augutis J., Ušpuras E. Updating of risk-informed ISI programme for Ignalina RBMK-1500 nuclear power plant in Lithuania: results and challenges // Nuclear engineering and design. ISSN 0029-5493. 2006. Vol. 236, Iss. 24, p. 2547-2555.
- Kriaučiūnienė J., Gailiušis B., Rimavičiūtė E. Modelling of shoreface nourishment in the Lithuanian nearshore of the Baltic Sea // Geologija. ISSN 1392-110X. 2006. Nr. 53, p. 28-37.
- Laukaitis G., Dudonis J., Milčius D. YSZ thin films deposited by e-beam technique // Thin solid films. ISSN 0040-6090. 2006. Vol. 515, Iss. 2, p. 678-682.
- Lukošiūtė I., Levinskas R., Kviklys A. Formation of a transition layer on the fillers of polymer composites // Mechanics of composite materials. ISSN 0191-5665. 2006. Vol. 42, No. 5, p. 485-490.
- Maknickas A., Kačeniauskas A., Kačianauskas R., Balevičius R., Džiugys A. Parallel DEM software for simulation of granular media // Informatica. ISSN 0868-4952. 2006. Vol. 17, No. 2, p. 207-224.
- Markandya A., Pedroso-Galinato S., Štreimikienė D. Energy intensity in transition economies: Is there convergence towards the EU average? // Energy economics. ISSN 0140-9883. 2006. Vol. 28, Iss.1, p.121-145.
- Milčiuvienė S., Milčius D., Pranevičienė B. Towards hydrogen economy in Lithuania // International journal of hydrogen energy. ISSN 0360-3199. 2006. Vol. 31, Iss. 7, p. 861-866.
- Miškinis V., Slihta G., Rudi Y. Bio-energy in the Baltic States: current policy and future development // Energy policy. ISSN 0301-4215. 2006. Vol. 34, Iss. 18, p. 3953-3964.
- Poškas P., Šmaižys A., Šimonis V. Radiological and thermal characteristics of CASTOR RBMK-1500 and CONSTOR RBMK-1500 casks for spent nuclear fuel storage at Ignalina Nuclear Power Plant // Kerntechnik. ISSN 0932-3902. 2006. Vol. 71, No. 4, p. 222-227.
- Pranevičius L., Milčius D., Pranevičius L.L., Templier C., Bobrovaitė B., Barnackas I. The role of grain boundaries in the mechanism of plasma immersion hydrogenation of

nanocrystalline magnesium films // Applied surface science. ISSN 0169-4332. 2006. Vol. 252, Iss. 12, p. 4202-4208.

- Punys P, Dumbrauskas A., Rimkus Z., Štreimikienė D. Renewable energy in the Baltic countries: the case of hydropower // Houille blanche-revue internationale. ISSN 0018-6368. 2006. No. 1, p. 91-101.
- Račkauskas S., Snitka V. Method for the simple catalytic carbon nano-fibers growth in air // Microelectronic engineering. ISSN 1392-110X. 2006. Vol. 83, Iss. 4-9, p. 1538-1541.
- Rimkevičius S., Vilemas J., Ušpuras E. Experimental investigation of heat transfer and flow mixing in pebble beds // Heat transfer engineering. ISSN 0145-7632. 2006. Vol. 27, Iss. 8, p. 8-15.
- Šlančiauskas A., Kalpokaitė R. Behaviour of a heavy fuel oil droplet on a hot surface // International journal of heat and mass transfer. ISSN 0017-9310. 2006. Vol. 49, Iss. 5-6, p. 1050-1057.
- Šliaupa S., Kačianauskas R., Markauskas D., Dundulis G., Ušpuras E. Design basis earthquake of the Ignalina Nuclear Power Plant // Geologija. ISSN 1392-110X. 2006. Nr. 54, p.19-30.
- Šmaižys A., Narkūnas E., Poškas P. Modelling of activation processes for GR-280 graphite at Ignalina NPP // Radiation protection dosimetry. ISSN 0144-8420. 2005. Vol. 116, No. 1-4, p. 270-275.
- Šmaižys A., Poškas P., Ragaišis V. Modelling of the shielding capabilities of the existing solid radioactive waste storages at Ignalina NPP // Radiation protection dosimetry. ISSN 0144-8420. 2006. Vol. 116, No. 1-4, p. 423-427.
- Tonkūnas A., Pabarčius R., Clemente M., Listopadskis N. Uncertainty and sensitivity analysis of the CPS-CC voiding in the RBMK reactor Ignalina-2 // Kerntechnik. ISSN 0932-3902. 2006.Vol 71, No.3, p. 104-112.
- Uspuras E., Matuzas V., Kopustinskas V., Augutis J., Krivoshein G., Lebedevichus N. Improvement of the method used for hydraulic profiling of an RBMK-1500 core at the Ignalina nuclear power plant // Atomic Energy. ISSN 1063-4258. 2006. Vol. 101, Iss. 5, p. 797-801.
- Ušpuras E., Kaliatka A., Vileiniškis V. Development of accident management measures for RBMK-1500 in the case of loss of long-term core cooling // Nuclear engineering and design. ISSN 0029-5493. 2006. Vol. 236, Iss. 1, p. 47-56.
- Valinčius V., Snapkauskienė V., Kėželis R., Valinčiūtė V., Mečius V. Preparation of insulating refractory materials by plasma spray technology // High temperature material processes. ISSN 1093-3611. 2006. Vol. 10, Iss. 3, p. 365-378.

Articles in science publications, registered in international science information databases

- Augutis J., Krikštolaitis R., Matuzas V., Ušpuras E. Evaluation of hazard distribution in network structures // Risk analysis V: Fifth Int. conf. on simulation in risk analysis and hazard mitigation, Malta, June 19-21, 2006. WitPress: 2006. ISBN 1-84564-172-8, p. 363-369.
- Baltušnikas A., Levinskas R. XRD analysis of carbide phase in heat resistant steels // Materials science. ISSN 1392-1320. 2006. Vol. 12, No. 3, p. 192-198.
- Birgiolas E., Katinas V. Vėjo srauto parametrų kitimo dėsningumų tyrimas Lietuvos pajūryje // Energetika. ISSN

0235-7208. 2006. Nr. 2, p. 29-33.

- Brazauskaitė A., Poškas P. Radionuklidų sklaida iš kristalinėse uolienose įrengto geologinio kapinyno RBMK-1500 panaudotam branduoliniam kurui laidoti 2. Geologinio kapinyno saugos vertinimui svarbių radionuklidų identifikavimas // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 47-56.
- Brinkienė K., Čėsnienė J., Kėželis R., Mėčius V., Baltušnikas A., Žunda A. Structural and surface analysis of plasma processed zirconia coatings // Materials science. ISSN 1392-1320. 2006. Vol. 12. No. 4, p. 300-304.
- Dundulis G., Grybénas A., Klimašauskas A., Makarevičius V., Levinskas R. Ageing asses-sment of RBMK-1500 fuel channel in case of delayed hydride cracking // Mechanika. ISSN 1392-1207. 2006. Nr.1, p. 5-11.
- Dzenajavičienė E.F., Kveselis V., Tamonis M. Gamybos decentralizavimo ir naujų technologijų vaidmuo skatinant subalansuotą konkurenciją šilumos ūkyje // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 16-22.
- Gaigalis V., Škėma R. Lietuvos ekonomikos ir pramonės vystymosi 2000-2004 m. tendencijos // Energetika. ISSN 0235-7208. 2006. Nr. 1, p. 42-48.
- Gaigalis V., Škėma R. Energetikos vadybos įgyvendinimo mažose ir vidutinėse pramonės įmonėse modelis // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 90-96.
- Gailiušis B., Kovalenkovienė M., Kriaučiūnienė J. Svarbiausios šiandieninės Lietuvos hidrologinių tyrimų kryptys // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 43-50.
- Gailiušis B., Kriaučiūnienė J., Tomkevičienė A. Investigation of outflow conditions of Klaipėda sewage // Aplinkos tyrimai, inžinerija ir vadyba. ISSN 1392-1649. 2006. Nr. 1, p. 12-17.
- Gailiušis B., Kriaučiūnienė J., Ušpuras E., Kaliatka A., Vileiniškis V. Kauno HE tvenkinio hidrodinaminio modelio kalibravimas remiantis neapibrėžtumo analizė // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 37-44.
- Galinis A., Tarvydas D. A new nuclear power plant in Lithuania in the light of power system development in the Baltic region // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 102-109.
- Kačeniauskas A., Česnienė J. Coupled FEM simulation of turbulent flow and temperature in insulated pipes // Mechanika. ISSN 1392-1207. 2006. Nr. 5, p. 32-37.
- Каlpokaitė-Dičkuvienė R., Stravinskas G. Поведение капли мазута на горячей поверхности // Инженерно-физический журнал. ISSN 1062-0125. 2006. Том 79, № 1, с. 11-19.
- Kalpokaitė-Dičkuvienė R., Stravinskas G. Behavior of a fuel oil droplet on a hot surface // Journal of engineering physics & thermophysics. ISSN 1573-871X. 2006. Vol. 79, No. 1, p. 10-17.
- Katinas V., Markevičius A., Burlakovas A. Vėjo energetika ir jos artimiausia perspektyva Lietuvoje // Energetika. ISSN 0235-7208. Nr. 3, p. 67-76.
- Kilda R., Poškas P., Ragaišis V. Radioaktyviųjų atliekų heterogeniškumo įtakos radionuklidų sklaidai iš paviršinio kapinyno gruntiniais vandenimis analizė. 2. Heterogeniškumo įtakos įvertinimas // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 10-15.
- Kopustinskas V., Padvelskis K., Augutis J. Branduolinių reaktorių saugos sistemų programinės įrangos patikimumas: vertinimo metodai ir problemos // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 45-49.

- Kriaučiūnienė J., Gailiušis B., Kovalenkovienė M. Pecularities of sea wave propagation in the Klaipėda strait, Lithuania // Baltica. ISSN 0067-3064. 2006. Vol. 19, No. 1, p. 20-29.
- 61. **Kugelevičius J. A., Kuprys A., Kugelevičius J.** Organinio kuro kainų prognozės // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 23-28.
- Kugelevičius J.A., Kuprys A., Kugelevičius J. Evaluation of ecological and energetic indicators in power production // Journal of environmental engineering and landscape management. ISSN 1648-6897. 2005. Vol. XIII, No. 4, p. 192a-199a.
- Kveselis V., Masaitis S., Urbonas P. Quality assurance for hot water supply from DH system: simulation tool and application // Journal of civil engineering and management. ISSN 1392-3730. 2006. Vol. 12, No. 1, p. 15-19.
- 64. **Kveselis V., Tamonis M.** Centralizuoto šilumos tiekimo konkurencingumo problemos: naujų technologijų iššūkis // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 110-118.
- Laukaitis G., Galdikas A., Čerepaitė-Trušinskienė R., Dudonis J., Milčius D. Microstructure and surface morphology of YSZ thin films // Materials science. ISSN 1392-1320. 2006. Vol. 12, No. 4, p. 305-310.
- Marcinauskas K., Korsakienė I., Kuzmickas P. Žemiau rasos taško temperatūros vėsinamų dūmų šilumos panaudojimo galimybių įvertinimas // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 66-72.
- Marcinauskas L., Valinčius V., Valatkevičius P., Grigonis A. Vienkamerinio linijinio plazmos generatoriaus, kaitinančio vienatomes dviatomes dujas, charakteristikų tyrimas // Energetika. ISSN 0235-7208. 2006. Nr. 1, p. 36-41.
- Matuzas V., Augutis J., Ušpuras E. Ageing assessment in network systems // Safety and reliability for managing risk: proceedings of the European safety and reliability conference (ESREL 2006), Estoril, Portugal, September 18-22, 2006. London: Taylor & Francis, 2006. ISBN 0-415-41620-5, p. 559-562.
- Milčius D., Pranevičius L., Templier C., Bobrovaitė B., Barnackas I. Role of grain boundaries in the mechanism of plasma hydrogenation of nanocrystalline MgAI // Hydrogen in Matter: second international symposium (ISOHIM), Uppsala, Sweden, June 13-17, 2005. American Institute of Physics, 2006. ISBN 0-7354-0329-5, p. 22-33.
- Miškinis V., Galinis A. Lietuvos nacionalinės energetikos strategijos gairės // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 24-32.
- Miškinis V., Konstantinavičiūtė I., Ušpuras E., Kaliatka A., Kopustinskas V. Neapibrėžtumo analizės taikymas energetikos ekonomikos vienmačių modelių uždaviniams // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 1-9.
- Nemura A., Klementavičius A. Vėjo elektrinių parko informacinės sistemos variantų analizė statistinio daugiakriterinio naudingumo metodu // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 34-42.
- Pakulytė G., Martinaitis V., Milčius D. Kietojo oksido kuro elemento energetinių sąnaudų analizė // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 80-83.
- 74. **Paulauskas A.,** Paulauskas S., Bražulionienė S. Klaipėdos miesto valdymo decentralizavimo tikslingumo vertinimas // Viešoji politika ir administravimas. ISSN 1648-2603. 2006. Nr. 16, p. 100-111.

- Pažėraitė A., Krakauskas M. Elektros energijos persiuntimo paslaugos kainų diferencijavimo patirties ES šalyse apžvalga ir jos taikymo Lietuvoje galimybės // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 119-127.
- Pedišius A., Tonkonogij J., Stankevičius A. Gamtinių dujų srautų matavimų tyrimai ir jų praktinis taikymas // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 86-93.
- Perednis E., Karbauskaitė J. Kačerginės vaikų sanatorijos šiluminės energijos vartojimas // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 63-67.
- 78. **Poškas P., Poškas R.** Mišrios konvekcijos tyrimai kanaluose // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 1-8.
- Poškas P., Šimonis V., Zujus R., Kilda R., Kolesnikovas J., Sirvydas A. Gaisrų pavojaus Ignalinos AE pirmajame bloke analizė. 3. Išsami analizė ir apibendrinantys rezultatai // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 16-21.
- Poškas P, Šmaižys A. Panaudoto branduolinio kuro saugojimas ir jo laidojimo perspektyvos // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 33-42.
- Poškas P., Zujus R., Jankauskas J. Нестационарная ламинарная смешанная конвекция в вертикальном плоском канале при попутных направлениях потоков // Industrial heat engineering. ISSN 0204-3602. 2006. Vol. 28, No. 1, p. 36-39.
- Poškas R., Poškas P., Kolesnikovas J. Opposing flow turbulent mixed-convection heat transfer in a vertical flat channel with one-sided heating // Heat transfer research. ISSN 1064-2285. 2006. Vol. 37, No. 1, p. 21-43.
- 83. **Poškas R.**, Šinkūnas S., **Poškas P.** Experimental investigation of opposing turbulent mixed-convection heat transfer in an inclined flat channel with one-sided heating 1. Method and investigations for an inclination angle $\varphi = 60^{\circ}$ // Heat transfer research. ISSN 1064-2285. 2006. Vol 37, No. 1, p. 35-43.
- Račkauskas S. Carbon nanotube growth and use in energy sector // Energetika. ISSN 0235-7208. 2006. Nr. 2, p. 43-46.
- Simaitytė J., Augutis J., Gailiušis B. Risk-based water level control in Kaunas hydropower system // Environmental research, engineering and management. ISSN 1392-1649. 2006. No. 3, p. 5-12.
- Simaitytė-Volskienė J., Augutis J., Ušpuras E. Risk based decision making in Kaunas hydropower system during flood period // Risk analysis V: Fifth int. conf. on simulation in risk analysis and hazard mitigation, Malta, June 19-21, 2006. WitPress: 2006. ISBN 1-84564-172-8, p. 219-228.
- Sirvydas A., Poškas P. Численное исследование теплоотдачи при ламинарной смешанной конвекции в плоском вертикальном канале для противоположных направлений потоков // Industrial heat engineering. ISSN 0204-3602. 2006. Vol. 28, No. 3, p. 20-24.
- Sirvydas A., Poškas R. Šilumos atidavimo skaitiniai tyrimai vertikaliame plokščiame kanale mišrios konvekcijos atveju priešingų krypčių tėkmėse 2. Sūkurinis tekėjimas esant simetriniam dvipusiam kaitinimui // Energetika. ISSN 0235-7208. 2006. Nr. 1, p. 9-15.
- Šeporaitis M., Pabarčius R., Almenas K. Kondensacijos pliūpsnio tyrimai: konstrukcinis pulserio kriterijus // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 77-85.
- Šlančiauskas A. Ekologiškas kuro deginimas, naujos technologijos // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 61-66.

- Štreimikienė D., Mikalauskienė A. Lietuvos mokesčių sistema ES kontekste // Organizacijų vadyba: sisteminiai tyrimai. ISSN 1392-1142. Nr. 38, p. 169-182.
- Štreimikienė D., Mikalauskienė A., Alėbaitė I. Local approach in climate change mitigation // Organizacijų vadyba: sisteminiai tyrimai. ISSN 1392-1142. 2006. Nr. 40, p. 181-202.
- Tarvydas D., Gatautis R. Liquefied natural gas in the world and Lithuanian perspective // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 94-101.
- Ušpuras E., Kaliatka A., Augutis J., Rimkevičius S., Urbonavičius E., Kopustinskas V. Probabilistic and deterministic analysis of BDBA in RBMK-1500 // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 8-23.
- 95. Ušpuras E., Matuzas V., Kopustinskas V., Augutis J., Krivošein G., Lebedevičius N. Усовершенствование методики гидропрофилирования активной зоны РБМК-1500 на Игналинской АЭС // Атомная энергия. ISSN 0004-7163. 2006. Том 101, № 3, с. 342-346.
- Valinčius V., Valatkevičius P., Kėželis R. Plazminis įvairių pavojingų atliekų nukenksminimas // Energetika. ISSN 0235-7208. Nr. 3, p. 51-60.
- Zujus Ren., Poškas P., Jankauskas J. Mišrios konvekcijos skaitiniai tyrimai vertikaliame plokščiame kanale pereinamojo tekėjimo zonoje esant vienkryptėms tėkmėms 1. Tėkmės struktūros analizė // Energetika. ISSN 0235-7208. 2006. Nr. 4, p. 84-89.
- Žiugžda V. Šiluminės fizikos tyrimai ir jų raida Lietuvos energetikos institute // Energetika. ISSN 0235-7208. 2006. Nr. 3, p. 1-7.

Articles in other reviewed science periodic publications

- Abraitis R., Brinkienė K., Griniūtė G. Aukštatemperatūrės medžiagotyros pradžia ir tyrimai Lietuvos energetikos institute // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 499-518.
- Džiugys A. Numerical simulation of dynamics and combustion of granular material // Science and supercomputing in Europe. ISBN 88-86037-17-1. Italy: CINECA, 2006, p. 664-668.
- Gailiušis B., Jablonskis J., Tomkevičienė A. Vandens išteklių tyrimų raida Lietuvoje // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 389-408.
- Gailiušis B., Kriaučiūnienė J. Baltijos jūros paplūdimių smėlio atsargų papildymas // Geologijos akiračiai. ISSN 1392-0006. 2006. Nr. 1, p. 21-26.
- Galinis A., Miškinis V., Vilemas J. Tyrimai energetikos sistemų optimizavimo srityje ir nacionalinės energetikos strategijos evoliucija // Lietuvos mokslas. Lietuvos energetikos instituto 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 71-106.
- Goshitashvili T., Krakauskas M., Abulashvili G. Georgia in the context of EU energy policy // Georgian economis trends, Quarterly review. ISSN 1512-018X. 2006. June, p. 59-66.
- Juška A., Miškinis V. Pirmieji moksliniai energetikos problemų tyrimai Lietuvoje // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46 X. 2006. 61 kn., p. 109-135.

- 106. Katinas V., Vrubliauskas S., Savickas J., Perednis E. Atsinaujinantys energijos šaltiniai ir jų naudojimas Lietuvoje // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 329-363.
- Kveselis V., Tamonis M. Regionų energetikos plėtra ir jos problemos // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 251-292.
- Kviklys A., Levinskas R. Polimerų ir kompozicinių medžiagų tyrimai Lietuvos energetikos institute 1956-2006. // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 411-443.
- 109. Lukošiūtė I., Levinskas R., Kviklys A. Образование переходного слоя на наполнителях полимерных композитов // Механика композитных материалов. ISSN 0203-1272. 2006. № 5, с. 693-700.
- Miškinis V., Deksnys R. Development of small and medium enterprises in Lithuania // International journal of Entrepreneurship and innovation management. ISSN 1368-5098. 2006. Vol. 6, No. 1/2, p. 74-88.
- Miškinis V., Vilemas J., Konstantinavičiūtė I. Analysis of energy consumption and energy intensity indicators in Central and Eastern European countries // Energy studies review. ISSN 0843-4379. 2006. Vol. 14, No. 2, p. 171-188.
- Navakas R. Simulation of motion of granular media in complex mechanical systems // Science and supercomputing in Europe. Report 2005. ISBN 88-86037-17-1. Italy: CINECA, 2006, p. 745-749.
- 113. Nemura A. Dinaminių ir energetinių sistemų identifikavimo, modeliavimo ir adaptyvaus valdymo tyrimai Lietuvos energetikos institute // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 137-160.
- 114. Pedišius A. Skysčių ir dujų srautų matavimai energetikoje // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 177-196.
- 115. Poškas P. Lithuania's approach to disposal of radioactive waste and spent nuclear fuel // Geological challenges in radioactive waste isolation: fourth worldwide review. Berkeley: University of California, 2006. LBNL-59808, p. 147-154.
- 116. Poškas P. Pasiekimai ir problemos tvarkant branduolinės energetikos atliekas Lietuvoje // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 199-220.
- 117. Šlančiauskas A., Džiugys A. Degimo procesai deginant įvairų kurą ir atliekas // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 223-248.
- 118. Štreimikienė D. Energetika ir jos įtakos aplinkai mažinimas // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 445-483.
- Štreimikienė D. Environmental issues of Ukrainian energy sector // Nuclear and radiation technologies. ISSN 1819-2106. 2005. Vol. 2, No. 2, p. 22-48.
- 120. Tonkonogij J., Stankevičius A., Krukovskij P. Исследование переходных процессов в турбинных счетчиках газа // Балтехмаш-2006: сборник научных трудов международной балтийской ассоциации машиностроителей:

прогрессивные технологии, машины и механизмы в машиностроении, ВАМЕ. Калининград, 2006, с. 167-175.

- Ušpuras E., Kaliatka A., Augutis J., Rimkevičius S., Almenas K. Branduolinės energetikos sauga Lietuvoje ir jos evoliucija po 1990 metų. // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 27-55.
- 122. Valatkevičius P., Valinčius V. Žematemperatūrės plazmos ir jos technologijų tyrimai Lietuvos energetikos institute // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 295-326.
- Vilemas J. Lietuvos energetikos strategijos ir politikos raida (1990-2006) // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 57-70.
- Vilemas J., Milčius D. Vandenilio energetikos technologijos // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X. 2006. 61 kn., p. 485-496.
- 125. Žiugžda V. Šiluminė fizika ir Lietuvos energetikos institutas // Lietuvos mokslas. Lietuvos energetikos institutas 50. ISSN 1392-4044. ISBN 9986-795-46-X.2006. 61 kn., p. 11-24.

Papers in international conferences' proceedings

- 126. Alzbutas R., Dundulis G., Augutis J., Ušpuras E. Probabilistic modeling of aircraft crash and impact on Ignalina NPP considering uncertainty // Proceedings of the PSAM 8, New Orleans, Louisiana, USA, May 14-18, 2006. USA, 2006, 1-9.
- 127. Strazdas D., Kveselis V. Cogeneration development possibilities in the Lithuanian cities in competitive and monopolistic heat market // 12th international cogeneration, combined cycle and environment conference and exhibition, Istanbul, Turkey, May 25-26, 2006. Turkey, 2006, p. 143.
- Ambrazevičius A., Valatkevičius P., Valinčius V. The application on the new plasma technologies in Lithuania // Plasma physics and plasma technology: V int. conf. (PPPT-5), Minsk, Belarus, September 18-22, 2006. Minsk, 2006. Vol II. ISBN 5-84389-069-4, p. 731-734.
- Augutis J., Ušpuras E., Matuzas V. Risk management of hazardous materials transportation // Proceedings of the PSAM 8, New Orleans, Louisiana, USA, May 14-18, 2006. USA, 2006, p. 1-9.
- Babilas E., Urbonavičius E., Rimkevičius S. Simulation of hydrogen distribution in Ignalina NPP ALS compartments during BDBA // Proceedings of the ICONE 14, Miami, Florida, USA, 17-20 July, 2006. USA: ASME, 2006. ISBN 0-7918-3783-1, p. 1-10.
- Brazauskaitė A., Poškas P. Modelling of radionuclide releases from the near field of the geological repository in crystalline rocks for RBMK-1500 spent nuclear fuel // Transactions international topical meeting: TOPSEAL 2006, Olkiluoto information centre, Finland, September 17-20, 2006. Olkiluoto, 2006, p.1-5.
- 132. Brinkienė K., Kėželis R., Mėčius V., Čėsnienė J. Исследование структуры и триботехнических характеристик плазменных покрытий // Вакуумные нанотехнологии и оборудование: Сборник докладов 7-й международной конференции, Харьков, Украина, 2006. Харьков:

Контраст, 2006. Том 1. ISBN 966-8855-21-3, с. 348-352.

- 133. Čėsna B. The thermal-hydraulic calculation model for gas flow in a fuel rod assembly // 13th international heat transfer conference, Sydney, Australia, August 13-18, 2006. USA: Begell House Inc, 2006. ISBN 1-56700-226-9, p. 1-12.
- 134. Dundulis G., Klimašauskas A., Grybėnas A., Makarevičius V., Kiselev V. Leak-before-break application for RBMK-1500 fuel channel // Material issues in design, manufacturing and operation of nuclear power plants equipment: proceedings of the 9th int. conf., Pushkin, St. Petersburg, Russia, June 6-8, 2006. St. Petersburg, 2006, p. 185-194.
- Dzenajavičienė E.F., Kveselis V., Tamonis M. Biomass gasification opportunities for small towns heating in Lithuania // 12th international cogeneration, Combined cycle and environment conference and exhibition, Istanbul, Turkey, May 25-26, 2006. Turkey, 2006, p. 140.
- 136. Grybėnas A., Makarevičius V., Dundulis G. Effect of variable loading on hydride cracking of zirconium alloy pressure tube // Material issues in design, manufacturing and operation of nuclear power plants equipment: proceedings of the 9th int. conf., Pushkin, St. Petersburg, Russia, June 6-8, 2006. St Petersburg, 2006, p. 164-173.
- Karalevičius R., Rimkevičius S., Dundulis G., Ušpuras E. Investigation of a shock absorber for safeguard of fuel assemblies failure // Proceedings of the ICONE 14, Miami, Florida, USA, July 17-20, 2006. USA: ASME, 2006. ISBN 0-7918-3783-1, p. 1-5.
- Kažys R., Sliteris R., Mazeika L., Voleisis A., Grybėnas A., Dundulis G. Ultrasonic estimation of hydride degradation of zirconium pressure tubes of RBMK fuel channel // 9th European conference on non-destructive testing conference proceedings ECNDT, Berlin, September 25-29, 2006. Berlin, 2006, p. 1-8.
- Kilda R., Poškas P., Ragaišis V. Modelling of nuclide migration for support of the site selection for near surface repository in Lithuania // Transactions international topical meeting: Topseal 2006, Olkiluoto information centre, Finland, September 17-20, 2006. Olkiluoto, 2006, p. 1-5.
- Klementavičius A. National balancing problem with value tradeoffs of power system's control parameters // Control of power & heating systems: 7th Int. conf., Zlin, Czech Republic, May 16-18, 2006. Academia centrum, 2006. ISBN 80-7318-409-5, p. P57-1-P57-8.
- 141. Klevas V., Štreimikienė D., Skališius V. Sustainability assessment of the energy projects implementation in regional scale // Securing energy in insecure times: 29th IAEE int. conf., Potsdam, Germany, 7-9 June, 2006. Cleveland OH: International Association for Energy Economics, 2006. ISSN 1559-792X, p. 69-70.
- 142. Kriaučiūnienė J., Kopustinskas V., Vileiniškis V., Kaliatka A., Gailiušis B. Calibration of hydrodynamic model of the Kaunas reservoir, Lithuania // 11th biennial ERB conference uncertainties in the monitoring-conseptualisation-modelling sequence of catchment research, Luxembourg, September 22-26, 2006. Luxembourg, CRP-Gabriel Lippmann, Belvaux, 2006. ISBN-10 2-919900-06-4; ISBN-13 978-2-91990-06-0, p.79-83.
- 143. Kriaučiūnienė J., Kovalenkovienė M., Gailiušis B. Climate change and possible impact on hydropower production in Lithuania // European conference on impacts of climate change on renewable energy sources, Reykjavik, Iceland, June 5-9, 2006. Iceland, 2006. ISBN 9979-68-189-6, p. 163-167.

- 144. Kriaučiūnienė J., Kovalenkovienė M., Meilutytė-Barauskienė D. Changes of the dry and wet periods in the runoff series of Lithuanian rivers // XXIV Nordic hydrological conference: Nordic water 2006, NHP report No. 49, Vingstend, Denmark, August 6-9, 2006. Denmark: PrinfoDjurs, 2006. ISBN 87-87656-11-6, p. 641-648.
- 145. Krivosik J., Škėma R. Household appliances labelingprogress made and needed in Central Europe // Energy efficiency in domestic appliances and lighting: proceedings of the 4th int. conf. (EEDAL'06), London, United Kingdom, June 21-23, 2006. Italy: European Communities, 2006. ISBN 92-79-02750-6, p. 285-295 (http:// www.jrc.cec.eu.int).
- Matuzas V., Augutis J., Ušpuras E. Degradation assessment in complex systems // Proceedings of the ICONE 14, Miami, Florida, USA, July 17-20, 2006. USA: ASME, 2006. ISBN 0-7918-3783-1, p. 1-4.
- 147. Matuzienė V., Tamonis M. Complex systems analysis according to energy economy example // Proceedings of the 2005 international workshop on optimization problems in engineering, Jaroslavl, Russia, December 17-22, 2005. Jaroslavl, 2006.ISBN 5-88610-081-4, p. 115-120.
- Meilutytė-Barauskienė D. Changes of spring floods in Lithuania // European conference on impacts of climate changes on renewable energy sources, Reykjavik, Iceland, June 5-9, 2006. Iceland, 2006. ISBN 9979-68-189-6, p. 183-186.
- 149. Poškas P., Brazauskaitė A., Narkūnas E., Šmaižys A., Sirvydas A. Generic repository concept for RBMK-1500 spent nuclear fuel disposal in crystalline rocks in Lithuania // Transactions international topical meeting: Topseal 2006, Olkiluoto information centre, Finland, September 17-20, 2006. Olkiluoto, 2006, p. 1-5.
- Poškas P., Poškas R., Sirvydas A. Opposing mixed convection heat transfer in the vertical flat channel in a laminarturbulent transition region // 13th international heat transfer conference, Sydney, Australia, August 13-18, 2006. USA: BegellHouse Inc., 2006. ISBN 1-56700-226, p. 1-11.
- 151. Poškas P., Poškas R., Zujus Re., Jankauskas J. Aiding mixed convection heat transfer in the vertical flat channel in a laminar-turbulent transition region // Proceedings of the 5th international symposium on turbulence, heat and mass transfer, Dubrovnik, Croatia, September 25-29, 2006. USA: Begell-House Inc., 2006. ISBN 1-56700-229-3, p. 201-204.
- 152. Poškas P., Zujus G., Drumstas G., Kolesnikovas J., Poškas R., Šimonis V. Radiological characterization of the Unit 1 at Ignalina NPP: historical assessment of the radiological situation // Int. conf. on lessons learned from the decommissioning of nuclear facilities and the safe termination of nuclear activities, Athens, Greece, December 11-15, 2006. Athens, 2006, p. 159-164.
- Reihan A., Koltsova T., Kriaučiūnienė J., Meilutytė-Barauskienė D. Changes in river runoff in Baltic states in 20th century // XXIV Nordic hydrological conference: Nordic water 2006, NHP Report No. 49, Vinsted, Denmark, August 6-9, 2006. Denmark: PrinfoDjurs, 2006. ISBN 87-87656-11-6, p. 601-608.
- Rimkevičius S., Ušpuras E. Experimental results of pebble beds thermal hydraulic characteristics // Proceedings of the 2006 international congress on advances in nuclear power plants: ICAPP'06, Reno, NV USA, June 4-8, 2006. USA, 2006, p. 125-130.
- Rimkevičius S., Ušpuras E. Experimental results of heat transfer distribution in the peble beds // 13th international heat transfer conference, Sydney, Australia, August 13-18,

2006. USA: Begell House Inc, 2006. ISBN 1-56700-226-9, p.1-10.

- Simaitytė Volskienė J., Augutis J., Ušpuras E. Ignalina NPP Unit 2 gas probabilistic evaluation // Proceedings of the ICONE 14, Miami, Florida, USA, July 17-20, 2006. USA: ASME, 2006. ISBN 0-7918-3783-1, p. 1-4.
- 157. Šeporaitis M., Gasiūnas S., Pabarčius R. Investigation of stratified wavy two-phase flow characteristics // 13th international heat transfer conference, Sydney, Australia, August 13-18, 2006. USA: Begell House Inc, 2006. ISBN 1-56700-226-9, p. 1-11.
- 158. Šlančiauskas A. Combustion rearrangement in boilers for lower capacity and less emissions at the abrupt change of countries economy // Proceedings of the 7th European conference on industrial furnaces and boilers, Porto, Portugal, April 18-21, 2006. Portugal, 2006. ISBN 972-99309-1-0, p. 1-8.
- Štreimikienė D., Širvys P. Corporate social responsibility in Lithuanian energy sector // Customer relationship management '06" (CRM 2006): the international scientific conference, Lazne Bohdaneč, Czech Republic, November 7-8, 2006. University of Pardubice, 2006. ISBN 80-7194-909-4, p. 230-235.
- Tarvydas D., Gatautis R. LNG VS. Russian piped gas in the Baltic States: can we afford the energy security? // Securing energy in insecure times: 29th IAEE int. conf., Potsdam, Germany, June 7-10, 2006. Cleveland, OH: International Association for Energy Economics, 2006. ISSN 1559-792X, p. 449-450.
- 161. Топкоподіј Ј. Анализ динамической погрешности турбинных счетчиков // Коммерческий учет энергоносителей: материалы 23-й международной научно-практической конференции, Санкт-Петербург, 23-25 мая 2006. Санкт-Петербург, 2006. ISBN 5-7187-0677-8, р. 148-153.
- 162. Tonkonogij J., Stankevičius A., Krukovskij P. Обобщенный анализ переходных процессов в турбинных счетчиках газа // Коммерческий учет энергоносителей: материалы 23й международной научно-практической конференции, Санкт-Петербург, 23-25 мая 2006. Санкт-Петербург, 2006. ISBN 5-7187-0677-8, р. 144-147.
- 163. Urbonavičius E., Kaliatka A., Rimkevičius S. Specific of loss of long-term core cooling accident in RBMK-1500 // Proceedings of the 6th int. conf. on nuclear option in countries with small and medium electricity grids, Dubrovnik, Croatia, 21-25 May, 2005. Croatia: Croatian nuclear society, 2006. ISBN 953-96132-9-9, S6-19-1-S6-19-11.
- 164. Urbonavičius E., Ušpuras E., Rimkevičius S., Kaliatka A. Application of RELAP/SCDAPSIM and COCOSYS codes for severe accident analysis in RBMK-1500 reactor // Proceedings of the international congress on advances in nuclear power plants: ICAPP'06, Reno, NV USA, June 4-8, 2006. USA, 2006, p. 1442-1450.
- 165. Ušpuras E., Urbonas R., Kaliatka A. Modelling of processes with disbalance of heat generation and heat sink in RBMK-1500 reactor // 13th international heat transfer conference, Sydney, Australia, August 13-18, 2006. USA: Begell House Inc, 2006. ISBN 1-56700-226-9, p.1-11.
- 166. Ušpuras E., Urbonavičius E., Kaliatka A. The specifics of RBMK core cooling at overheated conditions // Proceedings of the ICONE 14, Miami, Florida, USA, July 17-20, 2006. USA: ASME, 2006. ISBN 0-7918-3783-1, p. 1-9.
- 167. Vaidelienė A., Kadiša S., Glemžienė R. Estimation of power

potential for dams envisaged for small hydro electrical power // Proceedings of the union of scientists Rousse 3 conference energy efficiency and agricultural engineering EE&AE'2006. Association of agricultural engineering in southeastern Europe, Rousse, Bulgaria, June 7-9, 2006. Bulgaria, 2006. ISSN 1311-9974, p. 129-134.

- Valatkevičius P., Marcinauskas L., Valinčius V. Surface modification of steel alloys by nitrogen-hydrogen plasma // Plasma physics and plasma technology: V int. conf. (PPPT-5), Minsk, Belarus, September 18-22, 2006. Minsk, 2006. Vol. II, ISBN 5-84389-069-4, p. 471-474.
- 169. Varga M., Bangens L., Cavelius R., Isaksson C., Laia C., Leutgob K., Lopes C., Martinez Davison J., Nicol J., Pagliano L., Perednis E., Read G., Zangheri P. KeepCool: Promoting the market penetration of sustainable summer comfort // Technologies & sustainable policies for a radical decrease of the energy consumption in buildings EPIC 2006 AIVC: the 4th European conference on energy performance & indoor climate in buildings, Lyon, France, November 20-22, 2006. Lyon: Varga Marton, 2006. ISBN 2-86834-122-5, p. 1-11.

Papers in Lithuanian conferences' proceedings

- Adomavičius A., Kaliatka A., Ognerubov V. RBMK-1500 šilumą išskiriančių elementų sandarumo projektinių avarijų metu analizė // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 101-106.
- 171. Andruškevičius R., Bielinskis F., Klementavičius A. Kauno miesto 110-35 KV elektros tinklų plėtros gairės // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p 347-352.
- Babilas E., Urbonavičius E., Rimkevičius S. Simulation of containment hydrogen control system at Ignalina NPP // The reports of the XVIII international youth nuclear symposium: DYSNAI-2005, Visaginas, Lithuania, 2-9 July, 2005. Visaginas, 2006, p. 26-39.
- 173. Barnackas I., Milčius D., Lelis M., Wirth E. Hydriding behavior of nanocrystalline Mg₂Ni films // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 192-197.
- 174. Bertašienė A. Lazerinio doplerio anemometro praktinio taikymo tyrimai // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- 175. Brazauskaitė A. Radionuklidų sklaidos iš giluminio panaudoto branduolinio kuro kapinyno kristalinėse uolienose pažeisto laidojimo konteinerio scenarijaus atveju vertinimas // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92, p. 133-136.
- 176. Brinkienė K., Čėsnienė J., Matulionienė V. Investigation of the structure and properties of zirconia ceramics prepared from synthesized precursor // Proceedings of 11th int. conf.: Mechanika 2006, Kaunas University of Technology, Lithuania, April 6-7, 2006. Kaunas: Technologija, 2006. ISSN 1822-2951, p. 45-48.
- 177. Burlakovas A. Vėjo energetikos vystymosi perspektyva Lietuvoje // Jaunoji energetika 2006: doktorantų ir jaunųjų

mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-5.

- 178. Gaigalis V., Škėma R. Energijos ir kuro vartojimo Lietuvos pramonėje 2000-2004 m. tendencijos // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 49-52.
- 179. Galinis A., Tarvydas D. Naujos atominės elektrinės konkurencingumas šalies ir užsienio rinkose // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 97-102.
- 180. Gasiūnas S. Tarpfazinio paviršiaus trinties įtakos greičių laukui dvifazėje nesikondensuojančioje tėkmėje tyrimas // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-5.
- 181. Gatautis R. Suskystintos gamtinės dujos pasaulyje ir Lietuvoje // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-7.
- Iljinas A., Milčius D., Dudonis J. Deposition of amorphous Fe-Zr alloys by magnetron co-sputtering // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 166-169.
- 183. Jusevičiūtė A. RBMK-1500 kuro elementuose vykstančių procesų modeliavimas // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-5.
- 184. Jusevičiūtė A. Erbio priemaišų įtaka RBMK-1500 branduolinio kuro savybėms // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 119-122.
- 185. Katinas V. Atsinaujinančių energijos išteklių vartojimas energijos gamybai ir plėtros galimybės Lietuvoje // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 27-30.
- 186. Kavaliauskas A., Jensen A.D., Katinas V. No emissions during the combustion of straw in a packed bed furnace // Development of agricultural technologies and technical means in ecological and energetic aspect: 11th int. conf., Institute of agricultural engineering LUA, Raudondvaris, Lithuania, September 14-15, 2006. Raudondvaris: Milga, 2006. ISSN 1822-2706, p. 257-261.
- 187. Kilda R. Radionuklidų sklaidos iš planuojamo paviršinio radioaktyviųjų atliekų kapinyno Galilaukės aikštelėje vertinimas // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 127-132.
- 188. Klementavičius A., Savickas J. Trečiosios energijos rinkos kūrimas Lietuvoje ir ES // Technologijų mokslo srities specialistų kompetencija žinių ekonomikos kontekste: tarptautinė mokslinės-praktinės konferencija, Kaunas, 2006 gegužės 5. Kauno technikos kolegija, 2006. ISBN 9955-572-33-7, p. 69-77.

- 189. Klementavičius A., Savickas J. Energijos rinkos indikatorių formavimo ypatumai // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 61-66.
- 190. Konstantinavičiūtė I., Tarvydas D. Įgyvendintų elektros energijos kilmės identifikavimo sistemų analizė // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4-5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 301-306.
- 191. Krakauskas M., Bobinaitė V. Rizikos valdymas išplečiant Lietuvos elektros energijos prekybą į Skandinavijos rinkas // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 109-114.
- Kugelevičius J. Lietuvos magistralinių dujotiekių modeliavimas // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- 193. Laukaitis G., Dudonis J., Milčius D. Formation of ceria oxide thin films by electron beam deposition // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 178-181.
- 194. Marcinauskas L., Grigonis A., Valinčius V., Valatkevičius P. Influence of the hydrogen and plasma forming gases on the carbon coatings deposited from saturated and unsaturated hydrocarbons // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 233-235.
- 195. Marcinauskas K., Korsakienė I. VĮ Palangos vaikų reabilitacijos sanatorijos "Palangos gintaras" šilumos ūkio eksploatacijos 1997-2005 m. ekspertinis įvertinimas ir planuojamos rekonstrukcijos // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 285-292.
- 196. Marcinauskas L. Plazmos srauto parametrų įtaka modifikuojant medžiagų paviršius // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 191-194.
- 197. Marčiukaitis M. Vėjo elektrinių galios prognozavimas // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-5.
- Marčiukaitis M., Kavaliauskas A. Vėjo energijos prognozavimas // Technologijos mokslo darbai Vakarų Lietuvoje V. Klaipėda: Klaipėdos universiteto leidykla, 2006. ISSN 1822-4652, p. 273-278.
- 199. Marčiukaitis M., Kavaliauskas A., Katinas V. Vėjo energetikos naudojimas ir prognozavimo poreikis Lietuvoje // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 35-38.
- 200. Marčiukaitis M., Vaitiekūnas P., Cherniy D., Katinas V. Influence of the angle of attack on the flow over the wind turbine blade's airfoil // Development of agricultural technologies and technical means in ecological and energetic aspects: 11th int. conf., Institute of agricultural engineering LUA,

Raudondvaris, Lithuania, September 14-15, 2006. Raudondvaris: Milga, 2006. ISSN 1822-2706, p. 282-286.

- 201. Marčiukaitis M., Vaitiekūnas P., Katinas V. Oro srauto atakos kampo įtaka vėjo jėgainės vėjaračio sparno profilio aptekėjimui // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 39-44.
- 202. Markevičius A., Burlakovas A., Kavaliauskas A. Europos komisijos EIE programos projektas "Akredituoti šildymo sistemų, naudojančių AEŠ, montuotojų mokymo kursai (EARTH)" // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 45-48.
- Masaitis S., Strazdas D. Ekonominių šilumos transportavimo sąnaudų priklausomybė nuo šilumos tinklų apkrovos ir konfigūracijos // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 293-298.
- 204. Matuzas V. Daugiakomponenčių sistemų patikimumo vertinimas atsižvelgiant į elementų senėjimo įtaką // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- Matuzienė V. Energetikos ūkio raidos sisteminė analizė imitacinio modelio pagalba // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- Matuzienė V., Tamonis M. Energetikos ūkio raidos sisteminė analizė // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 299-302.
- Meilutytė-Barauskienė D. Lietuvos upių potvynių trendų analizė // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- 208. Mikalauskienė A. Rodiklių sistema ES direktyvų, skirtų energijos efektyvumo didinimo, atsinaujinančių energijos išteklių skatinimui bei klimato kaitos švelninimui, įgyvendinimo monitoringui // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- 209. Miškinis V., Konstantinavičiūtė I., Deksnys R. Elektros energijos poreikių ir galių balanso prognozė // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 76-80.
- Miškinis V., Konstantinavičiūtė I., Deksnys R. Forecast of electricity demand and power balance in Lithuania // Electrical and control technologies-2006: proceedings of int. conf., Kaunas University of Technology, May 4, 5, 2006. Kaunas: Techologija, 2006. ISSN 1822-5934, p. 52-56.
- Narkūnas E. Radionuclides inventory modeling in RBMK-1500 spent fuel assembly // The reports of the XVIII international youth nuclear symposium: DYSNAI-2005, Visaginas, Lithuania, 2-9 July, 2005. Visaginas, 2006, p. 61-74.
- Narkūnas E., Šmaižys A. Preliminarus branduolinio reaktoriaus RBMK-1500 atraminių ir apsauginių plokščių neutro-

ninės aktyvacijos skaitinis vertinimas // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 115-118.

- Narkūnas E., Šmaižys A., Poškas P. Modelling of neutron activation processes in the RBMK-1500 reactor metal structures // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas, 2006. ISSN 1822-508X, p.265-268.
- Navickas E., Milčius D., Laukaitis G. Chromium oxide thin films synthesis // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 236-239.
- 215. **Nemura A., Klementavičius A.** Multiple-criterion analysis of communication variants of information system of wind power park // Electrical and control technologies ECT 2006: proceedings of int. conf., Kaunas, Lithuania, May 4-5, 2006. Kaunas: Technologija, 2006, p. 21-25.
- 216. Nemura A., Klementavičius A., Vaičiukynas E. Vėjo elektrinių parko informacinės sistemos komunikacinių variantų daugiakriterinė analizė // Tarptautinės konferencijos elektros ir valdymo technologijos-2006: pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 44-49.
- Norvaiša E., Staniulis R. Analysis of Scandinavian and Polish electricity markets and electricity prices // Electrical and control technologies - 2006: proceedings of int. conf., Kaunas University of Technology, May 4-5, 2006. Kaunas: Technologija 2006. ISSN 1822-5934, p. 57-62.
- Norvaiša E., Staniulis R. Skandinavijos ir Lenkijos elektros rinkų bei elektros kainų analizė // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 91-96.
- 219. Perednis E. Kačerginės vaikų sanatorijos renovuoto šiluminio ūkio monitoringas // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 91-94.
- Poškas P. Mišrios konvekcijos tyrimai kanaluose Lietuvos energetikos institute // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 145-150.
- 221. Pranevičius L.L., Bobrovaitė B., Lelis M. The distribution of redeposited carbon atoms in tunsten film under ion irradiation // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 186-191.
- 222. Purlys R., Norgėla Z., Baltušnikas A., Atkočius V., Gricienė B., Urbonavičienė A., Leščiauskas V., Žiliukas Influence of the characteristic part of Ka spectrum on he soft X-ray radiation dose // Radiation interaction with material and its use in technologies 2006: int. conf., Kaunas University of Technology, September 28-30, 2006. Kaunas: Technologija, 2006. ISSN 1822-508X, p. 82-84.
- Račkauskas S. Anglinių nanostruktūrų sintezė ir vertikalus orientavimas naudojant cheminį garų nusodinimą // Jaunoji

energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.

- 224. Račkauskas S. Anglinių nanostruktūrų sintezė iš organinio kuro skaidymo produktų // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 223-226.
- 225. Savickas J. Biokuro naudojimo plėtros ypatumai Lietuvoje // Technologijų mokslo srities specialistų kompetencija žinių ekonomikos kontekte: tarptautinė mokslinė praktinė konferencija, Kaunas, 2006 gegužės 5. ISBN 9955-572-33-7, p. 50-55.
- Savickas J., Kadiša S. Mažosios hidroenergetikos plėtros resursai // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 53-56.
- 227. Savickas J., Michnenko E. The way of development of biofuels market in Eastern European countries // Development of agricultural technologies and technical means in ecological and energetic aspects: 11th int. conf., Institute of agricultural engineering LUA, Raudondvaris, Lithuania, September 14-15, 2006. Raudondvaris: Milga, 2006. ISSN 1822-2706, p. 195-199.
- 228. Savickas J., Savickas U. Atsinaujinančių energijos šaltinių mokslinės tiriamosios veiklos ir praktinių priemonių finansavimas. Kas laimi? // Technologijų mokslo srities specialistų kompetencija žinių ekonomikos kontekste: tarptautinė mokslinė-praktinė konferencija, Kaunas, 2006 gegužės 5. Kauno technikos kolegija, 2006. ISBN 9955-572-33-7, p. 45-49.
- 229. Shipkovs P., Kashkarova G., **Vrubliauskas S., Perednis E.** Wood fuel consumption for energy production in Latvia and Lithuania // Development of agricultural technologies and technical means in ecological and energetic aspects: 11th int. conf., Institute of agricultural engineering LUA, Raudondvaris, Lithuania, September 14-15, 2006. Raudondvaris: Milga, 2006. ISSN 1822-2706, p. 206-210.
- Simaitytė J. Pavasarinio potvynio valdymo problemos KHE // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p.1-6.
- Striūgas N. Biodyzelino gamyboje gaunamo glicerolio frakcijos skaidymas vandenilio atskyrimui //Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-6.
- 232. Štreimikienė D., Mikalauskienė A. Anglies rinkos ES analizė // Tarptautinės konferencijos elektros ir valdymo technologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4-5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 115-120.
- Štreimikienė D., Mikalauskienė A. Rodiklių sistema ES direktyvų įgyvendinimo monitoringui, skirtų energijos efektyvumo didinimo, atsinaujinančių energijos išteklių skatinimui bei klimato kaitos švelninimui // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-15.
- 234. Tarvydas D., Galinis A. Generuojančių šaltinių turinčių tikimybinį pobūdį vertinimas tiesinio programavimo modeliuose // Tarptautinės konferencijos elektros ir valdymo tech-

nologijos-2006 pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 313-318.

- 235. Tarvydas D., Gatautis R. Suskystintų gamtinių dujų bumas pasaulyje. O Lietuvoje? // Tarptautinės konferencijos elektros ir valdymo technologijos-2006: pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 307-312.
- Tarvydas D., Gatautis R. Suskystintos gamtinės dujos pasaulyje ir Lietuvoje // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas; LEI, 2006. ISBN 9986-492-91-2, p. 1-11.
- 237. Tarvydas D., Norvaiša E., Gatautis R., Galinis A. Baltijos šalių apsirūpinimas elektros energija ilgalaikėje perspektyvoje, įvertinant energijos tiekimo patikimumą // Tarptautinės konferencijos elektros ir valdymo technologijos: pranešimų medžiaga, Kauno technologijos universitetas, 2006 gegužės 4, 5. Kaunas: Technologija, 2006. ISBN 9955-25-054-2, p. 103-108.
- Tonkonogij J. Nestacionarių hidromechaninių procesų apibendrinta analizė // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 227-230.
- Tonkonogij J., Stankevičius A. Pereinamųjų procesų turbininiuose dujų skaitikliuose tyrimas // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 231-234.
- Vaišnoras M. Hidraulinio smūgio RBMK-1500 reaktoriaus pagrindiniame cirkuliacijos kontūre analizė // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-5.
- Valinčius M. Staigios kondensacijos modeliavimas RELAP5/ MOD3. 3 programų paketu // Jaunoji energetika 2006: doktorantų ir jaunųjų mokslininkų kasmetinė konferencija, Kaunas, LEI, 2006 birželio 8. Kaunas: LEI, 2006. ISBN 9986-492-91-2, p. 1-7.
- 242. Valinčius M., Šeporaitis M. Kondensacijos pliūpsnio modeliavimas RELAP5 programų paketu bei rezultatų neapibrėžtumo ir jautrumo analizė // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 219-222.
- 243. Valinčiūtė V. Kenksmingų medžiagų ir atliekų neutralizavimas plazmocheminiame reaktoriuje // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 187-190.
- Vrubliauskas S. Kietojo biokuro vartojimas Skandinavijos šalyse ir Lietuvoje // Šilumos energetika ir technologijos: konferencijos pranešimų medžiaga, Kauno technologijos universitetas, 2006 vasario 2, 3. Kaunas: LEI, 2006. ISBN 9986-492-92-0, p. 31-34.
- 245. Vrubliauskas S., Dzenajavičienė E.F. Energy assessment for forests, agriculture and municipal biomass // Gis-based methods for biomass modeling at regional level in the Baltic countries: conference proceedings, Lithuanian university of agriculture, Akademija, Kaunas r., May 18-19, 2006. Kaunas, 2006. ISBN 9955-448-49-0, p. 43-50.
- 246. Žutautaitė I., Augutis J., Simaitytė-Volskienė J. Estimation

of parameters in ageing model using Bayesian approach // The reports of the international XVIII youth nuclear symposium : DYSNAI-2005, Visaginas, Lithuania, 2-9 July, 2005. Visaginas, 2006, p. 86-93.

Articles of science popularisation

- Bubnienė R., Rimkus E., Štreimikienė D. Klimato kaitos politikos pagrindai // Vilnius: Aplinkos apsaugos politikos centras, 2006, p. 6-44. ISBN 9955-9711-4-2.
- Gailiušis B. Tasks of hydrology practice // Aplinkos tyrimai, inžinerija ir vadyba. ISSN 1392-1649. 2006. Nr. 3, p. 3-4.
- Katinas V., Markevičius A., Burlakovas A. Vėjo energetikos perspektyvos Lietuvoje // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr. 12, p. 10-11.
- Lisauskas A., Kveselis V., Strazdas D. Regioninių atliekų tvarkymo sistemų kūrimas: atliekų panaudojimas energijos gamybai // Šiluminė technika. ISSN 1392-4346. 2006. Nr. 4, p. 17-19.
- 251. **Milčius D.** Vandenilio saugojimas // Mokslas ir gyvenimas. ISSN 0134-3084.2006. Nr. 7-8, p. 4-5, 41.
- Milčius D., Stankutė A. Paraiška ateičiai Lietuvos nacionalinė vandenilio ir kuro elementų technologinė platforma // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr. 12, p. 6-7.
- Perednis E. Pastatų subalansuotas vėsinimas // Šiluminė technika. ISSN 1392-4346. 2006. Nr. 3, p. 18-19.
- Perednis E. Ne tik žiemą reikia taupyti energiją komfortui patalpose užtikrinti // Nauja statyba. ISSN 1648-4274. 2006. Nr. 4, p. 68-69.
- Punys P., Ruplys B., Jablonskis J. Užtvenktos upės: nauda ar netektys // Mokslas ir gyvenimas. ISSN 0134-3084, 2006, Nr.12, p. 14-19.
- 256. Škėma R. Europos efektyvaus apšvietimo programa // Šiluminė technika. ISSN 1392-4346. 2006. Nr. 4, p. 12.
- Štreimikienė D. Išoriniai energijos gamybos kaštai ir jų integravimo į energijos kainą problema // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr. 12, p. 7-9.
- 258. **Ušpuras E.** Sėkmės istorija // Mokslas ir technika. ISSN 0134-3165. 2006. Nr. 10, p. 8-9, 25. Nr. 12, p. 19-21.
- Valinčius V., Valatkevičius P. Kenksmingų medžiagų neutralizavimas aukštatemperatūrėje aplinkoje // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr. 12, p. 12-15.
- Valinčius V., Valatkevičius P. Plazminės technologijos Lietuvos energetikos institute // Mokslas ir technika. ISSN 0134-3165. 2006. Nr. 12, p. 22-24.
- Vilemas J. Lietuvos energetikos strategijos ir politikos raida // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr. 12, p. 2-3, 22-27.
- Vilemas J. Lietuvos energetikos institutui-50 // Mokslas ir technika. ISSN 0134-3165. 2006. Nr. 12, p. 18-19.
- Vilemas J., Augutis J., Alzbutas R. IRIS naujas modernus branduolinis reaktorius pačiu laiku // Mokslas ir gyvenimas. ISSN 0134-3084. 2006. Nr 1, p. 2-3, 22-23.
- Vilemas J., Milčius D. Member update: Lithuania // IEA agreement on the production and utilization of hydrogen. 2005 annual report. Bethesda, USA, 2006, p. 79-81.

Lithuanian Energy Institute in 2006



8 February. General meeting of Lithuanian Engineering Industry Association

9 February. Ms. Johanna RUIGROK, Ambassadress Extraordinary and Plenipotentiary of the Embassy of the Kingdom of the Netherlands





2 March. Commemoration of remembrance of Juozas Burneikis, corresponding member of the Lithuanian Academy of Sciences



7 March. 2005. The Lithuanian State Science prizes awarded to E. Uspuras, A. Kaliatka, J. Augutis, S. Rimkevicius, and K.K.Almenas for cycle of works "Deterministic and probabilistic research, engineering solutions and their implementation by improving safety and reliability of Ignalina NPP (1994-2004)"

30 March. Expanded session organized by the Confederation of Lithuanian Industrialists Engineering committee council "Concerning newly developed national energy strategy"



31 March. Lithuanian Energy Institute and Kaunas Regional Energy Agency organized seminar within the framework of RUSE "Reorientation of urban development towards sustainable energy using financing of structural funds". EC DG-TREN representative S. Furfari participated in the event





11-13 May. In the 4th international exposition "Kaunas 2006" the institute was awarded for the successfully implemented project "Development of technology of nuclear fuel transportation from Ignalina NPP Unit 1 to Unit 2 reactor for fuel reuse" (nomination "Implementation of the best scientific decision, developed in Kaunas, in business")



23-26 May. International exhibition "Balttechnika 2006"





29 May. Juozas Augutis and Povilas Poskas elected members-experts of the Lithuanian Academy of Sciences

30 May. Eugenijus Uspuras, the Director of LEI, elected as corresponding member of the Lithuanian Academy of Sciences

8 June. Conference of young scientists and Ph.D Candidates "Youth Energy 2006" at LEI



14 July. Co-operation agreement signed with Italian Aerospace Research Center (CIRA)



2 October. Seminar on thermonuclear synthesis. Main speaker – Prof. F. Wagner from Max Planck Institute for Plasma Physics -Garching, Germany





15 November. Opening session on EURATOM-LEI association in the field of thermonuclear synthesis energy



1 December. The 90th anniversary of corresponding member of the Lithuanian Academy of Sciences Prof. Mykolas Lasinskas



16 June. The first and only collaboration agreement signed between the Joint Research Centre and Lithuanian science and studies institution. On the left – LEI Director Prof. Dr. Habil. Eugenijus Uspuras, on the right – JRC Director General Mr. Roland Shenkel



6 October. Visit of representatives of A. V. Lykov Heat and Mass Transfer Institute of Belarus National Academy of Sciences, Minsk

Visit of Lithuanian State Science and Studies Foundation Director Dr. S. Rencys to Lithuanian Energy Institute

Solemnly celebrated the 50-year anniversary of Lithuanian Energy Institute





28 December. Farewell to the old year

> 29 December. EU structural funds support project agreement signed with Lithuanian Business Support Agency

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1956 Institute of Energy and Electrotechnics





1967 The first (laboratory) building on the campus of Institute for Physical and Engineering Problems of Energy Research



1972 Administrative building on the institute campus



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2002 LEI campus

