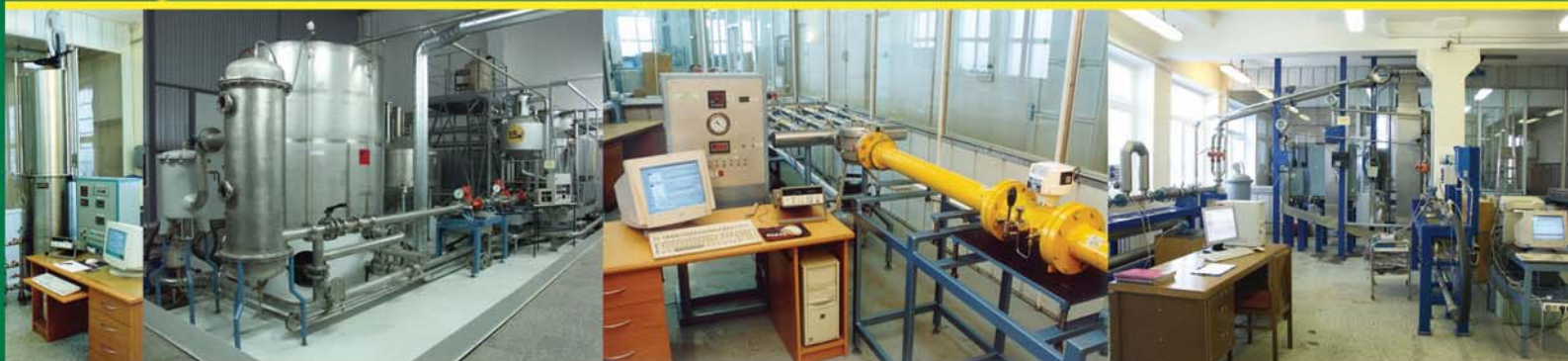




LITHUANIAN ENERGY INSTITUTE



Annual report 2004

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LITHUANIAN ENERGY INSTITUTE IN 2004



Year 2004 was especially meaningful for Lithuania – on May 1 Lithuania became a Member State of the European Union (EU). After joining the EU, Lithuanian Energy Institute, as well as all Lithuanian scientific community, faced with new challenges and objectives since it joined a competitive and enlarged European Research Area. It will have to compete with the most innovative EU science institutions. Lithuanian Energy Institute is seeking to be integrated into this scientific research area in order to be an equal member of European and world science community. Scientists of the Institute are well prepared for dealing with the newly formed objectives and issues.

In 1999 on the increase of scientific research importance in the society it was determined to implement a Quality Assurance System, corresponding to the requirements of ISO 9000 standards. Implementing such a system and having scientists of high qualification and competence, conditions emerged to obtain the licence of Lithuanian State Nuclear Power Safety Inspectorate (VATESI), which enables to perform safety analysis and safety assessments in the field of nuclear energy in the Republic of Lithuania. In 2001 the leadership of the Institute, seeking to improve the quality of performed science projects and supplied services, to guarantee the competence of the Institute, to implement consumers requirements, and consider the demands of the institute employees, decided to develop, implement and certificate the quality control system, corresponding to the ISO 9001:2000 standard. Lithuanian Energy Institute was the first Lithuanian science and studies institution to implement this system. Lithuanian Standardization Department on February 17, 2004 issued a Certificate *Institute's Quality Assurance System*, which corresponds to the requirements of LST EN ISO 9001:2001. The repeated Quality Assurance Audit on December 21 2004 was successful as well.

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 scientific R&D activities.

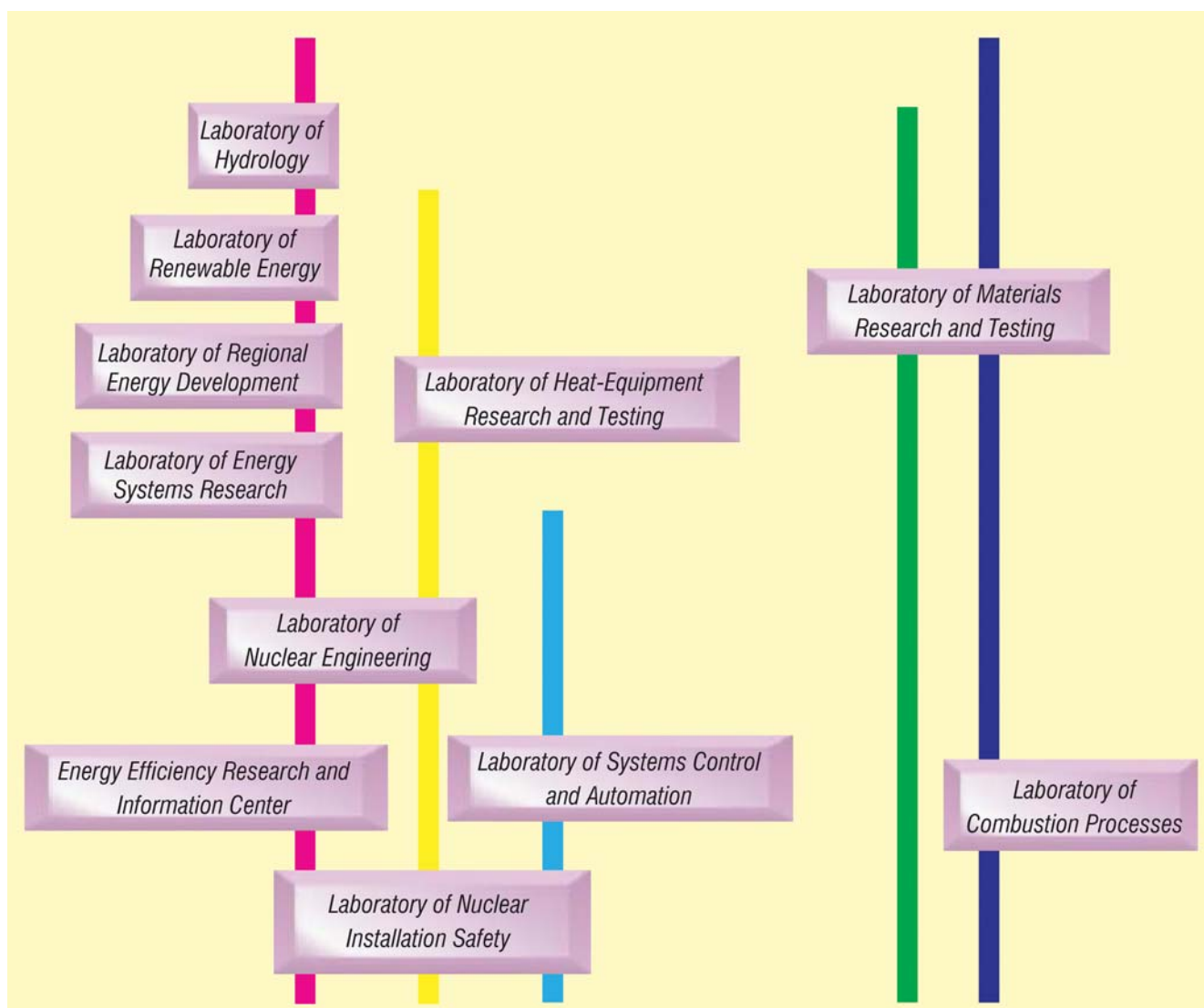
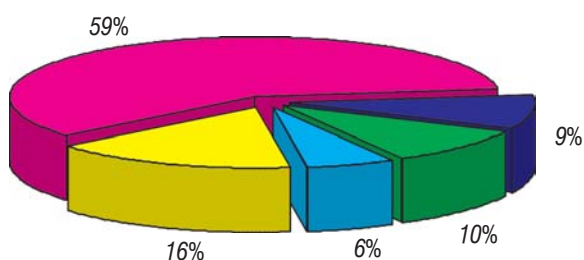
Strategic objective of the Institute is to act as the highest qualification expert in treating issues of science, engineering, metrology, safety of power industry and economics linked to efficient development of the Lithuanian energy sector.



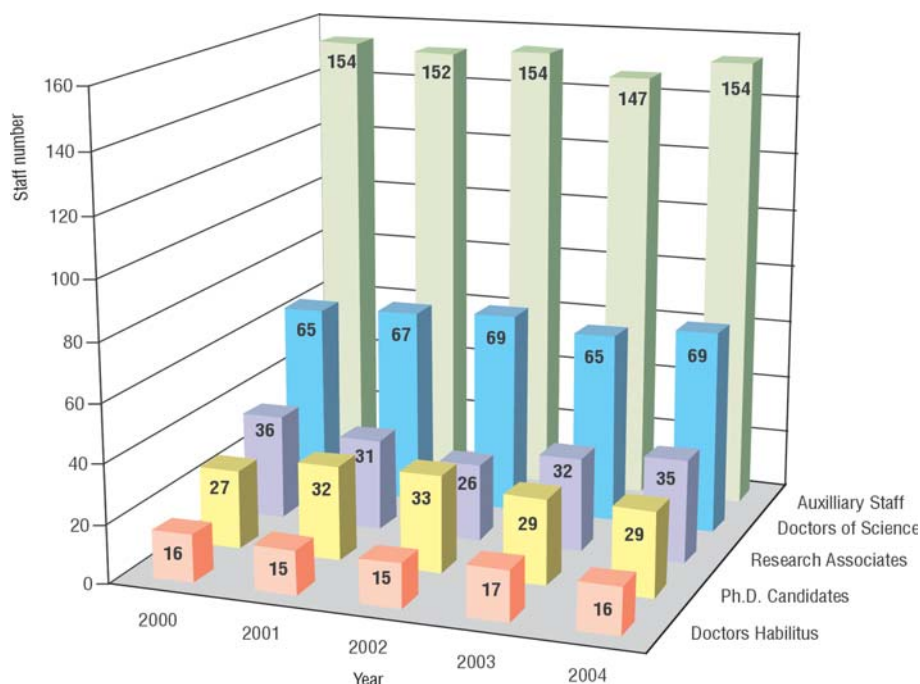
In 2004 scientific activities in the Institute were carried out according to five research directions approved and financed by the Government of the Republic of Lithuania:

- I. *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 to basic research directions



Variation of staff number



For several years the scientists of Lithuanian Energy Institute have been participating actively and successfully in a number of programmes financed by the EU, such as Fifth Framework Programme, COST, EUREKA, PHARE, etc. Recently the Institute has been participating in the Sixth Framework Programme, where the Institute scientists were partners of 25 submitted projects proposals. Six of them received EU financial grants, thus, a success indicator of the submitted projects by the Institute for this programme is rather high – 24%. All Lithuanian science and studies institutions were partners in 811 projects proposals for the Sixth Framework Programme, out of which 155 received funding, thus, their success indicator is 19%. The Institute was one of the most active research institutions according to the Sixth Framework Programme statistics. Scientists of the Institute and partners of the leading European scientific centres will implement projects of the Sixth Framework Programme, devoted to the research of nuclear power plants severe accidents phenomenologies (SARNET), hydrogen energy (NENNET, FET-EEU and HYTRAIN), new and renewable energy sources (CEERES and FET-EEU), social and economical investigations in the field of energy (NEEDS). It should be noted that scientists participated successfully not only in the Sixth Framework Programme but also in other programmes financed by the EU: e.g. in *Intelligence Energy Europe* programme alone scientists of Lithuanian Energy Institute are involved in eight projects.

*Title of the completed project
financed from the state sate budget*

*Direction
of scientific activity*

*Leading
researcher*

Investigation of heat transfer in channels in case of mixed convection under stable and unstable density stratification.

II

prof. P. Poskas

Experimental research of fuel and waste particles' gasification and combustion, and numerical modeling.

V

prof. A. Slanciauskas

Development and justification of macroeconomic methodology of municipalities' energy sector development in regard to formation tasks of the National Energy Strategy.

II

prof. M. Tamonis

Investigation of mini and microgeneration technologies' efficiency and their integration into geothermal energy utilization schemes.

I

dr. F. Zinevicius

Impact of energy equipments' exploitation factors for the degradation of austenitic and pearlite steels and for the structure and properties of zirconium alloy.

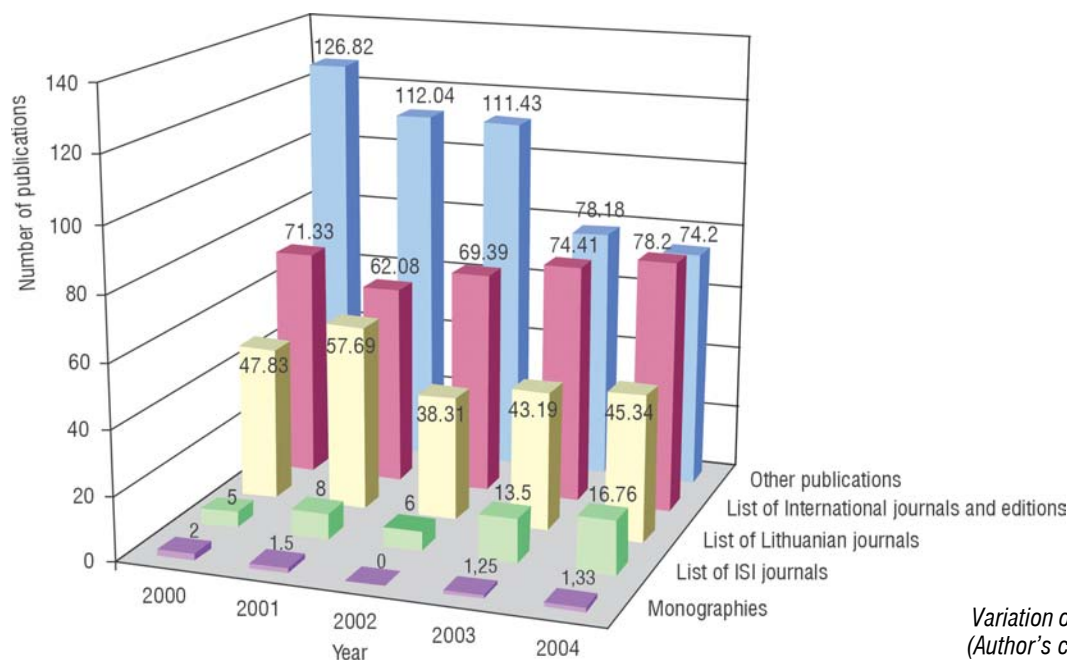
IV

dr. R. Levinskas



Greetings to the newly elected Chairman of the Institute Council Prof. J. Vilemas

Synergy between fundamental scientific research and applied science is necessary in order to achieve good work results. In the World Bank study *Lithuania: Aiming for a Knowledge Economy* (2003, March) it is noted that Lithuanian research institutions give too much attention and financing to the fundamental research, whereas too little attention is given to creating and implementing technologies. At the Institute was developed such fundamental research, which, in cooperation with Lithuanian industry and business organizations, enabled to implement new and competitive technologies and processes. Due to this reason the laboratories of the Institute received a considerable number of applied research projects from the institutions of industry and business. In addition, scientists of the Institute in cooperation with partners participate in implementing “turn-key” projects as well. The benefit is two-fold: there is a possibility for the Institute to get a long-term and larger financing, whereas industry companies and business organizations from the very beginning of the project, when ideas are only being discussed, have a possibility to get a qualified and necessary scientific and technical support in order to avoid mistakes and reduce financial risks. There is a number of examples of this successful cooperation: new operation methods of RBMK-1500, created together with Ignalina NPP and defended by patents of the Republic of Lithuania, the created technology of closed Ignalina NPP Unit 1 nuclear fuel unloading for the final utilization at Unit 2. The technology is to be implemented in 2006. Ignalina NPP will not only save approximately 100 million Litass, which would be necessary for purchasing about 600 nuclear fuel assemblies, but will also reduce significantly the amount of radioactive waste. In cooperation with JSC *Naujas kalcitas* the technology of tyres gasification was created as well.



Variation of publications number
(Author's contribution evaluated)

In 2004 Kaunas University of Technology together with Lithuanian Energy Institute conferred Doctor of Science degree for eight researchers of the Institute:

- on February 24, Regina KALPOKAITE-DICKUVIENE for her power and thermal engineering work **Regularities of Fuel Oil Drop Combustion on the Surface and Factors Determining Combustion of Carbon Derivative**;
- on May 20, Marijus SEPORAITS for his power and thermal engineering work **Investigation of Controlled Condensation Implosion Events in Cylindrical Volume**;
- on June 8, Jelena SAIMARDANOVA for her power and thermal engineering work **Numerical Modelling of Hydrothermal Transfer Processes**;
- on June 9, Robertas ALZBUTAS, for his power and thermal engineering work **Risk Minimization and Reliability Control of Systems in Nuclear Power Plants Considering Data and Modelling Uncertainty**;
- on June 11, Darius STRAZDAS for his power and thermal engineering work **Modelling of District Heating System and Investigation of Efficiency** and Aurimas LISAUSKAS for his power and thermal engineering work **Development Investigation of the Activity of District Heating Companies and Efficiency Assessment**;
- on September 24, Piotras BACHANOVAS for his power and thermal engineering work **Analysis of Efficient Energy Consumption Processes in Industry Applying Computer-Aided Energy Accounting Systems**;
- on October 21, Rita KRIUKIENE for her materials engineering work **Effect of Temperature and Chemical Environment Conditions on Microstructure and Metrological Characteristics of Thermocouple Alloys**.

Year 2004 was successful and productive for Lithuanian Energy Institute. Employees of the Institute performed successfully fundamental research, and implemented many projects together with national and international companies and institutions. They participated actively in submitting projects proposals and implementing projects, financed by the EU. However, in order to be a recognised partner in the European Research Area the Institute must:

- integrate more widely into various European and world science programmes and organizations activities;
- promote and develop the cooperation of the Institute and other EU countries science centres;
- further actively submit proposals for the Sixth Framework Programme;
- prepare for the Seventh Framework Programme;
- implement fundamental research of various science directions and retain the contemporary level of this research;
- develop research projects of applied science significant for Lithuania and the European Union.

Director of the Institute

E. Uspuras

LABORATORY OF RENEWABLE ENERGY

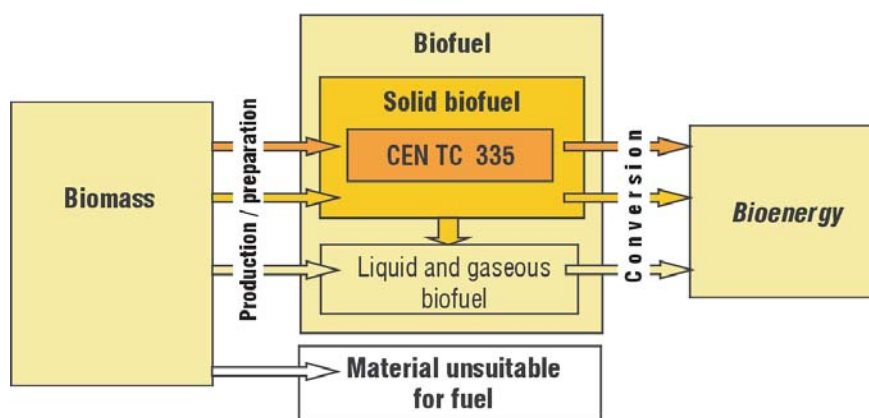
Main directions of the Laboratory research:

- research of solid biomass usage efficiency for energy production;
- research of solid biofuel thermochemical conversion processes;
- research of wind power plants' energy efficiency and operation reliability;
- research of renewable energy sources' (RES) efficient energy usage and environment protection issues;
- application of contemporary technologies using local and RES, technical economical assessment of their usage, preparation of standard documents and projects, formation of data basis, services and consultations for consumers.

In 2004 research, related to RES usage in heat and electricity production was performed at the Laboratory. It is determined that RES in Lithuania comprise approximately 8.2% of the total primary energy balance. Out of these sources electricity production comprises only about 3.2 % from all amount of consumed electricity energy. In order to implement the requirements of the EU Directive 2001/77EC (in 2010 to produce 7% of consumed electricity energy from RES) it is necessary to use various RES types at a larger scale, highlighting wind energy.

Research of solid biomass usage efficiency for energy production in the country. Possibilities of efficiency increase of solid biomass fuel usage for energy production were analysed. Data on biomass sources and their usage in energy sector were accumulated and analysed. All cycle of solid biofuel production and usage, from raw material preparation, its processing, fuel production and its combustion in boilers' furnaces, was analysed. Special attention was given to the issues of fuel quality. Since there are no standards of solid biofuel in Lithuania, Laboratory of Renewable Energy and Laboratory of Heat-Equipment Research and Testing contributed in creating 71st Technical Committee *Solid Biofuel* under Lithuanian Standardization Department. The new Technical Committee will guarantee an operative validation of standards and technical specifications in the country, prepared by the European Committee for Standardization, and will participate actively in preparing new standards.

Research of solid biofuel thermochemical conversion processes. Solid biofuel in Lithuania is widely used in energy sector, usually in heat production. The most prevailing technology is direct, lay-



Activity field of European Standardization Technical Committee "Solid Biofuel"
(biomass - biofuel - bioenergy)

ered combustion in the furnace on the moving grate. In cooperation with Denmark University of Technology, experiments of combustion process in the solid biofuel layer were carried out, using a furnace with non-moving grate. Impact of primary conditions (fuel type, shape of fuel particles, amount of supplied air, its temperature, etc.) on the parameters of combustion process (combustion front velocity, temperature and combustion products CO, CO₂ and NO_x concentrations) was determined. Results enabled to explain mechanism of thermochemical processes in a fuel layer, to optimise combustion process and efficiency, to reduce the amount of emissions, to improve and simplify mathematical models for the modelling of the latter processes.

Research of efficiency of biogas production, utilization and environment protection. In order to reduce the usage of primary energy sources for energy production and environment pollution with hazardous emissions, analytic-applied science work of biogas production from organic waste was carried out. Increasing the efficiency of heat and electricity en-

ergy production and consumption in Lithuania, the analysis of activity results of operating biogas production companies (biogas power plants) was carried out. Technologies used for the moment in the country are not efficient enough, therefore, cooperating with Lithuanian centre of innovations and other non-national organizations, search and assessment work regarding new, more progressive technologies for the utilization of biotechnologies organic waste (at the same time producing heat and electricity energy) were performed.

Research of biofuel production and promotion of utilization. Supporting the liability of Government of the Republic of Lithuania in implementing the requirements of the EU Directive that RES in 2010 in the primary energy balance would comprise no less than 12% and the requirements of the EU Parliament and Council Directive 2003/30/EC regarding biofuels (biodiesel and bioethanol) production, in the Laboratory research project of biofuels production possibilities, promotion expertise assessment of biofuels usage in the country, as well as world practice results, was performed.

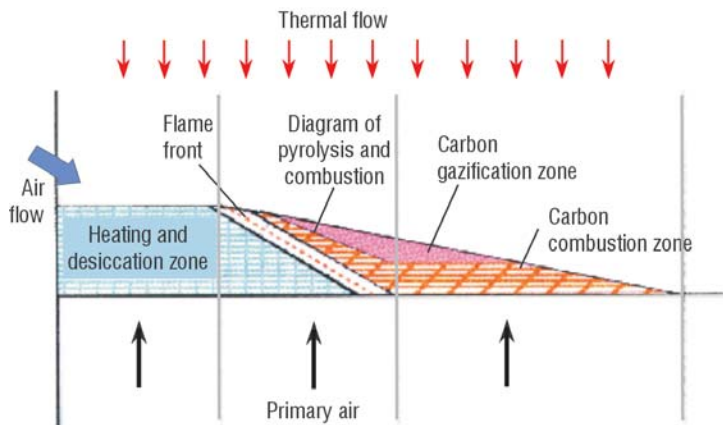


Diagram of fuel combustion on the non-moving grate



The first wind power plant of 600 kW power in Lithuania, equipped by ENERCON GmbH, near Vidmantai, Klaipeda region

Research of energy efficiency and work reliability of wind power plants. Regularities of wind power plants and their elements' crossflow, wind parameters and flow turbulence variation and other factors, having impact on the efficient work of wind power plants and their constructive elements, were analysed with the assistance of modern measurement equipment. Numerical modelling of crossflow of new generation wind power plants' elements was performed by mathematical model of atmospheric boundary layer formation, evaluating the impact of earth surface roughness and other factors. Research was performed by employing PHOENICS 3.5 programme. Wind power plants turbulent crossflow traces' interaction and earth surface relief impact on wind velocity profiles' deformation and power parameters were evaluated.

Zone scheme of wind power plants construction in Lithuania was prepared, power quotas of wind power plants' installation were determined. Wind energy potential, possibilities of connecting to electricity net and environment protection requirements were evaluated. In the zones of wind power plants construction the most suitable territories for developing wind energy were distinguished. These territories were separated according to priority order, in regard to wind energy parameters and conditions of wind power plants connection to transfer/distribution nets. Wind power plants construction territories selection criteria, land area demand and wind energy parameters in separate zones were investigated. Produced energy of wind power plants' was calculated, evaluating local meteorological and relief conditions and payback time. Variation of electricity energy price was analysed.

Research of RES efficient utilization and environment protection. Investigations

International projects and programs, related to RES utilization, were carried out in the Laboratory in 2004:

- *Development of constructive solutions of new generation wind power plants.* Project implemented with science institutions of Ukraine (2002-2004);
- *Enhancement of Local and Renewable Energy Sources Usage.* Cooperation with Danish Energy Management A/S);
- *Regional Bioenergy Initiatives Around Europe.* The project was carried out according to EU ALTENER programme (2003-2006);
- *Pre-normative Project on Solid Biofuel Samples Selection and Testing with the Aim to Create Quality Security Systems (BioNorm).* Project was performed according to EU Fifth Framework Programme (2002-2004);
- *European Network Organizations for the Promotion of Energy Technologies in District Heating Sector OPET CHP/DHC).* Project was performed according to EU Fifth Framework Programme (2003-2004);
- *RES in the EU and Countries-candidates.* Project was performed with the European Council of RES (2004).

of RES usage in agriculture were carried out according to the programme supported by the Lithuanian State Science and Studies Foundation – *Conversion of Solar Energy and its Use.* Calculation methodology of buildings solar passive heating systems was prepared, evaluating changes in heat processes heating systems and possibilities of their regulation during different seasons.

These projects on biomass, wind and solar energy, biogas and other RES and implementation of new technologies were performed in cooperation with EU research centres. Internet web page (www.avei.lt) on renewable and local energy sources and their usage technologies in Lithuania was created together with Danish Energy Agency.

Experts of the Laboratory were included into work groups formed by the

Government of the Republic of Lithuania for the preparation of biofuel production and usage programmes, solving problems of ecological fuel production. The experts also participated in the organized information seminars of the United Nations Small projects programmes.

Research results of 2004 were published in eight articles in science journals and in 11 international conferences proceedings. Laboratory researchers presented seven papers in international and 16 in Lithuanian science conferences. One doctoral thesis was defended.

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ENERGY EFFICIENCY RESEARCH AND INFORMATION CENTER

Main activities of the Center:

- to accumulate, analyze and impact to experts and society the experience of efficient energy consumption in Lithuania and worldwide;
- projects for the realization of National Energy Efficiency Programme;
- participation in international projects, organization of conferences and training courses.

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

- collects, accumulates and analyzes information concerning energy sources, efficient generation of various kinds of energy, energy distribution and consumption, provides information and consults on these subjects;
- investigates utilization possibilities of renewable and waste energy sources and propagates their significance in Lithuanian economy sector;
- executes energy audits in energy enterprises, industrial firms and buildings assists to implement means enhancing 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.

In 2004 the project ***Investigation of Mini and Micro Cogeneration Technologies' Efficiency and their Integration into the Schemes of Geothermal Energy Consumption*** financed from state grant was completed.

In project the types of cogeneration equipment, technical characteristics, legal environment, which has impact on cogeneration development in the EU and Lithuania, were presented. Modelling and selection programme of cogeneration power plants' work was created. Using this programme, possibilities of cogeneration usage in various Lithuanian economy sectors were determined. Possibilities of geothermal energy consumption in Lithuania, including cogeneration integration, were analysed.

Implementing work for the ***Realization of National Energy Efficiency Programme***, series of legal documents for Heat Law was prepared: regulations of heat supply and consumption, methodologies of heat supply to residential buildings, regu-

lations of license for heat supply and other document projects. Regulations' project for energy equipments' new or reconstructed thermal isolation, its construction design and installation was prepared.

The special plans of heat sector of Lazdijai and Veisiejai towns were prepared, where a comprehensive analysis of present situation of heat sector, JSC *Lazdijai heat* activity in 2003, was carried out. In the special heat economy plan of each town, the following designed solutions for the development of heat sector, based on the aspects of legal, technical, economical and environment protection, were presented:

- cases of centralized heat supply networks reconstruction;
- construction of boiler of boiling layer, burning local fuel – turfs, in Lazdijai boiler No 1;
- construction of boiler, burning an alternative biofuel – straw, in Veisiejai boiler No 1;
- RES – cases of usage of soil and soil water heat, soil energy in individual sector buildings.

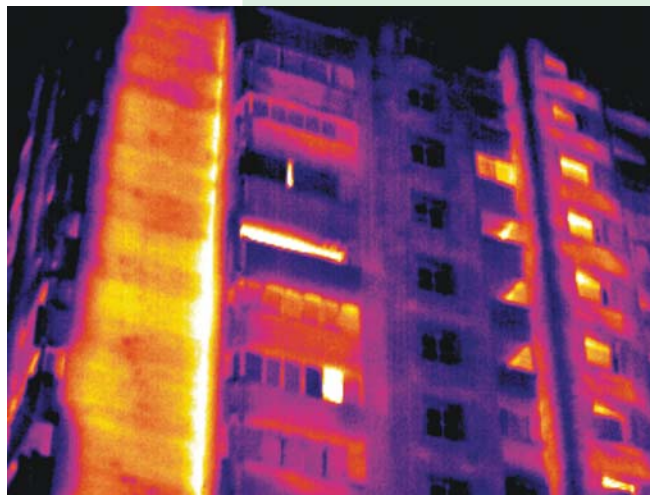
Timetable of 2005-2015 for the implementation of means designed for the improvement of towns heat sector were presented. Maps (M 1:20000) of the special plans of towns heat sector were prepared, where priority zones of centralized heat supply were determined. Regulations of Lazdijai and Veisiejai towns heat supply were prepared as well.

Expertise assessment of boilers' (total 19) activity, operated by Smalininkai higher school of Agriculture, Vabalninkai Agriculture school, JSC *Kalvarijos komunalininkas*, as well as price calculations of their supplied heat, according to the requirements of the National Control Commission for Prices and Energy in Lithuania, were carried out.

Expertise of technical project of food products conversion enterprise's (Mikalin village, Prienai region) boiler reconstruction (vortex combustion furnace of buckwheat shelling was implemented) was carried out.



Energy audit in water supply enterprise



Thermovisual research of apartment building

In 2004 the following international projects were carried out:

- *European Network Organizations for the Promotion of Energy Technologies in District Heating Sector (OPET CHP/DHC)*. The project was carried out according to EU Fifth Framework Programme, together with partners from 38 European countries. In the project the existing situation of centralized district heating sector was evaluated, means, enabling to increase the efficiency of heat production, transmission and distribution, as well as final consumption, were determined;
- *European Network Organizations for the Promotion of Energy Technologies in the Building Sector (OPET Building)*. The project was performed according to EU Fifth Framework Programme together with 36 organizations from 22 European countries. Promotion experience of EU Directives appliance in practice was interchanged, impact of used technologies and promotion of innovative technologies' usage were overviewed, the overview of residential buildings' condition was carried out, application of efficient energy usage means in renovating buildings was evaluated, technical assessment of solar and biomass technologies existing in renovated buildings was presented;
- *Development of Energy Saving Means in Heat Sector, Implementing Modular Energy Production Technologies in Modernized Heat Substations*. The project was carried out together with National Technical University of Charkov. In the project Lithuanian legal acts, regulating construction, modernization and operation of heat substations in apartment buildings, were analysed. Basic technological schemes of heat substations' modernization, heat energy record in apartment buildings in heat substations were presented. Efficiency assessment of heat substations' modernization of two apartment buildings (a five-floor and nine-floor) was carried out. Analogous research was carried out by partners from Ukraine;
- *Third Party Financing in Eastern Europe Centre*. The project was performed according to SAVE II programme together with partners from eight Central and Eastern European countries. In the project financing possibilities of energy saving projects were evaluated, applying the so-called *third party financing* schemes. Projects of legal documents (energy activity contract, supply contract, etc.) necessary for the usage of these schemes in Lithuania, were prepared. Investment project for energy saving in S. Kudirka hospital of Alytus town was prepared as well;
- *European Energy Award – European Certificate and Quality Management System for Municipalities – SAVE II programme project* performed together with partners from four European countries. Kaunas municipality was taken as an example, energy sector quality management system, designed for municipalities, was prepared. Municipality of Kaunas city was granted the European energy award for good results preparing and implementing energy sector quality management system.

Research results of 2004 were published in a collective monograph and seven scientific articles. Six papers were presented at international and five at Lithuanian conferences. Four international seminars were organised with partners from Sweden, Germany and other countries.

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LABORATORY OF HEAT-EQUIPMENT RESEARCH AND TESTING

Main directions of scientific research and applied work of the Laboratory:

- 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 national and international standards;
- test of the thermal equipment and gas appliances carried out with the aim to determine its conformity to the requirements of Lithuanian and European normative documents;
- application of theoretical and experimental methods, relating flow hydrodynamic parameters investigations to metrological parameters of unique standard facilities and working standards and measuring instruments;
- investigation 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.

The Laboratory, performing the authorization of the Government of the Republic of Lithuania, investigates and develops four state standards, comprising of six different standard aerodynamic and hydrodynamic facilities, designed for the reproduction of air velocity from 0.2 up to 30(60) m/s and air volume and flow rate from 0.016 up to 6500 m³/h, water volume and flow rate from 0.01 up to 100 m³/h, liquid oil products (fuel) volume and flow rate from 1 to 120 m³/h unit values and transfer them for working standards.

State standard facilities created in the Laboratory and their basic technical characteristics



Air(gas) velocity units (0.2-60 m/s) state standard

Reference measurement instruments: static Pitot tubes, convergent nozzles and ultrasonic anemometer. The best measurement capabilities of velocity: $\pm (7.0-1.0)\%$, when $v = (0.2-60) \text{ m/s}$



Air(gas) volume and flow rate (Part 2: 5.7-308.8 m³/h) units state standard

Reference measurement instrument: 5 critical nozzles. The best measurement capability of volume: $\pm 0.17\%$



Air(gas) volume and flow rate (Part 1: 0.016-16 m³/h) units state standard

Reference measurement instrument: bell type prover.

Working volume – 0.340 m³.

The best measurement capability of volume: $\pm 0.13\%$

In 2004 facilities designed for reproducing water and small viscosity oil products' volume and flow rate units were completed. In 2005 after preparation of all the required documentation, these units will be presented for the State assessment commission.

In 2004 calibration and measurement capabilities of Laboratory standards were evaluated positively at the international technical committee FLOW of EUROMET organization and were confirmed by heads of BIPM. During the last two years the following international comparisons were carried out: EA FLOW 3, EA FLOW 4, EUROMET No 669, NORDTEST No 1610-02 and EU/EFTA. Completed comparisons showed a good correlation of data.

All these standards created at the Laboratory correspond to the international level, satisfy basic and most significant metrological needs of Lithuanian economy and science.



Air (gas) volume and flow rate (Part 3: 1-6500 m³/h) units state standard

Reference measurement instruments: rotary displacement and turbine gas meters. The best measurement capabilities of volume:

$\pm 0.25\%$, when flow (1-1600) m³/h and $\pm 0.30\%$,

when flow (1600-6500) m³/h



Water volume and flow rate (0.01-100 m³/h) units state standard

Reference measurement instruments: reference scales – 60, 600 and 1500 kg. The best measurement capabilities:

volume $\pm 0.08\%$ and flow rate $\pm 0.12\%$



Oil products' volume and flow rate (1-120 m³/h) units state standard

Reference measurement instruments: reference volume standards 0.5, 2 and 5 m³ and liquid fuel meters.

The best measurement capabilities: volume $\pm 0.12\%$ and flow rate $\pm 0.15\%$



International seminar "New technical and financing possibilities for solid biofuel usage in boiler-houses of small and medium capacities"

In 2004 the Laboratory participated actively in implementing the directives of the European Commission (EC) Council in Lithuania, related to conformity assessment of gas, water and liquid fuel meters, as well as water boilers and gas appliances. New facilities were created for testing meters and subassemblies. The field of meters calibration was extended and accredited. Accreditation scope for testing water boiler and gas appliances was extended, following standards, which implement 92/42/EEC and 90/396/EEC directives. The competence of the Laboratory being confirmed, recently the documents were sent to EC to legitimate the status of the institution according to the directives indicated above.

Issues of efficient burning of renewable energy sources' fuel and pollution reduction remain relevant, therefore, the laboratory proceeds with the research efficiency and pollution of equipment burning wood fuel in order to give consultations and support for the companies that produce these equipments.

The Laboratory under the order (12 22 2003, No: 4-480) of Minister of Economy of the Republic of Lithuania is responsible for the preparation of conformity assessment reports according to the procedure of technical regulation for appliances burning the gaseous fuel.

The most significant projects in the field of scientific investigations are related to the development of state standard facilities, especially in reproducing values of small velocities and flow rates. Much attention is given to the research of energy supply and consumption balances.

Main research results of 2004 are as follows:

- extension of accreditation field for the test of hot water boilers and gas burning appliances;
- researchers of the Laboratory participated in training and qualification courses, organized by the Lithuanian state metrology service with participation of experts from Denmark and Germany as well as National accreditation bureau and Metrology institute of Kaunas University of Technology;
- performance of interlaboratory comparison of rotary displacement gas meter IRM G250 according to EA project FLOW4, provided by COFRAC (France) CESAME;
- performance of comparisons of air humidity measurement with Latvian hydrometeorology agency laboratory.

Laboratory researchers participated in Lithuanian and international conferences; presented two papers in conferences; two articles were published in journal *Measurements*.

Laboratory also created, completed and carried out the tests of two new facilities as the state standards for reproducing water and liquid oil products volume and flow rate units.

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LABORATORY OF NUCLEAR INSTALLATION SAFETY

Main research areas of 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;
- 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 building structures, components, piping and other parts of Main Circulation Circuit;
- fundamental investigations in thermo-physics;
- two-phase flow fundamental investigations;
- single failure analysis and engineering assessment for complex technical systems;
- risk and hazard analysis of industrial sites.

In 2004 researchers of the Laboratory together with Lithuanian and international partners worked on fundamental and applied research projects. These projects were devoted not only to the assessment and development of Ignalina NPP safety, but for the operational reliability assessment of other national industry objects as well.

PROJECTS FUNDED BY THE GOVERNMENT

Fundamental investigations

In the field of thermal physics the study *Investigation of Condensation Implosion Event Initiated by Hydrodynamic Instability* is continued. The objective of this study is related to the use of pressure difference, which occurs during the condensation implosion in the individual parts of thermal circuit to create an energy and mass transport cycle, opposite to a natural circulation. In 2004 the experiments of non-condensing two-component air-water flow were performed, the methodology of further experiments was developed, the results of experimental and numerical investigations were analysed. As a result of this work, it is expected to prepare recommendations for the thermal hydraulic system, where condensation implosion would be employed for energy transfer application in real objects.

In 2004 in the area of energy sector methods development, energy objects' safety and reliability, environmental impact, efficient energy consumption and renewable energy sources investigation two projects were initiated: *Uncertainty Analysis of Technical, Natural and Social System Modelling Results* and *Reliability and Risk Assessment and Control for Energy Objects*. The aim of the first project, which is performed together with LEI Laboratory

of Energy Systems Research, Laboratory of Hydrology, and Information Department, is the expansion of applicability of uncertainty analysis methodology for 2D and 3D equation systems, while solving tasks of technological science, also carrying out numerical investigations in the field of physical (hydrology) and social (energy economy) sciences. Additional programs were developed for SUSA software in 2004. The analysis of simplified models to solve tasks on 1D energy economics, 2D Kaunas sea hydrological regime assessment and 3D neutron-dynamic was performed. The aim of the second work is the assessment of complex energy systems risk and reliability and development of management methods, formation of risks analysis methodology and hazardous processes control optimisation methods. In 2004 developed hazards and risk assessment, as well as analysing methodology, are applied for Ignalina NPP, electricity transfer nets, Kaunas HPP, and other energy objects' reliability, risk and separate components technical sources.

Cooperation with State Nuclear Power Safety Inspectorate (VATESI). Laboratory of Nuclear Installation Safety is one of the technical support organizations, which closely cooperates with VATESI. In

2004 the review activities, related to the documents that are proposed for VATESI, were performed, new regulation documents were prepared. Ignalina NPP documents, related to the assessment of different RBMK-1500 reactor core modifications and to a modification of the present control rods withdrawal from the core during reactor transition into critical state, were analysed. Also the review of a new reactor passport, as well as the independent calculations, based on which the review conclusions concerning expedience and reliability of delivered safety substantiations are stated, were performed.

Projects with research institutions

of Ukraine. Cooperation activities with the Institute of Technical Thermal Physics of the National Academy of Sciences of Ukraine were completed in 2004. Using the best-estimate methodology, recommendations on the improvement of developed Ignalina NPP RBMK-1500 main circulation circuit model, analyses of heat transfer through graphite bricks between adjacent fuel channels and water hammer phenomenon in RBMK reactors cooling circuit were presented. Justification of RELAP5 model to simulate water hammer phenomenon was performed, employing UMSICHT (Germany) test facility data.

A close cooperation with Ignalina NPP and JSC *Lietuvos energija* was continued and a new contract was signed with IKSADA Ltd.

Reuse of Unit 1 fuel in Unit 2 Reactor of Ignalina NPP.

Preparing for a new operational stage, where only one unit being in operation, the works were continued to design, manufacture and delivery to the Ignalina NPP the set of the equipment intended for reusing of Unit 1 fuel in Unit 2 reactor of Ignalina NPP. A Preliminary technical safety justification report was prepared in 2004. All NPP safety issues were investigated in this report – description of the set of equipment, engineering assessment, development of probable accident list, analysis of failures and accidents, etc. All structural integrity, thermal, radiation and nuclear safety calculations for normal operation and accidental conditions were performed. The final technical safety justification report is under preparation. Considering the comments of VATESI independent review and technical decisions, accepted in the design of the equipment. Technical design for container, pilot protective shaft and other new developed equipment was prepared in 2004. Works on manufacturing such equipment were initiated as well. Technical and detailed designs of buildings and auxiliary systems renovation, the implementation of which will ensure a safe and reliable operation of set of equipment for the reuse of fuel, were prepared as well. All works are carried out in the terms according to “*Schedule of Work*”, therefore, there is no doubt that the project will be implemented successfully on time.

The support of Ignalina NPP probabilistic safety analysis.

An information basis, which would allow to develop Ignalina NPP probabilistic safety analysis models, to improve them and perform additional accident localization system analysis, was developed in the completed work in 2004. Existing leakages between compartments up to condensation pools and behind them were assessed, calculated variations of thermal hydraulic parameters, radioactive substances transport in accident localization system compartments, release of these substances into the environment and estimated possible radiation dose for population. The probabilistic analysis on construction of steam distribution devices,

assessing dynamic loadings after design basis accident, was performed.

Preparation of methodology and software on coolant flow profiling.

It is planned to prepare, test, adjust and present to Ignalina NPP a methodology of RBMK-1500 reactor parameters for software on coolant flow profiling (valve positions, activation signals). After processing the accumulated information about coolant flow rates, energy releases, critical heat flux margin, etc., reactor core coolant flow profiling methodology was developed in 2004. Software is to be supplied for the NPP in 2005.

Replacement of flowmeters due to the diagnostic results in Unit 1 and Unit 2.

In 2004 the work, devoted to the determination of flowmeters condition in Unit 1 and Unit 2 of Ignalina, was continued. In every technological channel of RBMK-1500 reactor coolant flowmeters are installed. When the flowmeter fails, the operation of the appropriate technological channel is interrupted until flowmeter's replacement during the next planned shutdown of the reactor. Flowmeter diagnostics is being carried out before annual maintenance in order to avoid failures. Under this project a diagnostic measures results analysis was carried out, and which of the flowmeters had to be replaced in Unit 1 and Unit 2 in order to guarantee a reliable flow measurement until the shutdown (Unit 1) and next planned maintenance (Unit 2) was determined.

The residual gas gap existence probability evaluation in the individual Ignalina NPP reactor cells and gas gap closure prognosis.

In the Laboratory a gas gap closure prognosis model has been developed since 1998, and annually it was renewed with statistical data by estimated justified parameters, etc. In 2004 having new measurements of reactor burn up and graphite bore diameter, the new prognosis of the Unit 1 gas gap closure was estimated for the end of 2004 and for the middle of 2005, and prognosis of the Unit 2 gas gap closure were estimated until 2006 preventive planning maintenance. The results of the

statistical analysis revealed that pressure tube diameter is well determined by linear regression. The results analysis confirmed that developed model, which also uses ABAQUS code, with a high confidence produces prognosis of graphite bore diameter behaviour.

Safety analysis report supplement regarding review comments on LOD technique application.

According to the agreement with Ignalina NPP the Laboratory has prepared Ignalina NPP Unit 2 safety analysis report supplement considering VATESI review comments on using LOD (lines of defence) technique, which is used in the systematized way to reveal safety problems (non-compliances) and categorize them according to the influence on safety. Substantiation of selection of accident scenarios is extended in work, additional scenarios are analysed employing LOD technique, analysis of particular accident scenarios is extended.

Condition of power transmission equipment and reliability assessment of power transmission network.

In 2004 the project with JSC *Lietuvos energija* was continued. Under this project a methodologies and software tool *NETPRAS* for power transmission network reliability assessment, upgrades planning, and estimation of energy not supplied, was developed. In the report working database structures, data import and export procedures from JSC *Lietuvos energija* databases and procedures, designed to connect separate equipment into network structures of software tool *NETPRAS*, are presented.

Safety justification of diverse shutdown system control rods servodrives.

In 2004 a contract with IKSADA Ltd was signed to perform safety justification of Ignalina NPP Unit 2 diverse shutdown system control rods servodrives. The Detailed content of the safety justification report and preliminary safety justification (system description, engineering assessment and accident analysis) was completed in 2004. Final safety justification study is to be completed in 2005.

INTERNATIONAL COOPERATION

In 2004 projects were continued with the international partners (Western and Eastern Europe, USA), new projects signed with other international companies, active participation in science programmes, funded by the international foundations.

EU Sixth Framework Programme

SARNET Network of Excellent. Contract on Network of Excellent for severe accident research and management (SARNET) was signed between European Community and Institut de Radioprotection et de Surete Nucleaire (France) in 2004. 49 European R&D organizations, including LEI, have participated in this project. The main SARNET activities are as follows: integrating activities in severe accidents research to strengthen links between organisations, harmonize and improve methodologies. A lot of attention in SARNET project is given to information exchange, development of integrated scientific database and preparation of severe accidents manuals and handbooks. Duration of SARNET Network of Excellent shall be four years with a possibility to continue it in EU Seventh Framework Programme. In 2004 Laboratory scientists participated in constituent assemblies of separate work groups, training courses for code ASTEC users, also they prepared review reports on LEI experience in the fields of probabilistic safety analysis level 2 and deterministic analysis. Information database on Ignalina NPP reactor and constructions of leak-tight compartments for the development of RBMK-1500 ASTEC model was prepared, numerical investigations have already been started as well.

PHARE projects

Implementation of Diverse Shutdown System at Ignalina NPP Unit 2. It is one of most important projects to improve the safety level of Ignalina NPP. In this successfully completed PHARE LI/TS/15 project (system was implemented at Ignalina NPP in 2004) the Laboratory scientists together with experts from Western countries checked and assessed the design documentation, performed independent calculations, in this way helping VATESI while making certain decisions in regard to the implementation of the above mentioned system. During this project, using Germany GRS mbH company softwares ATHLET and QUABOX/CUBBOX, Ignalina NPP Unit 2 reactor installation models with simulated both independent

reactor shutdown systems, were developed. The results of thermo-hydraulic and neutron-dynamic audit calculations confirmed reliability and validity of the suggested shutdown system. In the summary of the review it is stated, that after the implementation of this diverse shutdown system the safety of Ignalina NPP Unit 2 will be guaranteed.

Assistance Programme to VATESI and its TSOs in Structural Dynamics Analysis. This work was performed according to the project PHARE LI01.18.02 in which four Lithuanian research organisations participated. In Lithuania this project was coordinated by LEI. The review of the requirements, used for the structural dynamics analysis of the buildings in case of external events, was performed. The experiences of Sweden and the United Kingdom in the strength evaluation of nuclear building were reviewed. The events of seismic, aircraft crash and explosion were selected for the analysis. The draft of the requirements for dynamic analysis of structures in buildings of nuclear facility was prepared.

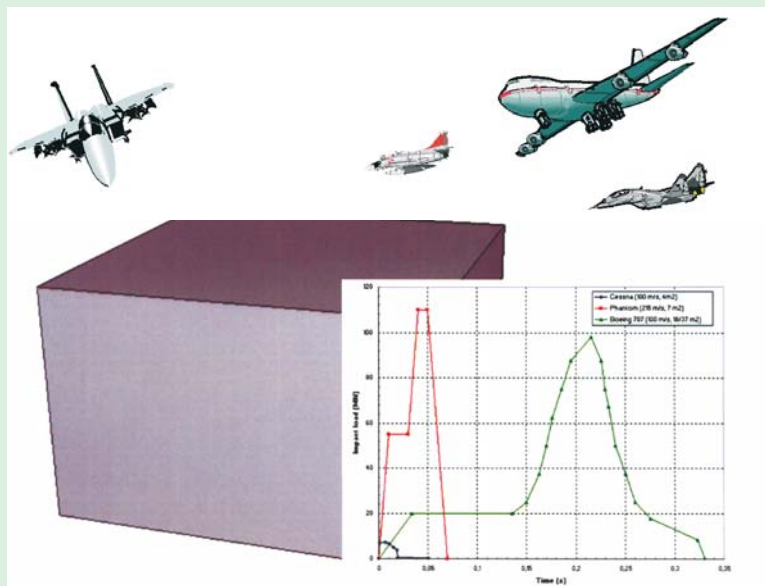
Support to VATESI for important tasks relevant to licensing activities of Ignalina NPP. In 2004 works have been started un-

der the project PHARE LI 0118-03-01-0001. Carrying out this contract, Laboratory scientists have investigated design and severe accidents assessment, as well as management principles and tasks. Four regulation documents were prepared and presented to VATESI. Activities on this contract will proceed in 2005 as well. For this time it is planned to prepare a training course material, related to RBMK severe accident phenomena, severe accidents management, etc.

Projects supported by the USA Department of Energy

Analyses of Ignalina NPP RBMK buildings and structures for external loading conditions. The object of this project is a possibility to perform the analysis of the building in case of external events. Probabilistic analyses were performed to evaluate failure of the Ignalina NPP building due to the crash of aircraft using computer code ProfES in 2004. The probability of failure of an Ignalina NPP building wall, in case airplane crashes, was defined. The thermal degradation of the structural strength of an Ignalina NPP building structure due to thermal loading in case of a fire, caused by burning aviation fuel on the roof, was carried out, using the TEMP-STRESS and NEPTUNE codes.

Structural analysis of Ignalina NPP building due to loading in case of airplane crash



Technical assistance in preparation of regulatory documents for licensing Iqnalina NPP operations. In cooperation

- *Requirement on Risk Assessment and Management;*
- *Probabilistic Safety Assessment Level 1 guide;*
- *Probabilistic Safety Assessment Level 2 guide;*
- *Requirements for operational feedback;*
- *Requirements for human factors evaluation.*

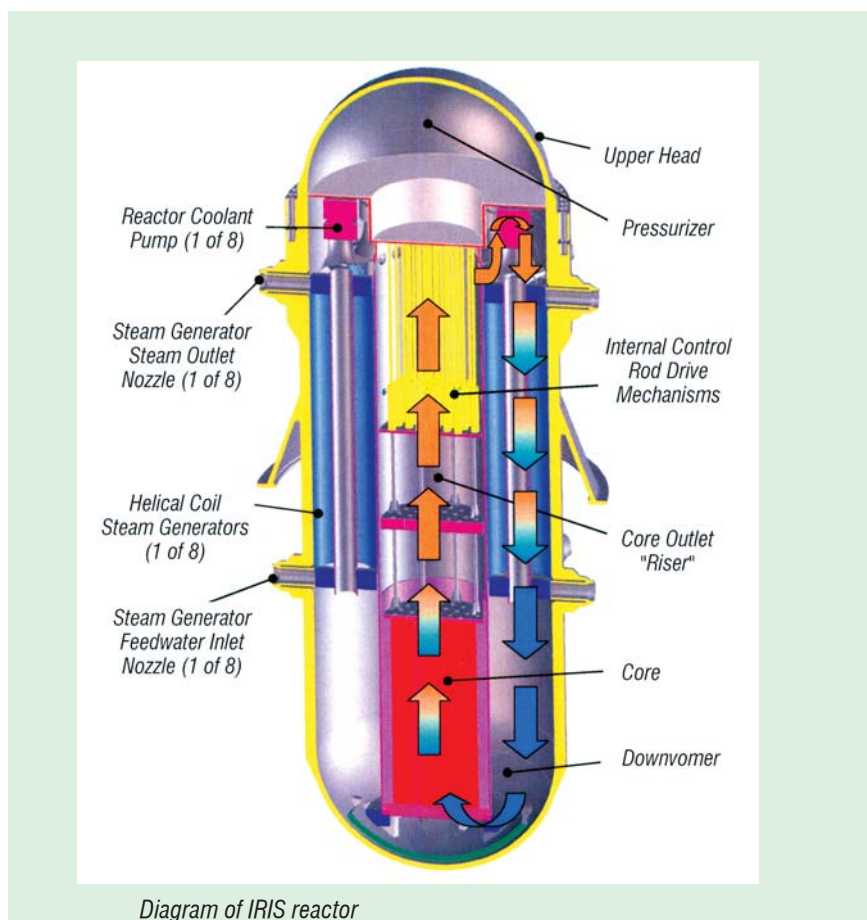
Ignalina NPP. In cooperation with Jacobsen Engineering Ltd (UK) and SCIENTECH (USA) the list of the beyond design basis accidents was developed, the information about the systems, equipment and emergency operating procedures currently valid at Ignalina NPP was collected. The models for simulation of NPP were developed and the analysis of the severe accident processes is close to completion. Based on the received results, the initial list of the strategies for severe accident management was developed, and now it is under discussion with Ignalina NPP. The severe accident management guidelines have been started to be developed. After Ignalina NPP approves these guidelines, the operators and the staff of the technical support centre will be trained to use them.

10-years of cooperation with GRS company was continued in 2004. Under the agreement between LEI and GRS researchers RBMK-1500 models were improved, applying German GRS mbH company's codes ATHLET, QUABOX/CUBBOX, COCOSYS, etc.

Uncertainty and sensitivity analysis using GRS tool SUSa. Uncertainty and sensitivity analysis of QUABOX/CUBBOX calculation results for Ignalina NPP Unit 2, i.e. power reactivity effect and control and protection system cooling circuit void effect was conducted according to GRS meth-

IRIS project. Since 2004 Lithuanian Energy Institute has joined the international project of the development of the most innovative and safe nuclear reactor IRIS (International Reactor Innovative and Secure). Project execution centre is in the Westinghouse Electric Co. LLC (US). Up to

At this moment, together with LEI, universities, institutes, laboratories and companies from ten different countries have joined this project. One of the primary objectives of this project is the essential improvement of the reactor safety. All efforts of project participants were focused on this issue. The finish of IRIS design and preparation for construction is planned for 2012-2015. In 2004 personnel of the Laboratory scientists participated actively in IRIS probabilistic risk assessment group activities related to the preparation of IRIS NPP risk assessment report. On the basis of safety analysis documentation of new reactors and US documents, which regulate NPPs, the estimation criteria and analysis methodology for external events, which are possibly hazardous for IRIS NPP, were improved. The external events, which are hazardous for NPP, were picked out after the preliminary analysis of external events. On the basis of the method for the safety analysis of seismic impact, the software CutSetRA was developed in order to analyse the seismic parameters and rank the probabilistic estimates. Using this software the limiting seismic characteristics were calculated. The risk analysis of separate external events (extreme winds, aircraft crash) was performed and these events' probabilities and consequences for IRIS NPP were estimated.

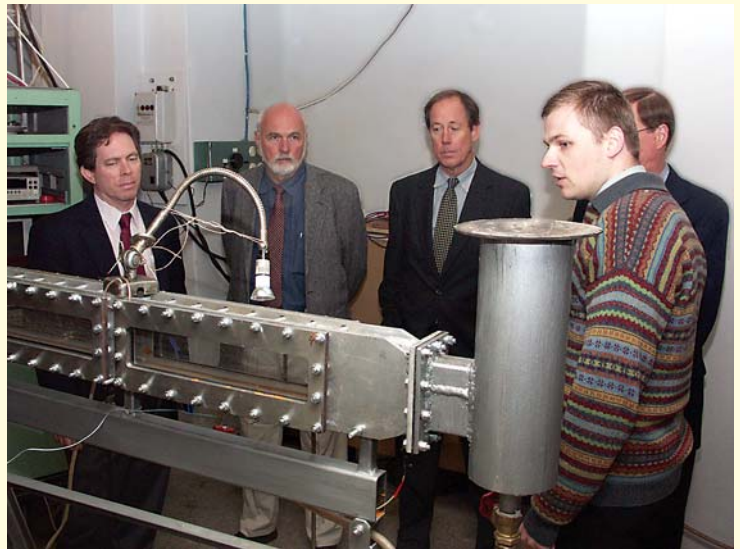


In addition to the abovementioned activities, Laboratory scientists participate in **ENIQ** (European Network on Inspection Qualification) network TGR (Task Group Risk) activities, which is established to develop European approach towards risk informed in service inspections, by integrating the best European practices. An observer type agreement was signed with **RIMAP** (Risk based Inspection and Maintenance Procedures for European industry) thematic network. In 2004 Laboratory scientists were involved in activities of **BEQUAR** (Benchmark Exercise in Quantitative Area Risk Assessment) project. The BEQUAR is coordinated by the European Commission Joint Research Centre Institute for Protection and Security of Citizens. The main objective of BEQUAR is to introduce 10 new EU states with the requirements of Seveso II 96/82/EC directive regarding dangerous industrial installations.

The active participation in the International Standard Problem **ISP-47** continued. This project investigates the problem of the gas mixing in the containments of NPP. This problem is especially important for the analysis of hydrogen distribution and possible hydrogen deflagration in case of severe accident at NPP. The experts of our Laboratory took participation in the Project meeting, which was held in 2004. In the meeting the calculated results were compared with the measured parameters and good agreement between them was observed. Additionally, during the meeting the following steps of the project were discussed and experimental facility THAI was introduced. The experiments performed in this facility are included in the program of ISP-47.

In 2004 two Doctor of Science theses were defended: M. Seporaitis. *Investigation of controlled condensation implosion events in cylindrical volume* and R. Alzbutas. *Risk Minimization and Reliability Control of Systems in Nuclear Power Plants Considering Data and Modelling Uncertainty*.

Investigation results obtained in 2004 can be traced in scientific reports, 52 scientific articles, 47 conference papers. Researchers of the Laboratory participated actively in different programmes, IAEA technical committee and coordinated meetings. The fact that Laboratory researchers are invited as EU Sixth Framework Programme experts-evaluators and participate in nuclear energy specialists meetings of the European countries, speaks of their high qualification.



M. Seporaitis presents to the representatives of USA research institutions an experimental facility for two-phase flow investigation



R. Alzbutas (second from the right) defended with success Doctor of Science thesis

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LABORATORY OF COMBUSTION PROCESSES

Main directions of scientific activities:

- efficiency increase of combustion processes;
- development and creation of combustion equipment and burners;
- utilization-gasification of solid waste;
- technologies of carbon nanotubes;
- numerical modelling of granular mediums.

The main focus of the Laboratory of Combustion Processes was the development of efficient and ecological combustion technologies, their utilization and practical implementation, waste material utilization using gasification process. Research of nanotechnological processes was initiated as well.

In 2004 the Laboratory renewed the Varian GC-3800 chromatograph for analysis of various gas and oxides compositions. Thermal conduction detector, which enables to determine and measure composition and quantity of inorganic gas and light hydrocarbons C_1-C_5 , was implemented. The previous flame ionisation detector and mass spectrometer enabled to determine only the composition of heavier hydrocarbons C_6-C_{32} . Thermal conduction detector will enable to measure hydrogen amount as well, further proceeding with fuel gasification processes research in the technology of hydrogen synthesis.

Utilization-gasification technology of solid waste (tyres). Laboratory of Combustion Processes together with JSC *Naujasis Kalcitas* developed a laboratory facility of used solid waste gasification. The laboratory performs its experiments, determines optimal construction parameters and prepares an experimental project of 3 MW power facility for the rotary combustion furnace. Laboratory gasificator (0.8 m diameter, height of gasification chamber 2.65 m, height of all facility 3.42 m) is already manufactured. Tyres are gasified at temperature 360-800°C under air surplus

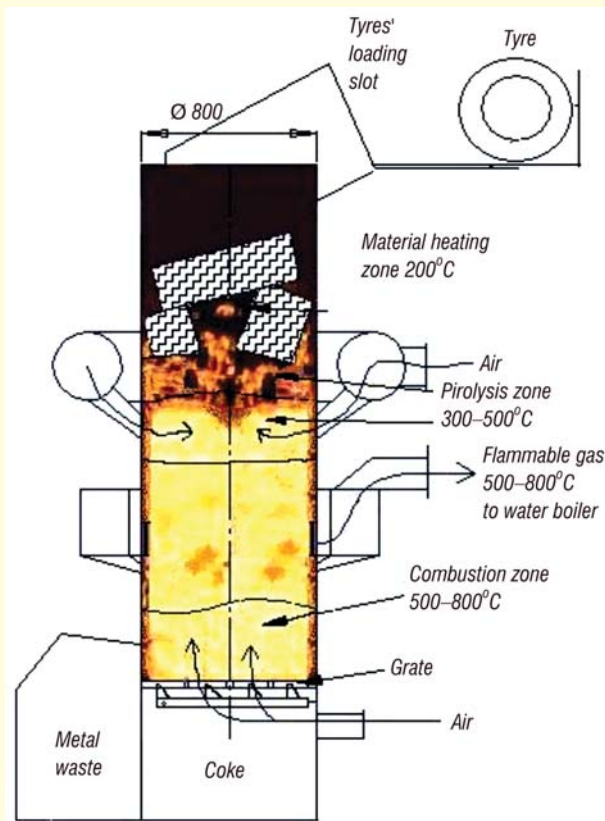
coefficient 0.1-0.4 and tyres' combustion rate 60-200 kg/h.

Work parameters' impact on layer temperature, gas composition and gas amount, as well as gas calorific, tarry, carbon amounts, reactor utility coefficient, was determined. The optimal working regime is reached when air surplus coefficient is 0.24, tyres combustion rate – 135 kg/h. In this case 3.5 MJ/m³ gas was generated, approximately 60% of the obtained heat was transferred to water heating boiler. Working in this regime thermal capacity of all system was 1200 kW (2400 kW/m² of grate area, 900 kW/m³ of reactor volume). Generated gas was comprised of CO, H₂, CH₄, C₂H₆ and heavy hydrocarbons. Their total calorificity was 2-12 MJ/m³. Carbon residue changed from 18 to 30%.

Facility is constructed from 12 mm thickness steel tube, construction is easily modified. Tyres are loaded, the remaining protectors' steel wires and other residues are removed manually. Generated gas is transferred to 2 MW water heating boiler VK-21 and there it is burned.

Research of nanotubes technology.

Nanotubes is a new and promising field of research (research has been initiated in 1992). Using chemical vapour deposition on the simple metal alloy wire during noncomplicated process carbon nanotubes are grown, without employing complicated and expensive technologies. Synthesis of



Setup of tyres' gasification research

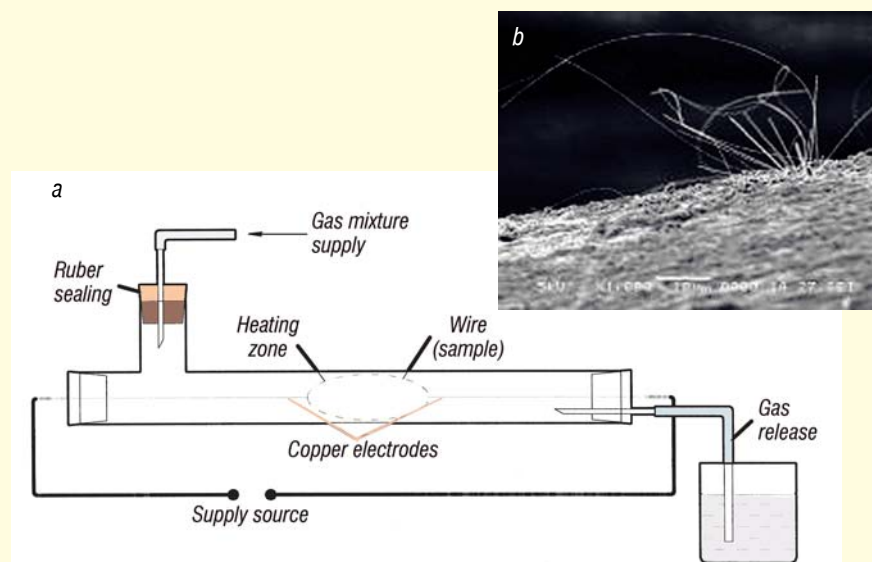


Diagram of nanopipes technology (a) and obtained nanopipes using SEM methodology (b)

nanotubes occurs employing chemical vapour deposition method. Reaction temperature is 800-1100°C. It is heated releasing current through the catalyst itself. Gas mixture, comprising of inert (nitrogen) gas, hydrogen and carbon source – hydrocarbon gas is necessary for the reaction and it is supplied to the reaction chamber. Catalyst particles are formed out of substratum, using oxidation-reduction reactions during which active catalytic particles are formed, necessary for the synthesis of nanotubes. Material used for the research is nichrome, the characteristics of which is active catalytic properties of intermediate metal-nickel and resistance of the material to heat. Implementing these investigations process is optimised, effect of various gas and environment is analysed.

Granular materials and their dynamic modelling. In these materials qualitative new physical phenomenon exist, if compared to individual solid bodies and homogenous materials – liquids or gas dynamic processes. The laboratory together with Karlsruhe Research centre developed the code, which enables simulations of the motion of each particle in granular material. The code was successfully applied for investigating:

- combustion of granular solid waste on the moving grate;
- granules mixture and distribution in rotary kiln;
- precipitation of electrical neutral and charged soot particles and porosity of collected particle layer;
- investigation of 3D particles mixture on moving grate.

The obtained modelling results are confirmed by the experiments. Modelling of a large number of particles' dynamics requires a considerable computing time. The code is further developed towards parallel calculation application using computer clusters and supercomputers. Modelling principles used in the code are employed in molecular dynamics as well. These principles will be used for dynam-

ics research analysing nanostructures formation in hydrocarbons derivatives. The obtained research results are to be applied for hydrogen energy technologies.

Applied science projects for industry and economy subjects. D10 burners, created in the Laboratory, were implemented in SC *Grigiskes* steam boiler GM-50-1. Six burners were used for natural gas, leaving a possibility, if necessary, to burn heavy fuel oil as a reserve fuel. This work was carried out together with JSC *Elinta*, which implemented computerized control project of burners and boilers.

Applying a complex of methods, combustion process was modified in Skuodas DH steam boiler DE-10-14 and Zarasai DH steam boiler DE-6.5-14, implementing heavy fuel oil burners, which were constructed in the Laboratory.

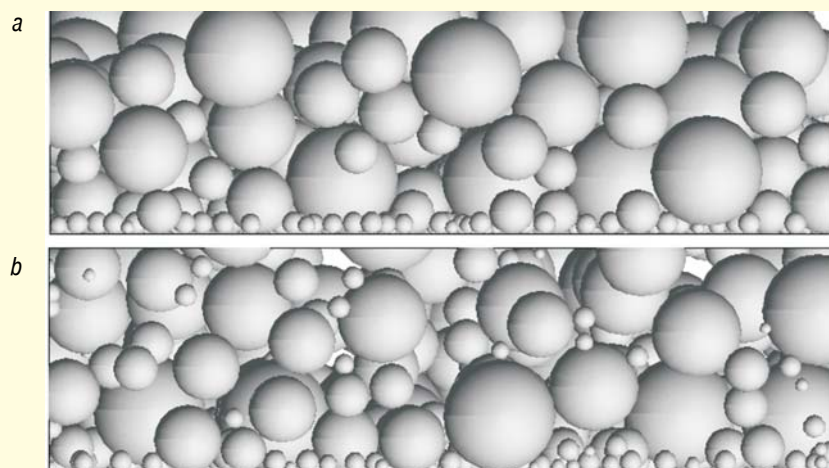
Burners of volatile organic compounds, constructed in the laboratory, were implemented in JSC *Metalo zenklai* and JSC *Elmoris* tinplate lacquering processes. Volatiles, relieved in the ovens, the concentration of which is 5-10 g/m³, are burnt up to the allowable environmental concentration of 50 mg/m³.

The project was prepared on heat return to the technological process, which

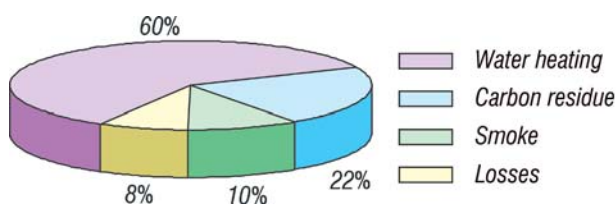
enables to reduce up to 30% of gas technological consumption. Environmental impact assessment of technical upgrading and erection of flue gas treatment equipment was carried out by SC *Lietuvos elektrine*.

Cooperating with AIE GmbH consulting company (Germany), the implementation study was prepared on orimulsion combustion in Vilnius power plant. Feasibility study for connection to gas network of Mazeikiai power plant was prepared as well, evaluating a possible join of power plant with refinery company *Mazeikiu nafta*. Other projects regarding environmental impact assessment were carried out: *Power plant No. 3 steam boiler TGME-206 No.1 small NO_x burners testing and conformity for orimulsion fuel* (in Vilnius); project of used oils combustion in Raudondvaris boiler house JSC *Radviliskio siluma*.

In 2004 doctoral thesis by R. Kalpoikaite-Dickuviene *Behaviour of a heavy fuel oil droplet on a hot surface* was defended. Two articles were published in Lithuanian journals, three – in international journals and conference proceedings. The laboratory researchers participated in two international conferences in Japan and Ukraine.



Calculation of soot porosity dropped on filter surface: neutral (a) and electric (b) soot layers



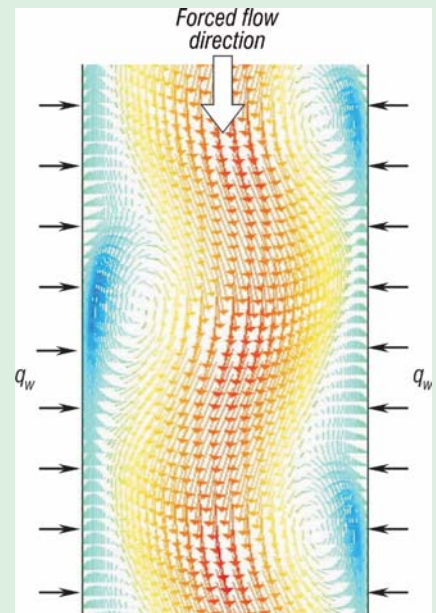
Power balance of tyres gasification

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LABORATORY OF NUCLEAR ENGINEERING

Main research areas of Laboratory:

- experimental investigation of turbulent convection heat transfer regularities in single-phase flows: 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: fuel characteristics, storage and disposal facilities, safety and environmental impact assessment;
- management of radioactive waste: strategy, treatment technologies, storage and disposal facilities, technology and storage safety and environmental impact assessments, normative and legislative base;
- evaluation of different factors related to decommissioning of nuclear power plants and fire hazard analysis.



Flow structure in a flat channel for transition region of mixed convection

Experimental and numerical heat transfer and turbulent transport investigation in channels and geological structures. Having a comprehensive experience in investigations of heat transfer, in 2004 the Laboratory continued investigations on turbulent mixed convection heat transfer and flow structure in inclined flat channels with one-side and two-sides heating for aiding and opposing flows, as well as stable and unstable air density stratification. Experimental and numerical investigations in laminar-vortex (transition) flow zone of vertical channel were started. Numerical modelling under different cases of mixed convection was performed applying FLUENT code.

It was determined that under strong effect of buoyancy the change in heat transfer is caused by the separation of flow near the channel wall. Under the conditions of stable and unstable air density stratification, correlations for calculation of heat transfer in the stabilized part and the thermal stabilization region for vertical and inclined channels were determined.

FLUENT code was also applied to perform the numerical modelling of heat removal from spent nuclear fuel deep geological repository and gas flows caused by fire.

Safety assessment of spent nuclear fuel (SNF) interim storage and disposal facilities. The dry interim storage facility for SNF at Ignalina NPP with CASTOR RBMK-1500 and CONSTOR RBMK-1500 type casks was commissioned in 1999.

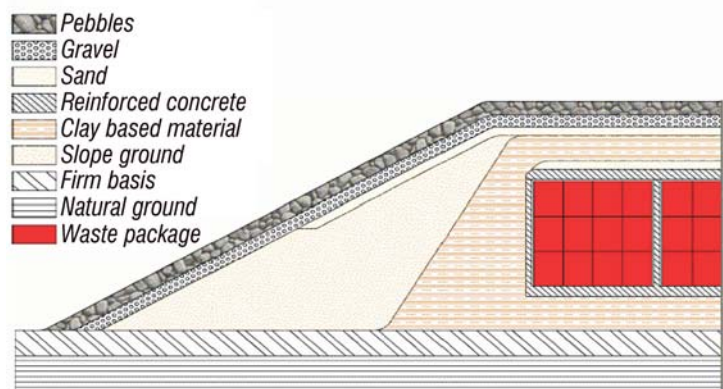
The Laboratory has been performing studies related to the safety assessment of SNF storage and disposal.

The Laboratory carried out criticality assessments for the casks of normal and extended capacity with fresh and burned-up nuclear fuel under normal operational and accident conditions, variation of radioactive nuclides activity during the interim storage period, radiation doses on the cask surface and at the specific distance from it, and temperatures of the cask.

While implementing *The Assessment Programme of the Possibility of Spent Nuclear Fuel and Long-lived Radioactive Waste Disposal in Lithuania* (2003-2007), the Laboratory proposed the concept of deep geological repository in clay in Lithuania and, within the framework of the project *The Preparation of the Generic Concept of Deep Geological Repository in Lithuania*, started preliminary safety (criticality, radiation doses, heat removal) as-

sessments. In the course of implementation of this project in 2004 the Laboratory proposed the generic concept of SNF and the intermediate level long-lived radioactive waste (LLRW) repository in crystal rock formations in Lithuania. The criticality under normal operational conditions, heat removal and other important disposal characteristics of RBMK-1500 reactor spent nuclear fuel disposal in copper container were assessed.

The Laboratory specialists with the assistance of Swedish experts carried out the evaluation of expenses for deep geological repository for SNF and LLRW. Two repository evolution scenarios were analysed and the numerical modelling of radionuclide migration in the near field and far field for defective disposal container were carried out. COMP23, COMPULINK, CHAN3D (Sweden), SCALE (USA), FLUENT, AMBER (UK) codes were applied in order to cope with these tasks.



Cross-section of a near surface repository

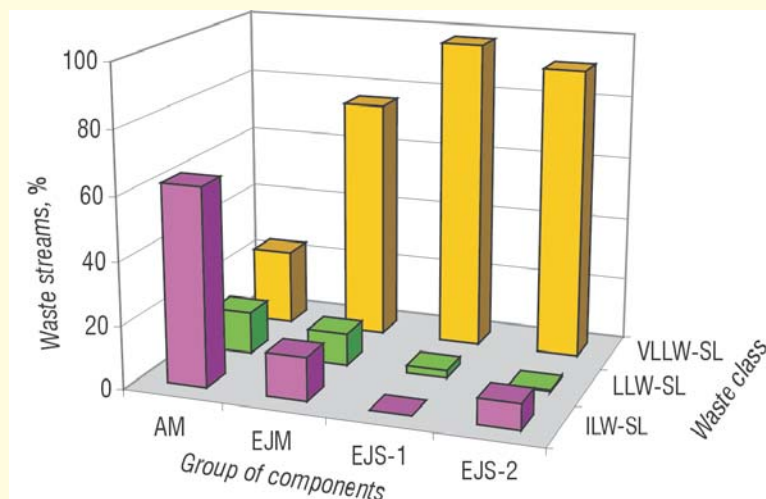
Safety evaluation of radioactive waste treatment, storage and disposal as well as environmental impact assessment.

Since 1994 the Laboratory has been actively involved in the analysis of the radioactive waste management problems at Ignalina NPP. Long-term safety assessment of existing radioactive waste storage facilities at Ignalina NPP and Maišiagala was performed, and the possibilities to transform these storage facilities into repositories were analysed. Laboratory experts together with experts from *SKB International* (Sweden) carried out a number of projects, including safety evaluation of existing waste storage facilities.

In 2001-2004 the Laboratory participated in the project – *Installation of a Cement Solidification Facility and Erection of a Temporary Solidified Radioactive Waste Storage Facility*. Together with *Framatome ANP GmbH Environmental Impact and Preliminary Safety Analysis Reports* were prepared, and the preparation of *Final Safety Analysis Report* was continued in 2004.

The Laboratory continued the search of the suitable site for the erection of a new near surface radioactive waste repository in Lithuania. Our specialists with the assistance of Swedish experts prepared the set of criteria for choosing a near surface repository site. Reference design and implementation programme for a near surface repository were prepared. Together with Radioactive Waste Management Agency, Geological Survey of Lithuania and Institute of Geology and Geography *Report on the Identification of Candidate Sites for a Near Surface Repository for Low and Intermediate Radioactive Waste* was prepared. DUST, GENII, GWSCREEN (USA), AMBER codes were used for the safety assessment.

Together with French companies *Thales Engineering and Consulting* and *ANDRA* as well as Institute of Physics the Laboratory started PHARE project *Safety Assessment and Upgrading of Maišiagala Repository in Lithuania* in 2004. The Laboratory created the database containing all information on the radioactive waste inventory, which is being stored inside Maišiagala storage facility, carried out the comprehensive nuclide composition analysis, and it is also participating in the preparation of the *Safety Analysis Report*.



Estimated decommissioning waste streams for Ignalina NPP (VLLW-SL, LLW-SL, ILW-SL – very low, low and intermediate level short-lived radioactive waste, respectively)

The Laboratory participates in IAEA coordinated research programme *Application of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities (ASAM)* (2002-2005). The investigations on the effect of the heterogeneity of the radioactive waste on the effective dose to the critical group were performed in 2004.

Evaluation of different factors related to decommissioning of nuclear power plants and fire hazard analysis. In 1998 the Laboratory specialists started a new activity related to the planning of decommissioning of Ignalina NPP. Our experts participated in PHARE project preparing *Preliminary Ignalina NPP Decommissioning Plan*. An extensive database containing 42 000 records describing the characteristics of the elements of different systems was accumulated and DECOM software was developed. This software enables to estimate the amount of radioactive 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 software of Belgium Company TRACTEBEL adjusted to RBMK reactors was used.

Since 2002 the Laboratory has been participating in IAEA coordinated research project *Disposal Aspects of Low and Intermediate Level Decommissioning Waste*. The Laboratory prepared radioactive de-

posits formation methodology and their activity assessment and analysed the expected amounts of the radioactive waste.

In 2004 the Laboratory specialists prepared the draft on *The Ignalina NPP Decommissioning Programme and the Plan of Means of Its Implementation* for the period 2005-2009.

One of the primary aspects in order to avoid nuclear accidents is the fire hazard prevention in nuclear facilities. In 2001-2004 the fire hazard analysis for Ignalina NPP Unit 1 and Unit 2 was carried out together with Swedish experts.

In 2004 the Laboratory completed one state funded project and performed 11 contracts. The specialists of the Laboratory actively participated in different training programmes, presented 18 papers in international conferences (USA, Germany, Austria, Denmark, Portugal, Spain, Cyprus, South Africa, Slovakia, Slovenia, Belarus), published 24 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, evaluation 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 characterisation of catalytic, tribological coatings and plasma polymers.

Research in the field of hydrogen energy

Hydrogen storage. Successfully finished project *Fabrication of hydrogen storage alloys and composites employing vapour deposition technologies* together with Sandia National Laboratory (USA). In this project synthesis of nanocrystallite Mg - alanate, using physical vapour deposition methods of thin coatings and hydrogen ions implantation from plasma methods, was investigated. The investigation on obtained structures was carried out, employing XRD, SEM, GDOES and AFM methods. During the project correlation of coatings synthesis technological parameters, microstructure and obtained coatings properties were determined. Work results were presented at *IEA Hydrogen Implementing Agreement Task 17: Solid and Liquid State Hydrogen Storage Materials* seminars, held in USA and Norway. The project *Synthesis of magnesium – nickel alloys and theirs application for hydrogen storage* was financed by Lithuanian State Science and Studies Foundation. In the project coatings Mg, MgH₂, Mg₂Ni, Mg₂NiH_{0.3} were synthesized employing ion beam – plasma technologies. Coatings'

structure, surface morphology (SEM) and composition (XRD, GDOES), depending on technological parameters of sputtering and hydriding in plasma, were analysed. Vacuum chamber, designed for performing a hydrogen quantity qualitative analysis (at 30-400°C temperature), was constructed. In the project the following films formation methods were employed:

- magnetron sputtering in Ar gas environment;
- saturation of thin coatings with hydrogen employing technologies of hydrogen ions implantation from plasma.

X-rays analysis method diffraction was applied, analysing materials' structures, crystallites' sizes and tensions. It was revealed that films, obtained by magnetron sputtering method, were nanocrystallite, and the size of crystallite was 20-120 nm.

The obtained results confirmed the advantages of ion beam – plasma technologies, the most significant out of which was control of formed films microstructure in nanometre level. Hydriding peculiarities of obtained films (1-5 mm thickness) in plasma were analysed. The ob-

tained results were used in explaining dynamic peculiarities of hydrogen transport from material surface into volume. Work results were presented at seminars of Nordic Energy Research Programme Network *New metal hydrides for hydrogen storage* in Norway and Lithuania.

In 2004 the Laboratory became the participant of EU Sixth Framework Programme projects NENNET and Marie Curie Research Training Network HYTRAIN, where synthesis of nanocrystallite alloys for hydrogen storage will be investigated.

Research of thermoporous alloys structure. Impact of temperature and chemical environment on thin (0.3 mm diameter) chromel and aludel thermoporous alloys' microstructure and metrological characteristics was analyzed. It was determined that thermoelectrodes, heated at 800-900°C temperature, oxidized. Aludel oxide film is formed on the surface, when thickness of it increases gradually according to the parabolic law, which is typical of nickel oxidation. Oxidizing chromel oxide film composes in separate seedbeds in uneven rate. Oxidation degree assessment, measuring thermoelectrodes resistance, was proposed. Proposals were presented for the assessment of oxide measurement sensors metrological characteristics and measurement accuracy.

Research of high-temperature materials. Cooperating with the Institute of Materials Science Problems of Ukraine, works were carried out seeking to create samples, designed for checking thermal conduction determination facilities' measurement accuracy. Zirconium dioxide, stabilized itrium oxide, ceramic samples, the characteristics of thermal conduction of which is stable in a wide interval of temperatures, were analysed. Thermal conduction of zirconium dioxide ceramic samples

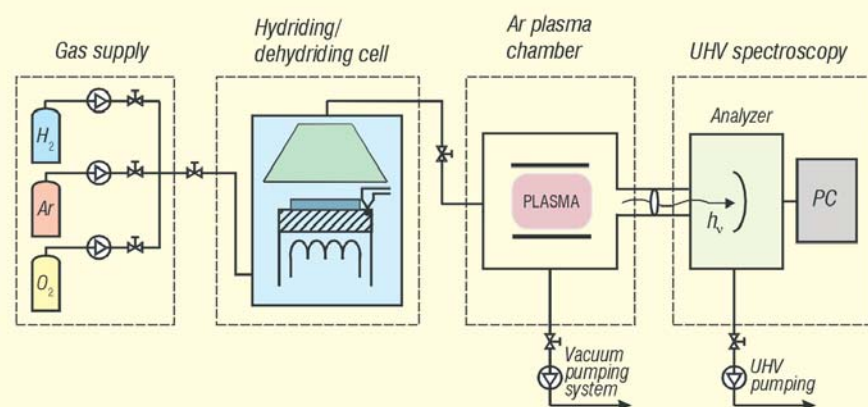


Diagram of experimental facility used for investigating hydriding/dehydriding properties



Scientists (USA) visited the Laboratory

was determined by two methods of hot wires (cross and parallel). Dependence of this material thermal conduction from temperature (20-1000°C) was determined. Results of thermal conduction measurements were compared to measurements performed by researchers from Ukraine applying method of reciprocal task solution.

Materials testing, assessment and analysis of their qualitative indicators. The laboratory is accredited to carry out tests of plastic and insulated pipes, building mortars, polymer bitumen sheeting, thermal insulating products, refractory materials and products. Permanent renewable of technical investigations basis enables to carry out building products testing according to the international standards and European Norms requirements.

Research of hydrogen and hydrides' degradation impact on mechanical and physical properties of zirconium-based alloys. Investigations related to zirconium-based alloys and fuel channels (produced out of alloys) pipes' properties, the objective of which is to guarantee fuel channels resistance and forecast their ageing process. After completing works, forecasted in IAEA programme, and cooperating with scientists from other countries, IAEA edition, in which results of RBMK and CANDU reactors' fuel channels hydrogen induced cracking research were generalized, was prepared and published.

Assessment of Ignalina NPP reinforced structures' concrete quality. The laboratory participated in works that were related to the burning of fuel unloaded from Ignalina NPP Unit 1 to Unit 2. Research of reinforced structures' concrete quality was carried out employing undisrupting control

methods and concrete samples' tests, determining strength properties and evaluating general state of reinforced structures.

Plasma investigations under atmospheric pressure conditions. Regimes of linear electric arc heaters and reactors, their operating characteristics in atmospheric and operation pressure environment; work duration expansion conditions were determined, methods of arc turbulisation were investigated. Means and conditions were determined on how to obtain air, nitrogen, argon, water vapour, and hydrogen plasma flows, and introduce solid and gaseous substances into reactor and arc reacting zone.

Thermal equilibrium conditions of atmospheric pressure plasma jet were investigated, applying contact methods. Regularities of rate, temperature and their pulsation distribution in high temperature plasma jet were determined.

Electric arc and plasma flow interaction with dispersed materials was investigated in order to neutralize harmful materials, form various coatings, synthesize new materials; physical, chemical and mechanical features of obtained coatings and materials were determined.

Catalytic coatings, the surface of which reached 100 m²/g, were formed in plasma flow.

The mechanism, which generated permanent chemical constitution and characteristics combustion products flow, was created for the investigations of catalytic properties of coatings and mass transfer processes near the active wall surface.

New plasma technology equipment was created for the synthesis of solid covers in low pressure atmospheric plasma. Investigations of synthesis processes of diamond, diamond-like carbon, fullerenes

and other solid coatings in argon, hydrogen and acetylene plasma were carried out, using the above equipment. Investigations on dense coatings, designed for fuel elements production applying supersonic plasma flow, were carried out.

Investigations in the field of atmospheric plasma were carried out in such EU programmes as COST and EUREKA.

An original monograph by A.J. Kviklys and R. Levinskis *Filled in polymeric systems and their properties* was prepared and published.



In 2004 the researchers of the Laboratory presented 15 articles in Lithuanian and 13 articles in international journals. Scientists of the Laboratory presented 22 papers in conferences, 12 of them at international conferences. R. Kriukiene defended materials engineer doctoral dissertation *Effect of temperature and chemical environment conditions on microstructure and metrological characteristics of thermocouple alloys*.

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LABORATORY OF REGIONAL ENERGY DEVELOPMENT

Main research areas of the Laboratory :

- analysis of planning development for municipal energy sector and the state of plans management;
- development of analytical modules for mathematical model of Lithuanian heat sector;
- analysis of district heating sector;
- analysis of economic development of wood fuel preparation and utilization;
- development of data basis for municipal energy sector and macroeconomic analysis of regional issues.

The research project ***Creation and justification of macroeconomic methodology for development of municipal energy sector with regard to the tasks of formation National Energy Strategy*** was completed in 2004.

This study formulated the concept of the development of municipal energy sector, which was based on the following principles:

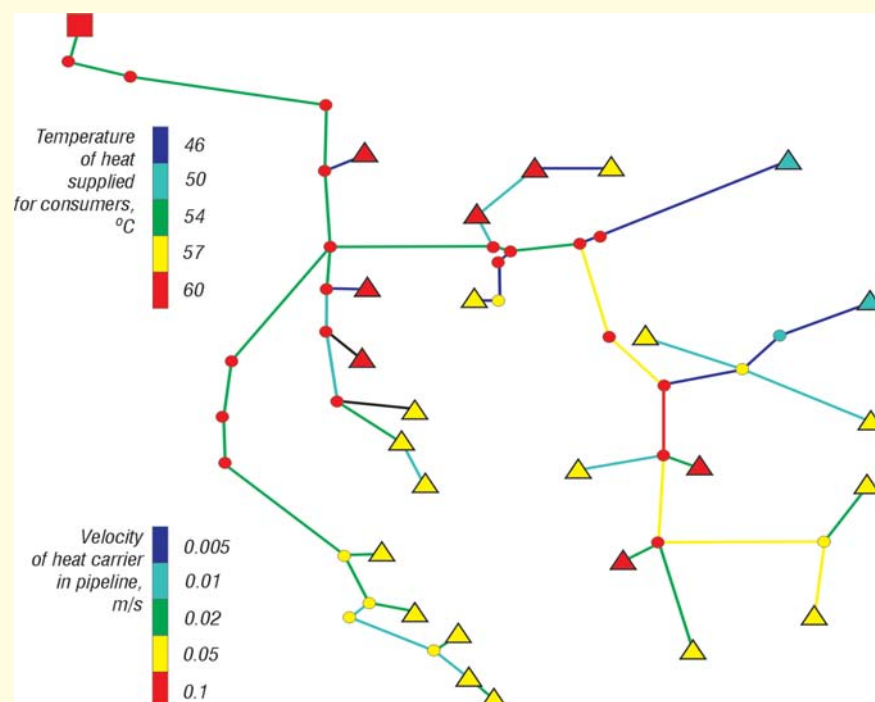
- development and improvement of self-governing;
- integrated resources planning (IRP) at municipal level;
- management of rehabilitation plans for municipal energy sector;
- analysis of opportunities and barriers for implementation of IRP concept;
- state regulation of monopolistic structures;
- the use of energy conservation opportunities;
- promotion of competition in providing energy products and services.

Laboratory started to create complex software and info tools for the analysis of the development of municipal energy sector and formation of renovation strategy with regard to the strategic tasks of National Energy Strategy. Mathematical analytical model is based on the description of financial flows of the companies through differential equations, which are harmonized with company budgets and profit (losses) accounts as well as income and costs statements. Elaborated algorithm is used for modelling of economic-financial indicators of a company and is implemented by EFINCOMACT module for efficiency assessment of technical renovation of DH companies.

Differential description of the financial flows of the companies is harmonized with National Accountancy system, which is in compliance with the requirements of EU directives, enabling aggregation of indicators of the companies involved in similar activities and including it into inter-branch national balance sheet.

Simulation model of national heat sector activities for macroeconomic analysis of municipal energy sector was created at the laboratory on the basis of formed Municipal Energy Info System (MEIS). The first version of this model includes formation of output vector for heat sector. Accumulated data for input vector of this national sector are formulated including creation of value added.

Investigation of financial flows, as well as selection of adequate functional expressions and definition of key parameters for various activities models, included into the model of heat sector, should be notified.



District heating network in Salininkai: the outcome of modelling.
Colouring of lines – velocity of heat carrier, Δ – consumers, \circ – pipeline nodes



D. Strazdas and his scientific mentor Dr. V. Kveselis



A. Lisauskas and his scientific mentor Prof. M. Tamonis

Mathematical model for the development of heat market evaluates the heat costs for heating of residential buildings versus energy characteristics of the buildings and heat tariffs. It was shown that current low heat consumption is achieved through worsening of comfort level.

Laboratory is also improving an economic model of heat transmission and distribution, including hydraulic and thermal simulation of heat network, as well as the value of production flows. Software connection between code TINKLAS and MEIS TAUSA was implemented.

The condition of maximum net revenue of the company was used for the assessment of the investment efficiency into enhancement of heat transmission and distribution. Quality analysis of heat supply was started.

Aggregated inter-sector balance matrix was used for the analysis of local energy sector for 3 or 4 sectors. Energy sector and production of local fuel were considered as separated sectors. The outcome of investigation shows that V. Leontieff's input matrix was unstable during the period of 1996-1999 in these sectors, i.e. significant restructuring processes were ongoing.

Feasibility Study and Business Plan for CHP plant to be Constructed in Siauliai includes analysis of five different scenarios for construction of CHP plant, which disclosed economic viability of CHP plant with installed capacity of app. 20 MWe with main fuel – natural gas. Such plant could improve financial indicators of the DH company, however, risks related to low electricity prices in Lithuanian market and undetermined quotas of electricity sales to the grid could arise.

Prefeasibility Study for Klaipeda City CHP Plant had to find the least costs heat generation solution. Investigated CHP solutions differed in the type of fuel and incineration:

- incineration of hard coal powder,
- incineration of coal in fluidised bed at atmosphere pressure,
- incineration of coal in pressurized fluidised bed,
- natural gas fuelled CHP plant,
- integrated local fuel gasification and CHP cycle.

Natural gas Combined Cycle CHP plant is the most economic technological solution, however, construction of such plant at present would not enable reduction of current heat generation costs.

It was determined that CHP units for covering own electricity demand would be the most expedient solution for JSC *Klaipėdos energija* at present power business environment.

Feasibility study of Salcininkai DHS renovation enabled to recommend a new boiler-house (using local fuel) construction, replacing old boiler-rooms with modern individual heat substations, and decentralizing heating of one catchment's area distant from central boiler-house.

The aim of the international project Redirecting Urban Areas Development towards Sustainable Energy (under INTERREG-IIIC programme) – to support new EU members energy policy reform towards sustainable development. This support is arranged at the level of urban development plans, through transfer of the experience of 15 old EU member-states in various aspects of energy sector. The task, assigned to LEI in the projects is a very important one – coordination of general project goals in formation of implementation strategy. This project has 20 partners from 14 countries.

Laboratory was actively preparing project proposals for the Sixth Framework Programme. The researchers of the Laboratory published 19 publications, including four articles in international journals and 13 presentations in Lithuanian and international conferences during 2004. Two Ph. D. Candidates – Darius Strazdas and Aurimas Lisauskas defended theses for doctor degree.

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Main directions of scientific activities:

- scenario analysis of macroeconomic development, modelling and forecasting of energy demand;
- analysis of medium- and long-term energy supply scenarios using widely approved optimisation models;
- environmental impacts of the energy sector, analysis on pollution reduction technologies and implementation and environment protection policies;
- generalization of energy restructuring and liberalization experience gained in European Union and East and Central European countries and application of the analysis findings for reforms in the Lithuanian energy sector;
- development of energy information system, collection of statistical data on energy development in Lithuania and worldwide.

During the year 2004 the Laboratory proceeded with the research directly associated with national energy sector and specific energy systems analysis and contributed to the future energy system plans crucial for the country's economy and energy.

The main focus of scientific research is concentrated on the improvement of methodology, energy planning tools and software as well as on statistical data basis necessary for energy demand forecasting and optimisation of energy sector development. During 2004 major efforts were devoted to the adaptation to Lithuanian conditions, improvement and testing of optimisation MESSAGE model of energy sector development in cooperation with the International Atomic Energy Agency (IAEA). This model is used as the main tool for the analysis of the energy sector development scenarios.

The package of reports associated with the implementation of National energy strategy was prepared for the Ministry of Economy based on the contracts for applied scientific research.

As one of the most important reports ***Preparation of studies on natural gas supply security and analysis of cogeneration extension as well as preparation and publication of statistical indicators in energy sector*** should be mentioned. This study generalizes research associated with the Lithuanian power sector development taking into account Lithuanian obligations to close Ignalina NPP.

The scenario of CHP development could be selected as an attractive option allowing the creation of rational structure of generating capacities, more efficient use of primary energy resources, modernization of district heat supply in towns and reduction of environmental pollution. The analysis performed in the study is based on the broad modelling of energy sector development because a variety of favourable and unfavourable factors have impact on the development of new generating capacities. Conclusions presented in the report are based on the analysis of different scenarios:

- The Baltic States' power sector development;
- Lithuanian power system development;
- Lithuanian power system and district heat supply sectors development based on comprehensive analysis of heat demand and potential of renewable energy sources in the counties of Lithuania. In addition, the study provides the impact on results due to changes of fuel prices, heat demand, discount rate and other factors.

The study provides a comprehensive analysis of CHP development scenarios by elaborating terms of new capacities construction, their distribution in the territory and preliminary estimates of necessary investments. However, only the main trends were emphasized during modelling and optimisation due to the lack of necessary information. The problem of CHP efficiency should be investigated further and based on regional approach, the most recent data and in as much detail as possible, in particular technical and economic information should be collected using special development plans of heat supply in municipalities, data bases of State price and energy control commission, Statistical department and other.

The study analyses reliability of natural gas supply as well. The projects of Lithuanian natural gas pipelines modernization and development, foreseen in General gasification scheme adopted in 1999, and other scientific technical studies were reviewed and analysis of their implementation during 1999-2004 was presented in the study.

The perspectives of new natural gas storage construction in the territory of Lithuania and a rent of Latvian Incukalna underground gas storage were analysed for the estimation of natural gas supply reliability. For making final decision on this strategic issue the feasibility study of natural gas storage construction in Lithuania and necessary geo-physical and geological research should be conducted urgently. The study presents the analysis of the opportunity of natural gas reservation by other fuels (asphaltene, HFO etc.) and the main issues of respective legislative framework formation.

Laboratory employees in
60-years anniversary
of the Head of Laboratory
Dr. Habil. V. Miskinis



The study ***Lithuanian feasibility to implement Kyoto protocol requirements applying GHG emission reduction measures*** provides a comprehensive analysis of GHG emission dynamics in Lithuania and feasibility analysis of GHG emission reduction by applying flexible Kyoto mechanisms and implementing EU GHG emission trading scheme. The analysis of climate change mitigation measures interaction and recommendations of their implementation in energy sector were presented in the study. The total allocated amount of tradable allowances for energy enterprises was estimated based on methodological approach for tradable allowance allocation for separate energy sector installations developed in the study.

In the study ***Action plan for the Implementation of National Energy Strategy*** an

analysis and generalization of measures, which were presented to the Ministry of Economy by Lithuanian energy companies, ministries, departments and municipalities, were performed. Some additional measures were recommended taking into account the necessity to upgrade generating capacities replacing Ignalina NPP and to comply with the increased environmental requirements. The Action Plan presents also measures aiming to increase energy efficiency, enhance use of renewable energy sources, etc. All these measures being reconciled with ministries and departments and adopted by the Lithuanian Government would make preconditions for a more efficient use of means from energy enterprises, State budget and the EU funds directed to modernization and development of energy sector.

Based on the analysis of legislation of the EU and individual countries the recommendations for the amendments of legal acts regulating Lithuanian energy sector and further harmonization with the EU legislation were developed in a study ***Analysis of EU laws and leading legal acts regulating energy sector activities and comparison of regulating principles with relevant legal regulation in Lithuania***. The laws on amendment of Lithuanian Electricity and Natural Gas laws were developed in the study. The drafts of leading acts for the foreseen changes in laws were presented in the study.

Based on the contract with JSC *Mazeikiu Nafta* in 2004 the Laboratory performed an analytical study ***Analysis of Lithuanian electricity market (supply and demand) taking into consideration the more global impact of all Baltic region and tendencies in demographics and demand growth***. The study presents the overview of the state of the Lithuanian natural gas and electricity sector, analysis of possibilities to apply for the EU financial support through Cohesion and Structural funds, the projection of the main macroeconomic indicators and final energy and electricity demand, analysis of energy price development trends and projections. The most important result of this study is the comprehensive evaluation of economic feasibility of Mazeikių CHP reconstruction. This analysis can be used directly by *Mazeikių Nafta* for the development of concrete project of power plant reconstruction. In addition, the study provides the analysis of the EU directives and their implication on electricity sector, evaluation of the main characteristics of Mazeikių CHP reconstruction and operation using heavy fuels produced at *Mazeikių Nafta*.

NATO Advanced Research Workshop "Baltic Energy Security and Independence"





Conversation of the participants in the NATO ARW "Baltic Energy Security and Independence"

The coordination and preparation of the international study **Analysis of energy supply options and security of energy supply in the Baltic States** is a very important input of the Laboratory staff in the formation of background for energy sector development until 2025. The experts of the Laboratory contributed significantly into the formation of methodological framework of this study, providing consultations for Latvian and Estonian working teams, formation of database and generalization of the main study results.

Laboratory is participating in the following projects of EU Fifth Framework Programme and Sixth Framework Programme:

- **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;**
- **The European Network for Energy Economics Research;**
- **The Development of New External Cost Research for Sustainable Development (NEEDS).**

In several international projects the actual energy sector development issues, the problems of electricity market in the Baltic States and other issues were investigated:

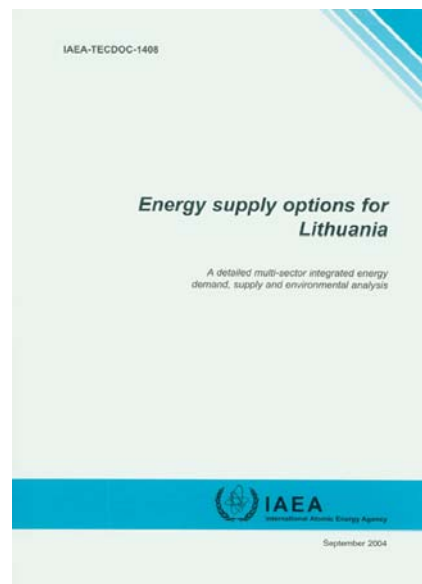
- IAEA supported project **Indicators for Sustainable Energy Development;**
- Danish company Elkraft System supported project **Energy Development in the Common Baltic State Electricity Market.**

Experts from Laboratory were involved in preparation of the following projects:

- **Lithuania's National Allocation Plan for GHG Emission Allowances for the period 2005 to 2007;**
- **Solar energy conversion and use;**
- **Institutional strengthening for implementation of EU requirements in field of chemical materials, genetically modified organisms, integrated pollution prevention and control and climate change field in Lithuania, etc.**

2004 was significant for increasing competence and qualification of Laboratory researchers. Dr. Arvydas Galinis is recognised by IAEA as the expert having the highest qualification in the field of energy modelling and he is permanently invited to participate in international courses conducted by IAEA and deliver his experience and knowledge in the field of energy planning and modelling for experts from other countries.

Ph.D. Candidate R. Gatautis with the assistance of Nordic scholarship fund was on the traineeship in the Technical University of Denmark. Dr. I. Konstantinaviciute, Ph.D. Candidates E. Norvaisa, R. Gatautis and D. Tarvydas participated in IAEA international training courses in USA and Italy. Ph.D. Candidates A. Mikalauskiene and J. Kugelevicius participated in training courses in Spain and Germany.



The most important expression of research being conducted in the Laboratory is study **Energy supply options for Lithuania. A detailed multi-sector energy demand, supply and environmental analysis**, which was published by IAEA in 2004, as a result of fruitful cooperation between Agency and Lithuanian Energy Institute.

In 2004 approximately 40 papers were presented in the international conferences in Bulgaria, Croatia, Germany, Iran, Kazakhstan, Poland, Norway, Portugal, Switzerland, Serbia, and USA. Researchers of the Laboratory published 40 articles in Lithuanian and international journals, proceedings of international conferences.

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LABORATORY OF SYSTEMS CONTROL AND AUTOMATION

Main research areas of the Laboratory:

- investigation of energy system control and modelling;
- modelling and optimization of control and data acquisition systems;
- modelling of power systems and power network development.

Power systems and networks are complex objects, which require application of complex mathematical models for the analysis of their operation, control and development problems. Their importance has increased recently since systems and networks' technical control and operation are increasingly becoming more complicated. It was determined by the requirements to increase energy supply security, to seek for higher energy systems' stability and reliability, to implement function of national power balance and other functions of regional co-ordination.

Control and modelling also became more complicated due to the functioning of electricity market, namely to the following aspects:

- energy system restructuring;
- electricity market relations with conventional power production, transmission, distribution and transit transfer processes;
- connection of small power production sources to energy systems;
- transfer of contracted power by large distances crossing multiple

power systems in regional electricity markets;

- emerging ancillary services market.

New automation equipment for system and network control requires to revise and adapt specific mathematical models.

In 2004, the Laboratory carried out two research projects according to the contracts with Lithuanian companies.

According to the contract with national power transmission company JSC *Lietuvos energija*, control of reactive power and voltage regimes was modelled by employing system protection devices in case of emergency situations. Calculation results and conclusions allowed the Lithuanian transmission system operator to determine emergency prevention measures and develop prevention plans.

According to the contract with JSC *Panevežio energija*, the study *Technical and economical analysis of power supply and consumption options* was carried out. The connection-to-network options for projected co-generation power plant were analysed. Optimal connection case was

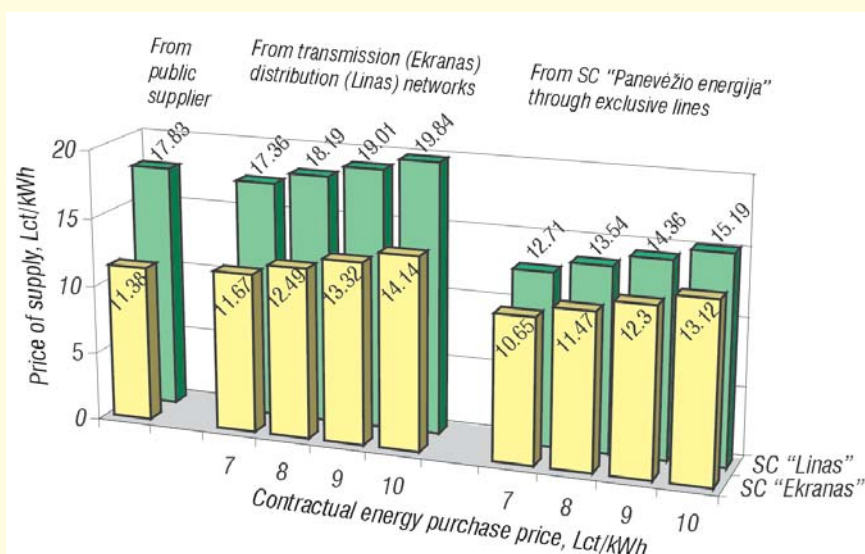
proposed after the evaluation of electricity market aspects. This investigation was performed in co-operation with the Energy Networks Institute in Kaunas.

The Laboratory proceeded with the scientific research project *Investigation of optimisation and functioning of power systems control algorithms and information systems*. This research is significant for upgrading the efficiency of information control systems, preparing models, principles and future milestones for power systems control, regional power and frequency regulation in Lithuania and other Baltic States.

The Laboratory proceeded with modelling the operation of power system with wind power plants, which were started in the previous years. Impact of wind power plants' generation on electricity market was analysed, as well as fluctuations in this generation and their impact on the operation of Lithuanian power system.

Doctoral dissertation *Research of efficient energy consumption processes in industry applying computer-aided energy accounting and monitoring systems* by P. Bachanovas (supervisor A. Burba) was prepared and defended. It presents the model of more efficient energy resources consumption in enterprises.

Research results of 2004 were published in 10 scientific articles: two in the international conferences proceedings, six in the Lithuanian conferences proceedings and two in journal *Energetika*. Two doctoral dissertations are under finalisation. In 2004 the Laboratory participated in preparing tenders for EU Sixth Framework Programme.



Possible variation of energy supply prices for companies "Linas" and "Ekranas" subject to contractual energy price and connection variants

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LABORATORY OF HYDROLOGY

Main directions of research activities:

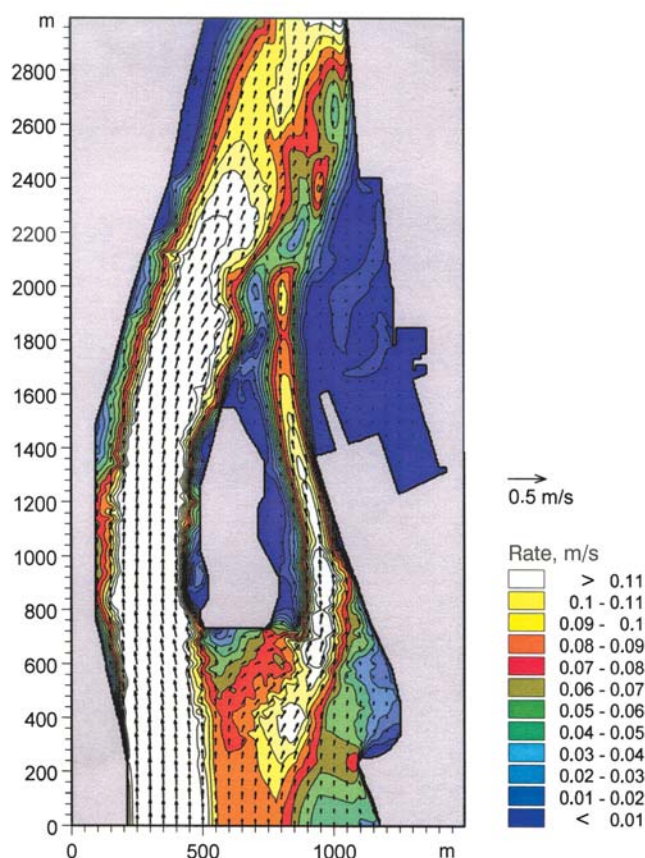
- the investigations on safety and reliability of energetic and transport objects and impact assessment for water environment;
- accumulation of data on Lithuania water bodies (rivers, ponds, the Curonian Lagoon and the Baltic Sea).

Scientific research object and methods

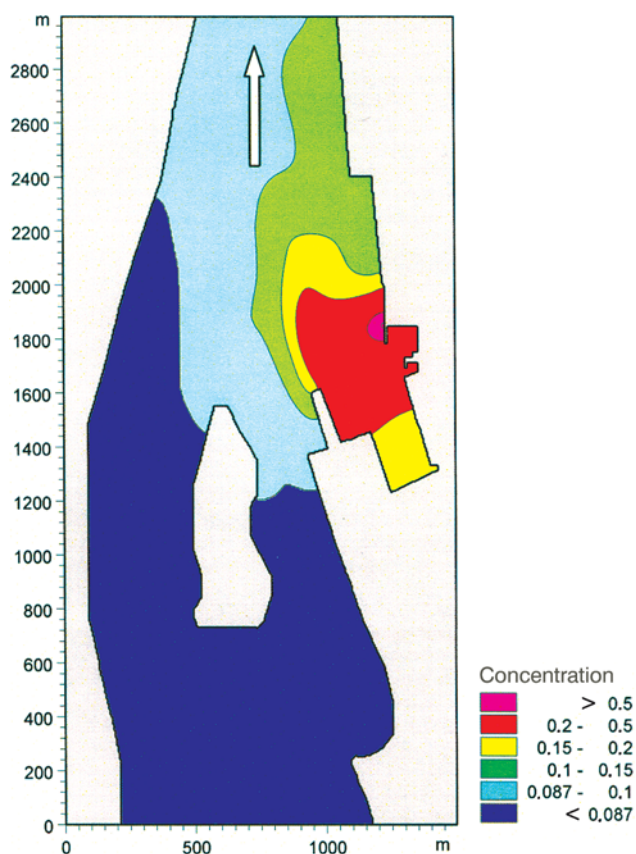
The investigation of Lithuanian water bodies has been performed using a numerous data of hydrography, hydrology, morphology, meteorology accumulated in the Laboratory of Hydrology since 1961. The modern modelling system from Danish Hydraulic Institute is used to solve the main task of environment protection – to evaluate the impact of human activities on environment. MIKE 21 models of hydrodynamic, wave, advection and dispersion, sediment (sand and mud) transport are used to describe water levels, flow rates, surge, dynamic of sediments (erosion of bottom and coast, sediment accumulation, turbidity), dispersion of pollution.

The main scientific research objects of the Laboratory are as follows: the lake Druksiai, the Kaunas Reservoir, the Nemunas river, the Curonian Lagoon and the Baltic Sea. These water bodies are under the extreme nature expressions (storms, excess rainfalls, draughts) and are affected by human activities. Using an accumulated database the following tasks are solved:

- the assessment of environmental impact of human activities in water bodies and reasoning of environment protection ways;
- protection and management of the Baltic Sea coasts;
- determination of the extreme hydrological and hydraulic conditions under the exploitation of the hydrotechnic constructions;
- determination of work regime of the energetic objects taking into account the environment;
- numerical assessment of mixing and dispersion of contamination under the critical work conditions in water bodies;
- exploitation of Seaport and water ways maintaining secure depth for navigation.



Flow structure of the Klaipeda Strait in case of 440 m³/s discharge from the Curonian Lagoon to the Baltic Sea



Dispersion of pollution in the Klaipeda Strait in case of 440 m³/s discharge from the Curonian Lagoon to the Baltic Sea

Cooperation with public institutions

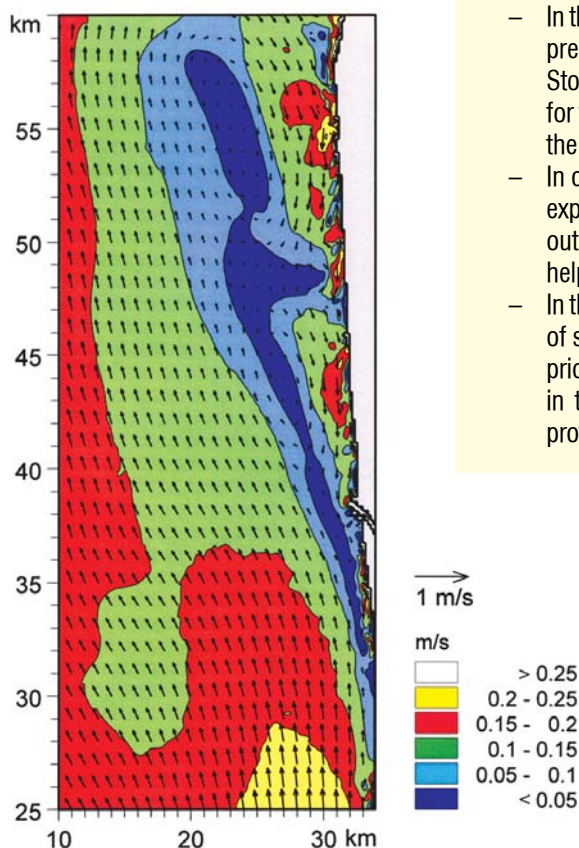
The Laboratory of Hydrology closely cooperates with a number of Lithuanian institutions. The main areas of cooperation are as follows:

- the contract between the Ministry of Environment of the Republic of Lithuania and Lithuanian Energy Institute in the area of water bodies protection, hydrography and hydrology, assessment of human activities impact on water bodies;
- joint doctoral studies between Lithuanian Energy Institute and the Institute of Environmental Engineering of Kaunas University of Technology in the area of environmental engineering and land management;
- publishing of scientific journal *Environment research, Engineering and Management* in cooperation with others scientific institutions in Lithuania (Kaunas University of Technology, Vilnius University, Vilnius Gediminas Technical University, etc.);
- complex environmental research together with the Institute of Geology and Geography, the Institute of Ecology of Vilnius University, Vilnius Gediminas Technical University, Lithuanian University of Agriculture.

Main applied research works in Laboratory

Applied research works are performed and technical projects of hydrotechnical construction are prepared according to the contracts with companies and organizations from energy and other branches of economy.

- In the frame of the project with *Klaipeda State Seaport Authority* the report *Environmental Impact Assessment Report for Dredging of Harbour Entrance up to -13 m* was prepared, the means of environmental protection of ecosystem of Curonian Lagoon were proposed.
- The projects of dredging works in water territory of JSC *Laivite*, *Smiltynes Perkela* and *Klaipeda Seaport* entrance channel were prepared proposing works' technology, order of priority and conditions.
- In the frame of the project with company *Lithuanian Energy* the risk studies were prepared for the Kaunas Hydro Power Plant and the Kruonis Hydro Pumped Storage Plant, which were used for the preparation of accident liquidation plans for these dangerous objects. The means of these plans soften consequences if the dams of the plants fall.
- In cooperation with company *Pramprojektas* the reconstruction project of the expulsion of Klaipeda town sewerage water into the Klaipeda Strait was carried out. Modelling results of mixing of the sewerage water with the Strait water will help to avoid negative effects for the Curonian Lagoon.
- In the frame of the project with *Klaipeda State Seaport Authority* the programme of seaport dredging up to 2009 was prepared. In this programme the order of priority of dredging works of seaport and the channel of navigation is assessed in terms of navigation safety, increasing of port cargo and environmental protection.



Flow structure of the Baltic Sea nearshore with the west wind of 15 m/s

Research results of 2004 were published in eight articles in Lithuanian and international journals. Laboratory researchers presented four papers in international conferences (Estonia, Italy, Russia).

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FINANCIAL HIGHLIGHTS

The financial sources of the Institute consist of:

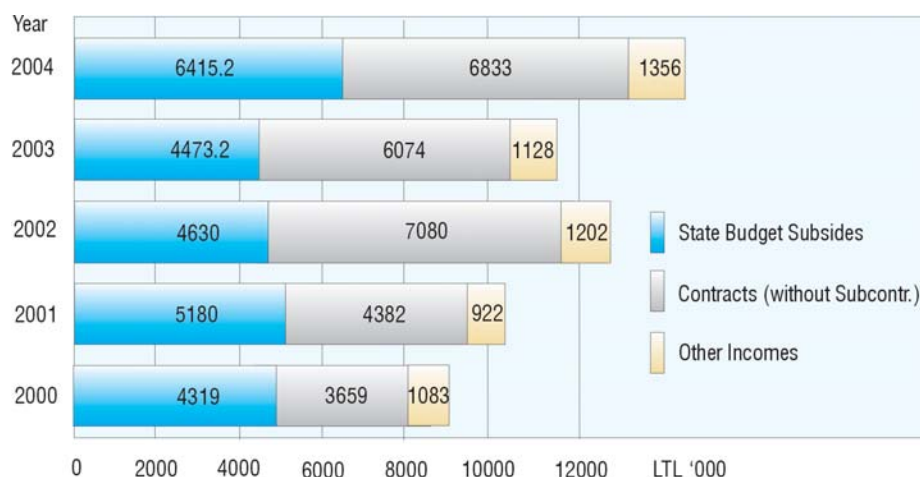
- State budget subsidies;
- financing for research programmes and education of specialists;
- financing received from Lithuanian and foreign enterprises and organizations for contract works, realization of products and services;
- funds received from various international research programmes and funding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

Structure of Income and Total Expenses (LTL '000)

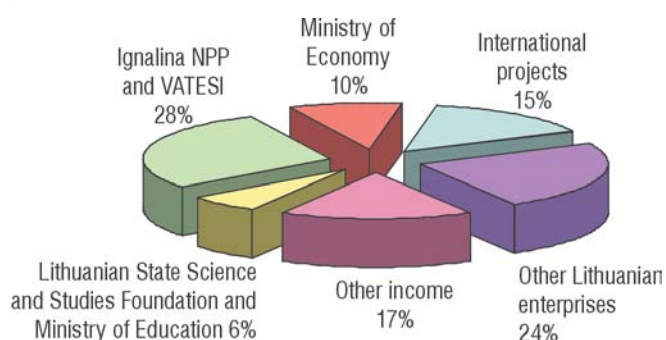
	2000	2001	2002	2003	2004
Income:					
State Budget Subsidies	4319	5180	4630	4473.2	6415.2
Contracts (incl. subcontr.)	4224	4684	7785	11658*	22641*
Other Income	1083	922	1202	1128	1356
Total:	9626	10786	13617	17259.2	30412.2
Expenses:					
Salaries (soc. ins. incl.)	7002	6362	7181	7783	8667
Operating Expenses	1573	2544	2842	3572.2	3699.7
Capital Funds	935	659	1887	571	1564.3
Subcontracts	565	302	705	5584*	15808*
Total:	9435	10178	12615	17510.2	29739
Long-term Projects Assets	346	954	1956	1705	2378.2

* – bank guarantee included

Variation of Financial Structure



Financial Sources of Economical Activity in 2004



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February 17. The Institute was granted Lithuanian Standardization Department Quality Assurance System Compliance Certificate LST EN ISO 9001:2001



March 29. Election of the Institute Director



June 8. Inauguration of Prof. Dr. Habil. Eugenijus Uspuras, new Director of LEI



June 21-23. NATO Advanced Research Workshop "Baltic Energy Security and Independence"



September 30. 1st scientific conference of LEI Ph. D. Candidates



December 8. Meeting of Phébus FP representatives and Lithuanian institutions regarding the issues of severe accidents research



December 28. Employees of LEI bid farewell to year 2004

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