



LITHUANIAN ENERGY INSTITUTE



Annual report 2003

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UDK 061.6:620.9(474.5)
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ISSN 1822 - 0088
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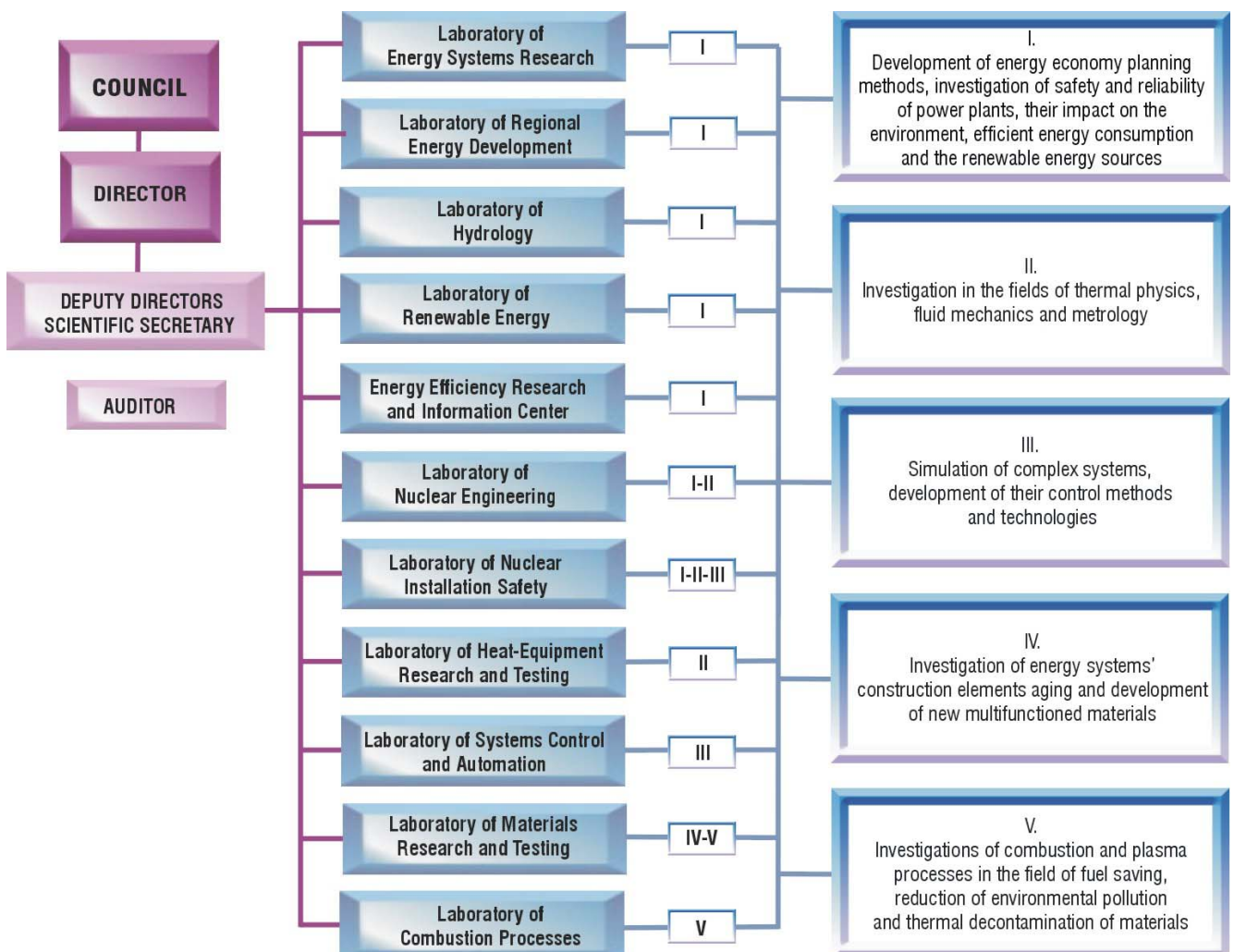
Lithuanian Energy Institute in 2003

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.

- Carry out fundamental research in the fields of thermal physics, fluid mechanics, metrology, energy installation safety, materials science, hydrology and process control.
- Prepare conceptual and methodology basis for the formation of state policy in energy sector, for energy economy planning and control.
- Prepare the highly qualified professionals for power engineering and scientific investigations related to it.

Institute Organizational Structure and Basic Directions of Scientific Research





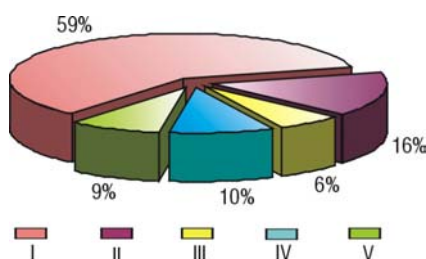
The Council of the Institute. In the first row (left to right): Prof. Dr. Habil. B. GAILIUSIS, Dr. R. URBONAS, Dr. R. DEKSNYS (Kaunas University of Technology), V. PASKEVICIUS (Stock Company “Lithuanian Energy”), Prof. Dr. Habil. E. USPURAS – Chairman of the Council, J. R. KAZLAUSKAS (State Enterprise “Energy Agency”), R. RUKSENAS (Nacional Energy Asociation), K. ZILYS (State Nuclear Power Safety Inspectorate - VATESI), Prof. Dr. Habil. J. VILEMAS – Director, Dr. R. SLEZAS.

In the second row (left to right): R. GATAUTIS, Prof. Dr. Habil. P. POSKAS, Dr. Habil. V. MISKINIS, Doc. Dr. Habil. J. AUGUTIS (Vytautas Magnus University), Dr. Habil. A. PEDISIUS, Dr. V. KVESELIS, Dr. R. SKEMA – Deputy Director, Dr. R. LEVINSKAS – Deputy Director, Dr. A. GALINIS, A. VAISNORAS (Environmental Protection Agency), G. KRIVOSEIN (Ignalina NPP), Prof. Dr. Habil. A. SKRINSKA (Vilnius Gediminas Technical University), Dr. G. ZYGMANTAS, R. ALZBUTAS.

In 2003 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.

- Energy Infrastructure Operating Analysis was carried out on solving energy regular development modelling issues. Mathematical model of integrated energy sector was launched.
- Lead radiation characteristics of Ignalina NPP reactors and migration of nuclides from designed Lithuanian near surface radioactive waste disposal facilities were evaluated.
- Ecological boundaries of economy sector in the Baltic Sea near-shore and Klaipeda Strait, as well as sediment transport dynamics due to hydrometeorological conditions were determined.
- Optimization methodology of centralized heat supply systems on the grounds of integrated design principal, evaluating generalization sources dispersion, was prepared.
- Optimal information supply system was formulated for regional energy planning.
- Information was accumulated on solid biofuel, fuel conversion, its combustion processes in various facilities and under different conditions.
- Assessment of velocity profiles turbulence and other extreme parameters impact on power plants procedure was carried out while modelling wind power plants.
- Information was accumulated on the employment of mini and micro cogenerators in energy sector.
- Renewal of efficient energy consumption network was performed.
- Investigation and implementation methodology of economizer’s condensation surfaces in Lithuania was designed. Buildings’ renovation and buildings’ energy input saving issues were tackled.



Distribution of researches according to basic research directions

II. Investigations in the fields of thermal physics, fluid mechanics and metrology.

- According to three-dimensional mathematical model, natural water bodies - energy objects’ coolers hydrothermal mass and heat exchange processes investigation was carried out. Results of numerical and experimental investigation were compared.
- Investigating hydrodynamic process of condensation implosion in unstable two-phase state, its visualization system and integral experimental case were de-

- signed, numerical modelling programme was developed.
- Heat exchange transfer under mixed convection in the channels given stable and unstable flow stratification is obtained by experimental and numerical methods.
- Water warming and temperature regulation system in standard water flow/volume measuring hydrodynamic facility was installed, enabling to raise the temperature of facility operation up to 50°C. Data accumulation and facility control algorithm, and software were created.
- Experimental water-fuel substitute determination method, which evaluates quantity of melted gas in liquid and reduces uncertainty, was designed.
- Measured flow prehistory, pressure, temperature and pulsation impact on calibrated operating standard metrological characteristics was determined.
- International - interlaboratory comparisons of obtained investigation results were performed together with analogical standards of other countries, good coincidence was confirmed.

III. Simulation of complex systems, development of their control methods and technologies.

- Investigation on energy objects' reliability and risk assessment was carried out. Mathematical and calculation models were designed.
- Energy systems control rate and rate flow interdependence was analysed, when primary and secondary regulation systems were operating, modernization of their mathematical models was performed, as well as preparation of control and energy accounting information systems.

IV. Investigation of energy systems' construction elements aging and development of new multifunctioned materials.

- Thin coatings were designed and analyzed, evaluating their sputtering velocity and processes' efficiency dependence on parameters of coating technologies, structure of coatings was investigated, as well as ionic conductivity and their interdependence.
- Carbided phase high temperature in steels X-ray diffractometer determination methodology was designed. Conditions of hybrid cracks in zirconium alloy pipes were investigated under the influence of cyclic loads. Interaction of water chemistry and corrosion in steel pipes was investigated.

V. Investigations of combustion and plasma processes in the fields of fuel saving, reduction of environmental pollution and thermal decontamination of materials.

- New data was obtained on thermal crude oil conversion fraction decomposition, which enables to reduce environmental pollution on burning heavy fuel oil and controlling hydrogen separation.
- Calculation programme package of granular material, which designs gasification and combustion processes, was created.
- Gas dynamic facility was modernized while investigating heat and mass exchanges of metal oxides catalyst surface.

At the same time the applied science investigations were carried out according to the contracts with organisations and companies of power sector and other branches of economy sector. Programs, standards and other documents, regulating energy sector activities, were prepared.

Important place in research activities was occupied by carrying out works of the international programs and investigations according to bilateral and multilateral contracts with international partners. Significant projects were performed according to the EC-5th Framework Programme:

- In the Laboratory of Renewable Energy two projects were carried out: *ERA Bio-energy Strategy – Short-Term Measures for Developing the European Research Area in the Field of Bio-Energy RTD* (project completed in 2003); *Organization for*

- *the Promotion of Energy Technologies Lithuania* (OPET-Lithuania) (2003-2004);
- Energy Efficiency Research and Information Center carried out three projects: *Network Organisations for the Promotion of Energy Technologies* (OPET, CHP/DH, (with Denmark) ir *OPET BUILDING* (with Austria) (2003-2004) and *Efficient Energy Consumption in Buildings* (with Ireland, 2002-2003);
- *MID-Procedures*. Project was carried out in 2001-2003 by the Laboratory of Heat-Equipment Research and and Testing and NMIN, Holand;
- *Thermochemical Conversion of Solid Fuels*. Project is being carried out in 2002-2005 by the Laboratory of Materials Research and Testing, and Institute for Chemical Processing of Coal, Zabre, Poland;
- Two projects – *Analysis of Policy Instruments and Identification of Tools for the Implementation of Rational Energy Use and Renewable Energy Sources in EU Candidate Countries* (2003-2006) and *The European Network for Energy Economics Research (NAS-ENER)* (2001-2004) is being carried out by the Laboratory of Energy Systems Research.

Out of a number of proposals of the Institute for EC FP6 in 2003, the Institute signed three contracts with European Commission to participate in projects performance of EU FP6.

State funded scientific research programs included 21 scientific research projects, six of which were completed in 2003 (listed below).

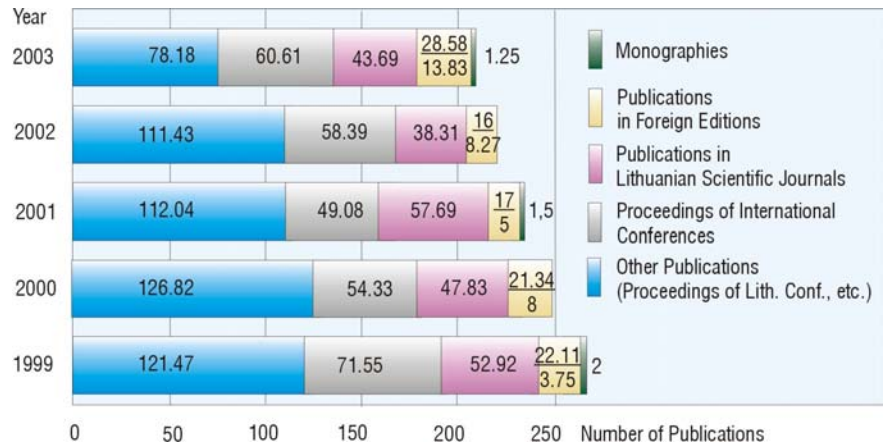
Title of the completed project	Direction of scientific activity	Leading researcher
Analysis of the Nuclear Fuel Back-End Cycle Problems in the Preparation of the Decommissioning of the Unit 1 of Ignalina NPP.	I	Prof. P. Počkas
Assessment of Lithuanian Energy and Transport Systems' Impact on Water Bodies, Implementing Environmental Objectives.	I	Prof. B. Gailiučis
Development of Air Volume and Flow Rate Units Standards Based on Weighing Method.	II	Dr. Habil. A. Pedičius
Investigation of Flow Rate Standards Aiming at Developing standard Value Sources and Reestablishing Liquid Flow Units.	II	Dr. G. Zygmantas
Modelling of Three-Dimensional Thermo-Hydrodynamic Transfer Processes in Water Reservoirs.	II	Dr. Habil. P. Vaitiekūnas
Development of Solid Oxide Fuel Cell Electrolyte Using Physical Vapor Deposition Methods.	IV	Dr. D. Milėšius

On 31st of December, 2003 the number of employees of the Institute was 290 including 17 Doctors Habilitus, 65 PhD, 29 PhD Candidates and 32 with M.Sc. and B.Sc.



Variation of staff number

In 2003 scientists of the Institute presented 185 papers in various international and national conferences. They published 213 publications (taking into account co-authors) in international and national scientific journals, conference materials and other editions.



Variation of publications number (Author's contribution evaluated)

In 2003 three researchers of the institute defended Doctor of Science theses and two – Doctor Habilitus of Science theses:

- on February 25, 2003 Doctor of Science degree was conferred by the LEI on Egidijus URBONAVICIUS for his work *Simulation of the Thermalhydraulic Processes in the Compartments During Loss-of-Coolant Accidents* (power and thermal engineering);
- on December 1, 2003 Doctor of Science degree was conferred by the Vytautas Magnus University on Aučra PAZERAITE for her work *Formulation of Pricing Methodology for Electricity Transmission Service* (social sciences and management);
- on December 22, 2003 Doctor of Science degree was conferred by the Kaunas University of Technology on Robertas POČKAS for his work *Turbulent Mixed Convection Heat Transfer in Flat Channel with Opposing Flows* (power and thermal engineering);
- on February 11, 2003 Doctor of Science Habilitus degree was conferred by the LEI on Juozas AUGUTIS for his work *Risk Assessment and Control of the Hazardous Energy Objects by Integrated Methods* (power and thermal engineering);
- on April 30, 2002 Doctor of Science Habilitus degree was conferred by the LEI on Algirdas KALIATKA for his work *Accidents Management for RBMK-1500 Type Nuclear Reactors* (power and thermal engineering).

On December 29, 2003 in the field of thermal physics a patent was legitimated on *Method for Initiation of Condensation Implosion Events* (authors – K. Almenas, R. Pabarcius, M. Seporaitis; patent No. LT 5087B).

Institute had bilateral cooperation agreements with the Danish, German, Polish Swedish, and USA organizations. The contracts for scientific research and applied scientific activities were concluded with partners from Denmark, France, Holland, Latvia, Norway, and other countries.

The Institute cooperates closely with many Lithuanian institutes and universities, including Kaunas University of Technology, Vilnius Gediminas Technical University, Vytautas Magnus University, Vilnius University, Institute of Geology and Geography, Institute of Ecology and others.

Main directions of cooperation:

- scientific and pedagogical cooperation in conferring scientific degrees and arranging post-graduate studies;
- mutual employment and strengthening of the scientific experiment facilities;
- joint scientific investigations with participation of scientists and students;
- participation in scientific projects and programs and formation of scientific joint groups to solve urgent topical problems;
- participation in the training process and educational experimental works;
- preparation and organization of publishing activities, conferences, seminars and other important events;
- analysis of important problems for Lithuania in the fields of hydrology, environmental protection and water economy.

Main directions of the Laboratory research:

- Determination of renewable energy sources (RES), assessment of their utilization prospects and solution of environmental protection problems;
- Search for updated technologies of utilization of local and RES, feasibility assessment, preparation of regulation norms, legislation and project documents, formation of databases, services and consulting of customers;
- Modelling of heat transfer and hydrodynamic processes in water reservoirs-coolers;
- Investigation of application of the heat cost allocators by implementing the method of payment for actual energy consumption of separate flats in multi-storey building. Creation of calibration equipment for heat and fluid flow-rate metering devices.

In 2003 main investigations in the Laboratory were carried out solving the problems related to promoting RES utilization, adjusting to the requirements of the EU directives. Investigations were also performed in the field of modelling of heat transfer and hydrodynamic processes in water reservoirs-coolers.

Investigations of efficient utilization of RES and environmental protection issues.

Investigations were performed in regard to RES utilization for heat and electricity production. It is determined that RES in Lithuania comprise about 8.5% in primary energy balance. However, power production from these RES comprises only about 3.2% from consumed power quantity. In order to fulfill the requirements of the EU directives 2001/77/EC it is obligatory to master different types of RES, especially emphasizing wind energy.

The investigation was launched in order to increase the efficiency of solid biomass utilization for power production. All cycle of fuel production and utilization will be analyzed, starting with feedstock preparation, its conversion into various fuel types – wood chips, briquettes, pellets and finishing with the investigation of combustion process in furnaces.

While cooperating with Technical University of Denmark, experimental investigations of combustion process in biomass fuel bed were carried out. Primary conditions (fuel type, shape of fuel particles, humidity, delivered air quantity, temperature, etc.) impact on combustion process parameters (ignition front velocity, temperature and combustion products (CO, CO₂, NO) concentrations) was determined. Obtained results enabled to optimize combustion process and increase the efficiency of combustion system as well as to reduce the quantity of emissions in the environment.

Calculation method for the solar passive heating systems of the buildings was designed. The latter method evaluates thermal processes variation, which occurs in heating systems, and their regulation possibilities due to different seasons of the year.

Scheme of the territory zones for wind turbines sitting in Lithuania was developed. It evaluated wind energy potential, technical possibilities of power transmission nets and environmental requirements, determining for each zone economically justified wind turbine construction total power quota. Pre-design studies on wind power plants construction were carried out.

Investigations of the RES utilization 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*. Assessment of wind turbulence impact on the power indicators of wind power plants was carried out as well. On the seaside a modern measuring equipment (WICOM-C, Germany) was installed in order to determine wind velocity, its turbulence and other power parameters. Measurements were performed 10, 30, 50 m above the land surface. Computer codes were developed to calculate wind integral characteristics (velocity, direction, wind rose, Veilbul parameters, etc.)



Straw combustion boiler in Juknaiciai boiler-house (thermal power of one boiler – 250 kW, four boilers installed, total power – 1000 kW)



Solar collectors.
SE Children's sanatorium of Kacergine

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

- *Development of the Elements of Innovative New Wind Turbines* (Cooperation with Ukraine);
- *Enhancement of Local and Renewable Energy Sources Usage – Lithuania* (Cooperation with Danish Energy Management A/S);
- *ERA Bio-energy Strategy – Short-Term Measures for Developing the European Research Area in the Field of Bio-energy RTD*. The project was executed according to FP5 programme (finished in 2003).
- *Organization for the Promotion of Energy Technologies Lithuania (OPET- Lithuania)*. Project has been carried out according to FP5 programme (2003-2004).
- *Regional Bioenergy Initiatives Around Europe*. The project was carried out according to EU ALTENER programme.
- *Pre-normative Project on Solid Bio-fuel Samples Selection and Testing with the Aim to Create Quality Security Systems (Bio-Norm)*. The project was carried out according to FP5 programme.

Utilization of landfill gas and municipal waste. Projects, related to the assessment of landfill gas collection and utilization possibilities in Lithuania, are completed. Information is gathered and experience is applied, giving consultations for the concerned organizations.

Modelling of heat transfer and hydrodynamic processes in the water reservoirs-coolers. In the Laboratory investigations were performed on the assessment of Druksiai lake thermo-hydrodynamic state. Turbulent model of water mixing was created, inter-phase friction and heat transfer coefficients were determined, numerical model of the three-dimensional thermo-hydrodynamic transfer process in water reservoirs was prepared.

Account of heat consumption in residential buildings. Heat saving possibilities in the multi-storey buildings in various Lithuanian cities by introducing a new method of accounting for actual heat consumption in each flat, based on the data

gathered by heat allocators, mounted on the radiators, were examined. Engineering specifications of the equipment used for heat and flow meter checking and validation were prepared and construction of validation rigs was continued.

In the course of implementation of these programmes the Laboratory in cooperation with the institutions of other countries carried out investigations on biomass, wind and solar energy, biogas, landfill gas and other RES resources, and possible utilization of other technologies. Together with Danish Power Agency, a home page on renewable and local energy sources and their utilization technologies was created (<http://www.avei.lt>).

The experts of the Laboratory took part in preparation of the *Lithuanian National Solar Program 2000–2005*, supported by UNESCO, which in turn will be included into the *World Solar Program 1996-2005*. This programme includes not only solar energy but also other RES (biomass, wind, water and geothermal energy, etc.) utilization.

Presentations were made in LITEXPO exposition-conference *Renewable Sources Energy in Lithuania and Other Countries*. Laboratory experts are included into work groups, structured by the Government of Lithuanian Republic, preparing bio-fuel production and utilization programs and solving ecological fuel production problems, participate at United Nations Development Programs conferences. Three scientific articles were published in scientific journals and other scientific publications. Laboratory researchers participated at four international and seven Lithuanian scientific conferences.

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Main activities of the Center:

- To accumulate, analyze and convey to experts and society the experience of efficient energy consumption in Lithuania and abroad;
- Projects for the realization of National Energy Efficiency Programme;
- Participation in international projects, organization of conferences and training courses.

In 2003 two projects funded by the government were completed: ***Investigation and assessment of the implementation of progressive, energy efficient technology, tools and technologies and their usage in industry and buildings***, and ***Investigation of mini and micro cogeneration technologies' efficiency and their integration into geothermal energy consumption schemes***.

Data was collected on energy consumption in industry during 1996-2002, the analysis was carried out. The possibility of using waste heat, existing in smoke, cooling it under dew point temperature, burning natural gas or bio-fuel in boilers, was investigated. International experience, applying condensation economizers, designed for eliminated heat consumption, was analyzed. Calculation method was developed for choosing these economizers and implementing them in Lithuania.

Possibilities of using mini and micro cogeneration power stations in Lithuania were analyzed.

The Center took part in the implementation of National Energy Efficiency Programme. Series of legal documents for **Heat Law** was prepared: regulations of heat supply and consumption, methodologies of heat allotment in residential buildings, regulations of license for heat supply and other document projects.

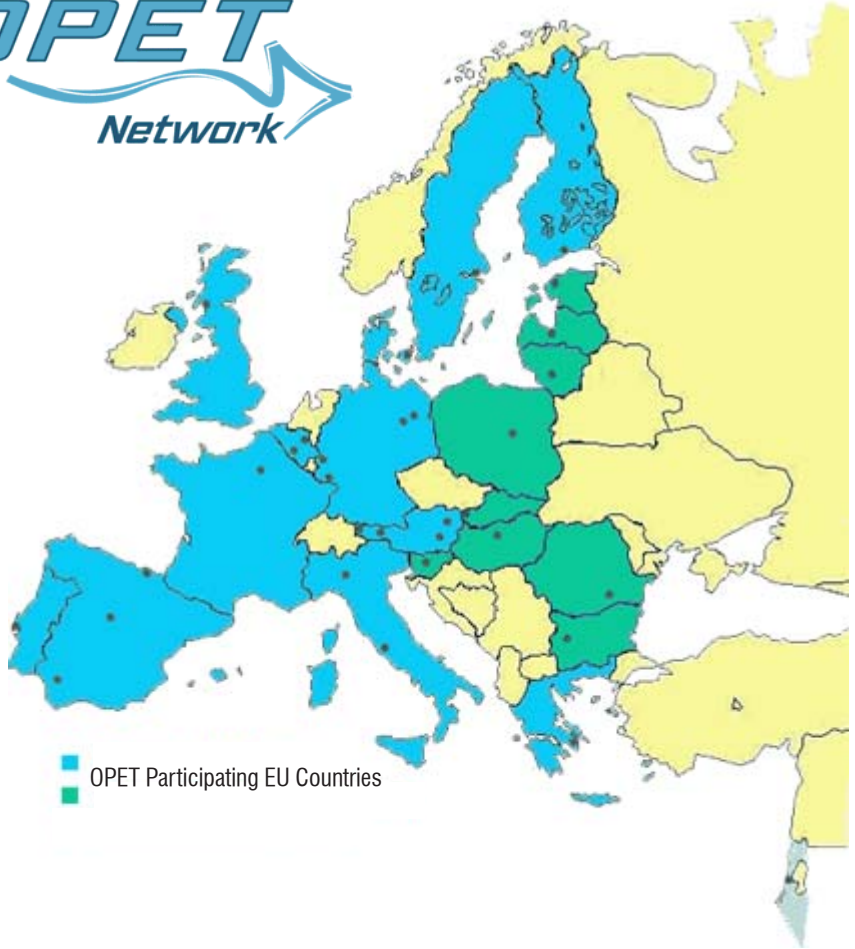
In pursuit of selected aims the Center:

- 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 helps 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.



International seminar *Realisation of Projects on Rational Energy Use and Renewable Energy* (November 27–28, 2003)





In 2003 several international projects were carried out.

Main projects: *Network Organisations for the Promotion of Energy Technologies* (OPET, CHP/DH, OPET BUILDING, EC-5th Framework Programme, performed together with partners from 46 European countries) and *Clearing House for Third Party Financing in Eastern Europe* (SAVE programme, performed together with partners from nine European countries). These projects are designed for the implementation of new progressive technologies, which increase energy generation and consumption efficiency, for increasing the diversity of supply and broadening the use of renewable energy sources, and for the implementation of energy efficiency means, applying the so-called *third party financing* schemes.

Together with National Technical University of Charkov, the project *Development of Energy Saving Means in Heat Sector, Implementing Modular Energy Production Technologies in Modernized Heat Substations* was carried out. The objective of the project was to create technical and economical means, the implementation of which would enable to increase the efficiency of final heat energy consumption.

Other significant projects: *Efficient Energy Consumption in Buildings* (EC-5th Framework Programme, 45 European countries participated), *Energy Service Companies in Lithuania* (ESCO)(SAVE programme, partners – AF-International AB (Sweden) and MAICON (Great Britain), *Europe Energy Award – European Certificate and Quality Management System for Municipalities, which Use Energy Efficiently* (SAVE programme, four countries participated). These projects are designed for the increase of energy consumption efficiency, promotion of private funds into energy consumption efficiency means, improvement of energy consumption management in municipalities.

According to the investigation results, in 2003 10 scientific articles were published, 7 papers were presented in international conferences. 3 international seminars were arranged together with partners from Germany, Sweden 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 parameter measurements, establishment and maintenance of state flow standards and ensuring measurement traceability to national and international standards;
- Tests of the thermal equipment and gas appliances carried out with the aim to determine its conformity to the requirements of Lithuanian and European regulated documents.
- Application of theoretical and experimental methods, relating flow hydrodynamic parameters investigations to unique metrological parameters of reference facilities and working standards and measuring means;
- Investigation of liquid physical characteristics and influence of flow disturbances on the metrological characteristics of reference and working volume and flow rate meters, operating under different principals. Assessment of metrological characteristics, obtained from calibrating meters by fluids-substitutes, and reliability in measuring real flows of technical and nutritional liquids;
- Scientific research in order to develop methodologies of liquid and gas flow, to determine the impact on measuring accuracy and forecast energy sources consumption non-balances.

The Laboratory, performing the authorization of the Government of the Republic of Lithuania, investigates and develops state standards, comprising of four reference aerodynamical facilities, intended for the recreation of air velocity from 0.2 up to 30(60) m/s and air volume and flow from 0.005 up to 6500 m³/h unit values and transfer them for working standards.

According to State Metrology Service specifications of 2003, in 2004 it is expected to complete the development of remaining facilities, intended for recreating water and liquid fuel volume and flow rate units. After the implementation of these procedures, covering standard facilities construction, investigation, laboratory comparisons, all state standards, created in the Laboratory will meet the international level and main metrological demands of Lithuanian economy and science.

At present measurement ranges of Laboratory standard facilities are the following:

- Air (gas) velocity 0.2-60 m/s;
- Air (gas) volume/flow rate 0.005-6500 m³/h;
- Water volume/flow rate 0.01-50(100) m³/h;
- Liquid fuel volume/flow rate 1.0-120 m³/h.

The Laboratory is also accredited for the calibration of heat, pressure, temperature and liquid level in tanks measurement devices.

In 2003 calibration and measurement capabilities of Laboratory standards were evaluated positively at the international technical committee FLOW of EUROMET organization and were confirmed by BIPM leadership.

In 2003 the Laboratory actively participated in implementing the directives of EU Council in Lithuania, related to conformity assessment of gas, water and liquid fuel meters, as well as water boilers and gas appliances. Four new testing facilities were created for testing meters and heat-equipments. The field of meters calibration was enlarged 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. Besides, the Laboratory prepared and presented all necessary documents for Lithuanian National Accreditation Bureau in order to establish and accredit the inspection body.

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



Scientific researchers and PhD candidates of the Laboratory nearby state standard of water volume and flow units



In 2003 heat-equipment testing facility was designed

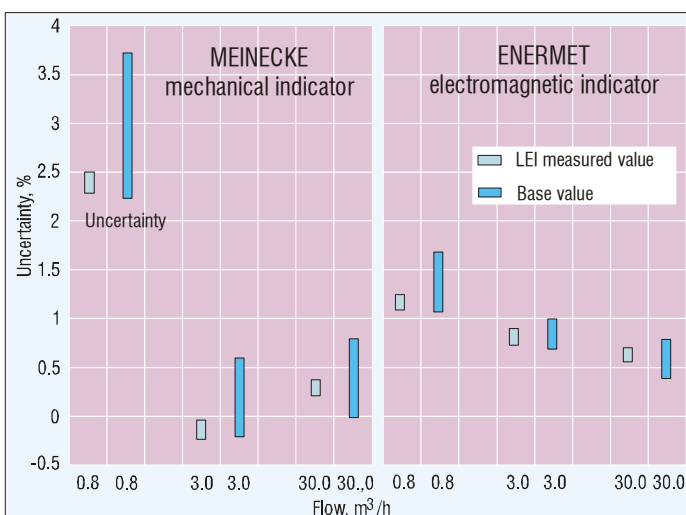
In 2003 water meters testing facility was validated



The most significant projects in the field of scientific investigations were related to the development of state standards, especially recreating small values of velocity and flow rate. Much attention was given to the investigations of gas, water and liquid fuel supply consumption balance.

Main research results of 2003 are the following:

- two state budget funded reports were prepared on developing and investigating standards of air and liquids volume and flow rate;
- researchers of the Laboratory participated in training and qualification courses, organized by the specialists from Denmark, Sweden and Metrology Institute of Kaunas University of Technology;
- successful participation in the activity of comparisons of flow meters calibration results, organized by metrology institutes of Denmark and Austria; comparison of liquid fuel meter calibration results;
- Laboratory researchers participated in Lithuanian and international conferences, presented eight papers, seven articles were published in the following journals: *Measurements, Power Engineering*. Interlaboratory comparison FL3 prepared by European Accreditation Organization (in which 35 metrology laboratories from 18 countries participated) was completed.



FL3 results of international interlaboratory comparison

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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;
- Numerical simulation of the motion of granular material and its employment in combustion processes.

The focus of the Laboratory of Combustion Processes was the development of efficient and ecological combustion technologies, their utilization and practical implementation.

Investigations were carried out in order to increase the efficiency of fuel combustion, applying the interaction of heavy fuel oil droplets with hot surfaces. Investigations revealed that 90% of droplet mass evaporates in the first seconds of droplet's interaction with hot surface. Coke residue burns five times longer than the droplet evaporates.

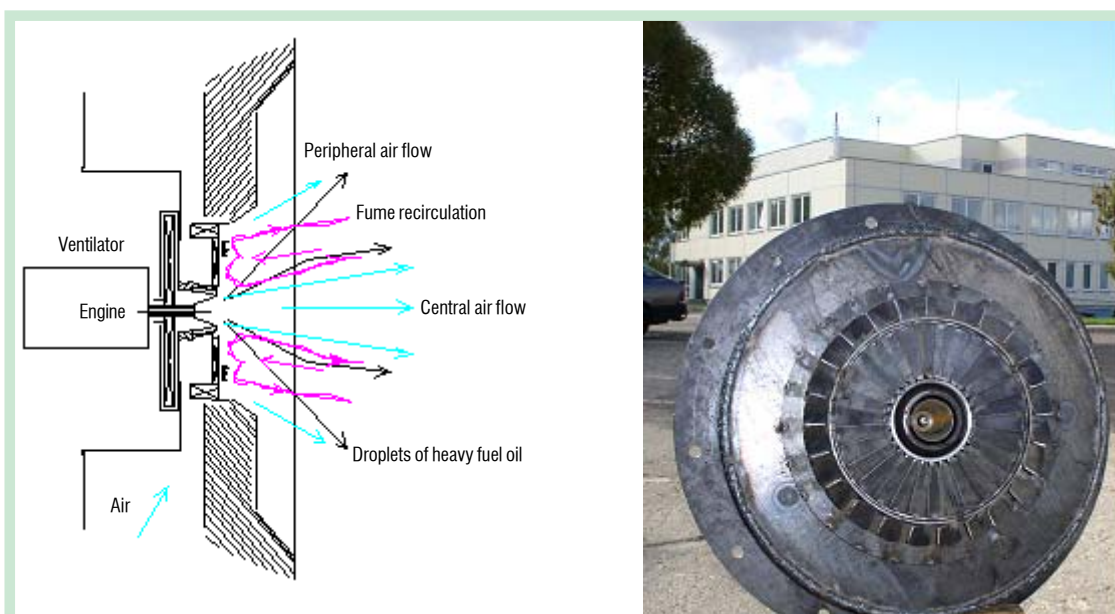
When the thermal conductivity of hot surface increases, the micro-explosion of droplet is reached much faster, which speeds up droplet's combustion. The increase of droplet or its flow velocity and the employment of catalyst allows for several times to speed up the combustion of coke residue.

The process of small heavy fuel oil droplets combustion in a furnace was investigated, when droplets are spread out from the burner by individual jets. It was determined that when concentrated small heavy fuel oil droplets ignite in jets, combustion products that spread up very rapidly in the environment of jets, compose secondary transversal turbulent flow. This speeds up and improves fuel combustion, fewer CO and other not completely burnt products remain in comparison to small heavy fuel oil droplet combustion, when droplets are gradually spread out in a furnace all over the burner.

A rotary cup burner of low capacity (2 MW) was designed. A better method was applied to it for controlling air jets of a burner and recirculating flow.

Numerical simulation of the motion of granular material. Recently much attention all over the world is given to the numerical simulation of particle system dynamics, when each particle motion is solved directly. For the present the motion of granular material, as well as atoms and molecules, can be calculated.

The Laboratory together with the researchers of the Karlsruhe Research Center (Germany) developed the code, which enables calculations of the motion of granular



Principal working scheme of rotary burner for steam boiler DE-6.5-14

Rotary burner for steam boiler DE-6.5-14

material. It was applied for thermal decomposition and utilization of solid waste in rotary kilns, on moving grate and for other analogous processes. The calculation methodology is based on the direct motion determination of each particle of granular material. Particles are described, applying Object-oriented technique. It enables to simulate the motion of three-dimensional particles in various technological facilities. This code can be easily adapted for solving molecular dynamics tasks.

The code was successfully applied while investigating the precipitation of electrical neutral and charged soot particles and porosity of collected particle layer. The obtained results supplemented existing experimental data and revealed new details, e.g. calculations of granule movement on the moving grate gave not only the average granule stay duration on the grate, but also showed that due to granule particle size segregation the small granules remain longer on the grate and this significantly affects and changes combustion processes over the grate.

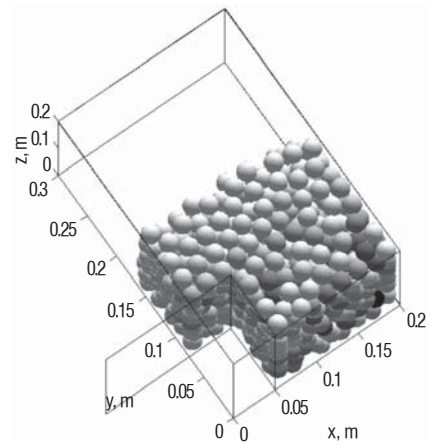
Other significant projects. D10 burners, designed in the Laboratory, were implemented in JSC *Grigiskes* steam boiler GM-50-1. Six burners were used in it for natural gas, leaving a possibility, if necessary, to burn heavy fuel oil as a reserve fuel. This work was carried out together with JSC *Elinta*,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

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

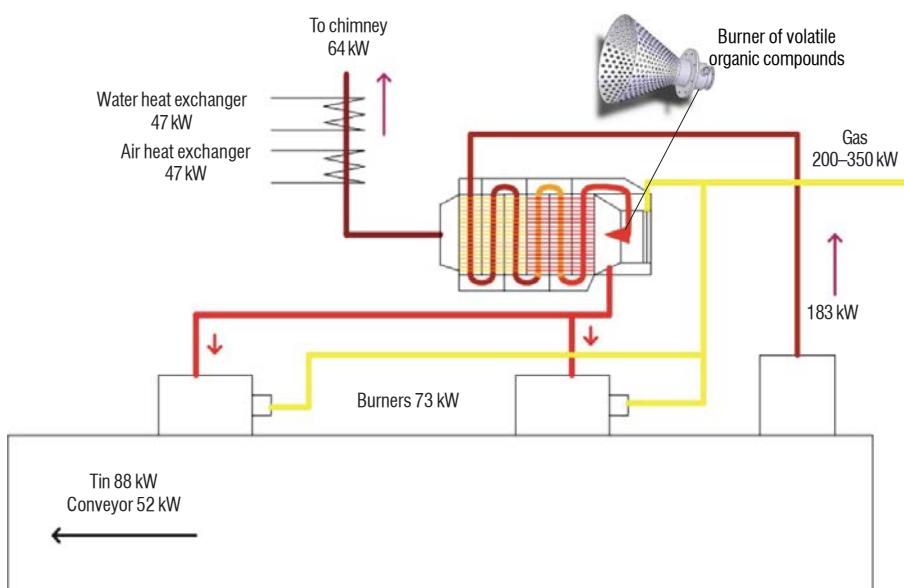
Burners of volatile organic compounds, constructed in the Laboratory, were implemented in JSC *Metalo zenklai* and JSC *Elmoris* tinplate lacquering processes. Volatiles, relieved in the ovens, the concentration of which is 5-10 g/m³, are burnt up to the allowable value of 50 mg/m³. The Project is prepared on heat recuperation to the technological process, which enables up to 30% reduce natural gas technological consumption.

Environmental impact assessment of technical upgrading and erection of flue gas treatment equipment is carried out by JSC *Lietuvos elektrine*.

Cooperating with AIE GmbH consulting company (Germany), the implementation study was prepared on orimulsion firing in Vilnius power plant. Feasibility study for connection to gas network of Mazeikiai power plant was prepared as well, evaluating possible join of power plant with refinery company *Mazeikiu nafta*.



Numerical simulation of 3D particles mixture on moving grate



The scheme of volatile organic compounds burning in tin-plate lacquering processes

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Main research areas of Laboratory:

- Experimental investigation of turbulent mixed convection heat transfer regularities in single-phase flows;
- 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 assessment;
- Management of radioactive waste: strategy, treatment technology, storage and disposal facilities, safety assessment of technology and storage facilities, legal and regulatory base;
- Fire hazard analysis in nuclear power plants;
- Assessment of different factors related to decommissioning of nuclear power plants.



High pressure chamber for investigation of mixed convection in oblique channels

Experimental and numerical heat transfer and turbulent transport investigation. The Laboratory has an comprehensive experience of 30 years in investigations of heat transfer and flow hydrodynamics to support design of different applications (nuclear reactors, heat exchangers and their elements, etc.).

Experimental investigations on turbulent mixed convection heat transfer in inclined flat channel (10° , 20°) with one-side heating for opposing airflows were continued in 2003. Also numerical modelling of local heat transfer, velocity and temperature profiles with FLUENT6 code was performed in vertical flat channel with symmetrical heating for aiding flows under different cases of mixed convection. Modelling of hot gas flows, caused by fire in high shafts, was carried out as well.

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

Laboratory has been and is performing studies related to safety assessment of spent nuclear fuel storage. Assessments

have been made for the casks with fresh and burned-up nuclear fuel, at the beginning and at the end of interim storage period, under normal operation and accident conditions.

In cooperation with the Institute of Physics, dosimetric and spectroscopy measurements on the surface of casks and in different distance from them were experimentally performed in spent nuclear fuel storage site. Measurement data was compared to modelling results.

In 2003 criticality assessment of casks with larger fuel assembly capacity under normal and accident conditions was performed. SCALE4.3, ALGOR (USA), APPOLO1, PEPIN (France) codes were used for the assessment of spent nuclear fuel characteristics, casks criticality safety and radiation doses, and thermal assessment.

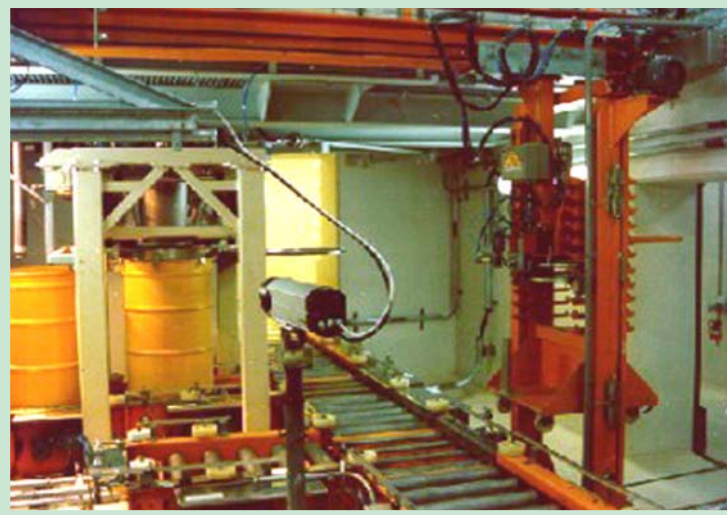
Safety evaluation of radioactive waste management. Since 1994 the Laboratory has been actively involved in the analysis of the radioactive waste management problems at INPP.

Laboratory experts together with experts from SKB International (Sweden) carried out many projects, including safety evaluation of existing radioactive waste

storage facilities. The laboratory actively participates in the project - *Installation of a Cement Solidification Facility for Treatment of Liquid Radioactive Waste and Erection of a Temporary Storage Building for INPP* (2001-2004, Framatome ANP, Germany). Together with Framatome ANP GmbH *Preliminary Safety Analysis Report and Environmental Impact Assessment Programme and Report* were prepared and approved by competent institutions of the Republic of Lithuania. In 2002-2003 *Technical Project* was approved by competent institutions of the Republic of Lithuania as well. In 2003 INPP got a permission to launch construction procedures. In 2004 it is expected to prepare *Final Project Safety Analysis Report* and to launch the activity of project commissioning licencing.

In 2003 Laboratory experts together with SKB International experts completed the study on *Feasibility Study to Establish a Facility for Handling Radioactive Waste at Maisiagala*. Laboratory experts performed a preliminary safety assessment of proposed facilities.

Long-term safety evaluation of radioactive waste repositories. Since 1996 laboratory experts have been participating in projects related to the long-term safety assessment of existing radioactive waste storage facilities at Maisiagala and Ignalina sites. Important conclusions were drawn concerning limitations and possibilities to convert these storage facilities into repositories. Laboratory also participated in the IAEA coordinated research programme *Improving Long-Term Safety Assessment Methodologies for a Near Surface Radioactive Waste Disposal Facilities (ISAM)*, in SKB-SWECO International-Westinghouse Atom Joint Venture project *Reference Design for a Near Surface Repository for Low- and Intermediate-Level Short-Lived Radioactive Waste in Lithuania*.



Cementation facility of liquid nuclear waste



In 2002 Laboratory staff together with Swedish experts drafted regulations *General Radioactive Waste Acceptance Criteria for Disposal in Near Surface Repository*. Continuing this project in 2003 recommendations on admissible activity limits for a short lived low and intermediate level radioactive waste package series to be considered as a candidate for a near surface disposal were prepared.

In 2003 our specialists with the assistance of Swedish experts prepared criteria for choosing near surface repository, design concept and implementation programme for a near surface repository. Together with Radioactive Waste Management Agency, Geological Survey of Lithuania and Institute of Geology and Geography was prepared *Report on the Identification of Candidate Sites for a Near Surface Repository for Low and Intermediate Level Radioactive Waste*. For the safety assessment of near surface repositories DUST, GENII, GWSCREEN (USA), AMBER 4.4 (Great Britain) codes were applied.

Moreover, in 2003 Laboratory proposed the concept of deep geological disposal in clay in Lithuania, it also launched preliminary safety (criticality, radiation doses, heat removal) assessment, applying COMP23, COMPULINK (Sweden), SCALE4.3, FLUENT6 codes. The Laboratory constantly participates in IAEA coordinated research projects, such as *Improving Long-Term Safety Assessment Methodologies for Near Surface Radioactive Waste Disposal Facilities (ISAM) (1998-2001)*, *Application of Safety Assessment Methodologies for Near Surface Waste Disposal Facilities (ASAM) (2002-2005)*.

Fire hazard analysis in nuclear power plants. One of the primary aspects in order

to escape nuclear accidents is protection from nuclear objects fire hazard. From 2001 up to 2003 extensive and complex projects on performing INPP Unit 1 and Unit 2 fire hazard assessment were carried out together with Sweden experts. Complex fire hazard assessment of most important rooms with safety related systems elements and adjacent rooms was performed. During fire hazard assessment the consistency of INPP to safe reactor shutdown criteria was evaluated. Modelling of fire propagation in the most important rooms was also performed. These projects are one of the most successful conditions for licencing of INPP units.

Evaluation of different factors for decommissioning of NPPs. In 1998 Laboratory scientists started a new branch of research activity related to the planning of the decommissioning of Ignalina NPP. Our experts participated in PHARE project preparing *Preliminary INPP Decommissioning Plan*. An extensive data basis was accumulated, DECOM software was developed, which enables to evaluate INPP equipment extent, preliminary nuclear waste quantities and expenses of designed procedures. This code is further developed in the Laboratory, supplementary radiological and technical data of INPP systems is revised.

In 2002-2003 Laboratory experts commenced preparing final decommissioning project for INPP decommissioning department paying basic attention on radioactive contamination evaluation of the most important systems. For this purpose LLWAA-DECOM software of TRACTEBEL (Belgium) was used, which was adjusted to RBMK type reactor, additional software means, created in Laboratory, were used as well.

In 2003 in the Laboratory the project *Substantiation of Methodology for Deducations into INPP Decommissioning Fund* was carried out. International practice in deducations into decommissioning funds of nuclear power plants was evaluated and generalized. Calculation methodology for deducations into INPP decommissioning fund and DECOM/IMOKA-2 code were prepared.

In 2002-2003 our experts together with RWE NUKEM specialists prepared the programme for INPP personnel training, which corresponds to the training programmes of UK nuclear energy objects decommissioning.

Since 2002 Laboratory participates in IAEA coordinated research project *Disposal Aspects of Low and Intermediate Level Ignalina NPP Decommissioning Waste*. In 2003 radioactive deposit formation and their activity assessment methodology at the final reactor shutdown was prepared, also expected amounts of radioactive waste to be formed in the circuits were analyzed in detail and were evaluated in the whole power plant.

In 2003 the Laboratory completed state funded project and performed 11 commissioned procedures. The personnel actively participated in various training programmes, presented 17 papers in international conferences (USA, Great Britain, Germany, Austria, Ukraine, Lithuania), published 25 scientific articles in Lithuanian and international journals.

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Main research areas of the Laboratory:

- Testing of materials, evaluation and analysis of their quantitative indicators;
- Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium-based alloys;
- Investigation of degradation of heat carrier pipes;
- Research and development of arc-plasma reactors, diagnostics of plasma jets and flows;
- Neutralization of hazardous waste;
- Synthesis and characterization of catalytic, tribological coatings and plasma polymers.

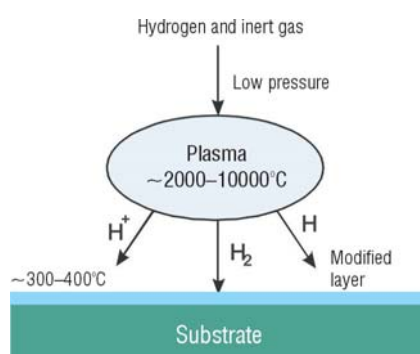
Hydrogen storage. Successfully finished and prolonged project together with Sandia National Laboratory (USA) in the area of hydrogen storage employing metal hydrides. Synthesis of nanocrystallite metals and their alloys, intended for hydrogen storage, was carried out, employing physical synthesis methods of thin structures, one of which is magnetron sputtering with plasma activation. The investigation was carried out on obtained structures' features, employing four probes method, i.e. XRD, SEM, GDOES. XPS, SIMS, SEM+EDS methods that are applied in the work, are also used at Pouters University (France). The hydriding of nanocrystallite metals and their alloys is performed employing non-equilibrium plasma processes, which enables to escape thermodynamics restrictions while enriching nanomaterials with hydrogen and synthesizing them under low temperatures (lower than 100 °C).

Investigations in the field of hydrogen energy. Thin layered solid oxide fuel cells. In 2003 the primary study on synthesis possibilities of active elements, designed for hydrogen energy, applying ion-plasma activated methods, was finished. Firstly, materials were selected that meet the functions of electrolyte and anode of thin layered solid oxide fuel cells. Technologies of magnetron sputtering and plasma spraying were used for synthesis procedures. Electronic-ionic conductivity methods of thin structures were analyzed and primary ionic conductivity measurements of obtained structures were performed. Synthesis projects of yttrium stabilized zirconium oxide electrolyte, applying oxidation of metal structures (Y/Zr) in the air and oxygen plasma, had been carried out. The obtained coatings were analyzed, using the scanning electron microscope (SEM), atomic force microscope (AFM), x-ray diffraction method, and second ion mass spectroscopy (SIMS). Ion conductivity of the above given coatings was measured as well.

Investigations on the impact of temperature and chemical environment for micro-structure of thermocouple alloys and metrological characteristics. Complex high temperature investigations of thin chromel-alumel thermal electrodes in oxidized environment had been carried out determining regularities of oxide coating and variation of resistance. Means were proposed for the assessment and control of thermoporous oxidation degree. A method was proposed for determining materials' heating conductivity rate by two measuring methods at one time.

Investigation of heat carrier pipes degradation. Experimental facility was created for experiments of permanent thermal insulated pipes, the impact of temperature for pipe systems and their characteristics performance. Temperature distribution pipe system cross-section analysis was carried out. Density of foam polyurethane and pairs distribution in polyurethane coating were investigated. Impact of technological changes on isolated pipes set and their physical mechanical features were investigated as well. Investigations and analysis on casing surface of polyethylene pipe were performed.

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 allows to carry out building products testing according to the international standards and European Norms requirements.



Plasma hydriding scheme



Pipe breaking facility

In 2003 together with ten laboratories from other countries IAEA coordinated project *Hydrogen and Hydride Induced Degradation of the Mechanical and Physical Properties of Zirconium-based Alloys* was carried out. During this project investigations of hydrogen induced cracking process were carried out, main aspects were determined, which influenced hydride crack propagation and growth in technological channels of nuclear reactors. Significant objective of this project was to create a consistent methodology of hydrogen induced cracking process rate in technological channels and to guarantee the exchange of technologies, experience and obtained results among project participants.

Safety Analysis Report of Ignalina NPP Unit 2. In 2003 analysis assessment of Ignalina NPP Unit 2 technological channels ageing was performed. Laboratory staff together with Lithuanian and international experts participated in performing expertise projects on security of management programme of ageing, operating norms, rules and procedure analysis. The aim of these investigations was to guarantee maintenance of relevant safety level of Ignalina NPP.

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 turbulization were investigated. Means and conditions were determined how to obtain air, nitrogen, argon, 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 reaches 100 m/g, were formed in plasma flow.

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

In 2003 the staff of the Laboratory participated in 18 international conferences, presented 17 papers in Lithuanian and international conferences. Results of the investigations were presented in 30 articles, 19 of which were published in prestigious journals.

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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;
- Structural analysis of plant components, piping and other parts of Main Circulation Circuit;
- 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;
- Development and validation of coupled neutron kinetics thermal-hydraulic RBMK-1500 model for RELAP5-3D code;
- Single failure analysis and engineering assessment for complex technical systems;
- Investigation of condensation implosion phenomena in water-steam contact;
- Risk and hazard analysis of industrial sites.

In 2003 researchers of the Laboratory together with Lithuanian and international customers performed fundamental and applied projects. These projects were intended not just for the assessment and development of INPP safety but also for the safety and reliability assessment of other industry objects.

Fundamental investigations

One of the main objectives of the Laboratory is fundamental investigations and experimental development. In 2003 the personnel of Laboratory of Nuclear Installation Safety carried out experimental and simulation investigations in the fundamental investigations' programs, that are funded by the government.

In thermal physics the study is being proceeded – *Investigation of Condensation Implosion Event Initiated by Hydrodynamic Instability*. The strategy of this study is connected to the employment of pressure drop, which occurs during the implosion in individual parts of thermal hydraulic system, forming a transport cycle of energy and mass, opposite to a natural circulation. It is expected to improve experimental setup, to carry out a thorough investigations on condensation implosion in the water-vapour system, applying CFD code FLUENT in order to perform simulation investigations, to determine the parameters of steam and water inflow and to describe conditions, under which the hydrodynamic instability initiates condensation implosions in the system.

In the area of energy sector methods development, energy objects' safety and reliability, environmental impact, efficient energy consumption and renewable energy

sources investigation in 2003 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 employment of uncertainty analysis for 2D and 3D equation systems, while solving energy, economics, hydrology and neutron-dynamic tasks. The second work is related to the assessment of complex energy systems risk and reliability and development of management methods, formation of risks analysis methodology and hazardous processes control optimization methods. The methodology is expected to be applied for the assessment of INPP, 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 has been in close relations with VATESI for many years.

One of the main research areas in 2003 was review activities, related to the documents that are proposed for VATESI, in which the implementation of 2.6% enrichment uranium fuel with erbium in Ignalina NPP RBMK-1500 reactors, continued justification of replacement of mod. 2091-01 manual control rods with modified mod. 2477-01 rods and test justification for 4 new cluster control rods, were analyzed. Supplements expertise of INPP Technical regulations for reactor operation

was carried out. Performing another work, a regulated VATESI document, for the assessment of violation of RBMK-1500 intergranular corrosion, was prepared.

Cooperation with the Ministry of Economy of the Republic of Lithuania.

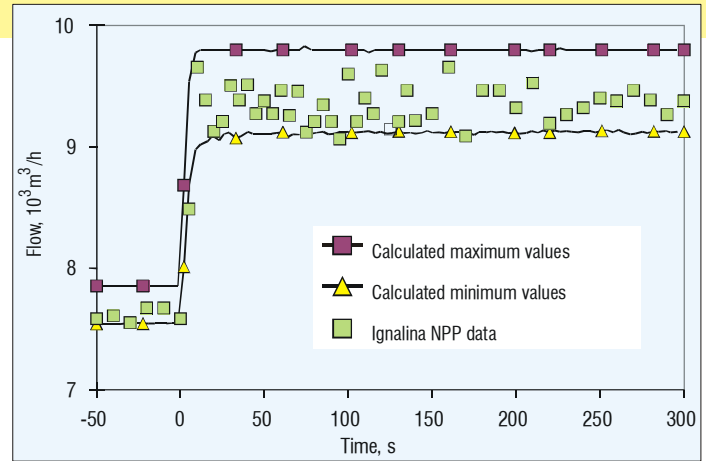
In 2003 the work *Review of Law on Nuclear Energy of the Republic of Lithuania and Documents, Related to it, Development and Arrangement of the Projects for Required Law Acts*, was performed. In the work the compatibility among the Law on Nuclear Energy of the Republic of Lithuania and legislation acts and their correspondence to other Lithuanian legislation acts were evaluated. Discrepancy of Lithuanian legislation acts to EU legislation acts, Euratom Treaty and international conventions, are analyzed. Project on the new Law on Nuclear Energy was prepared.

Cooperation with Lithuanian State Science and Studies Foundation.

A group of researchers initiated the study on *Investigation of Condensation Implosion Events in Water – Steam System*, which in 2003 was supported by Lithuanian State Science and Studies Foundation. A thorough review of investigations references on water-air/steam flow together with Kaunas University of Technology specialists had been carried out. Employment possibilities of condensation implosion in industry had been discussed. According to the review of performed investigations, experimental channel is designed, investigation limits in the case of non-condensing and condensing flow are chosen, obligatory measurement equipment is discussed. After performing primary experiments, it was determined that in the con-



Experimental setup for two-phase flow investigation



Probabilistic analysis of one compulsory circulation circuit possible rupture. Heat-exchanger flow directed through reactor's accident pump

structured rectangular channel it is possible to achieve designed flow regimes, register typical wave formation stages on the water-air surface.

Projects with science institutions of Ukraine.

In the second year of ongoing cooperation with the Institute of Technical Thermal Physics of the National Academy of Sciences of Ukraine, the verification of RBMK-1500 cooling circuit model in the field of heat and mass transfer, hydrodynamics and CHF analysis in the water-cooled nuclear reactors, was performed, employing INPP measuring data and accomplished transitional processes analysis. In the case of a single or all main circulation pumps cost down, uncertainty and sensitivity analysis was carried out. The work was supported by the Ministry of Education and Science, using the funds of Lithuanian and Ukraine State Cooperation Programme of 2002-2004 and funds of State Science and Studies Foundation.

Projects with Lithuanian partners

A close cooperation with INPP was continued and a treaty had been signed with JSC *Lithuanian Energy*.

The support of INPP probabilistic safety analysis.

The objective of this work is to create an information basis, which would allow to develop INPP probabilistic safety analysis models. In 2003 applying state-of-the-art codes, a complete loss of offsite power analysis had been carried out, evaluating possible operators' actions, their sequence and performance duration. This accident,

which had the most severe consequences, was chosen in order to foresee and justify the control means of unpredictable accidents. Probabilistic analysis of main circulation circuit possible rupture of downcomer pipes and pipe whipping consequences, after the guillotine pipe rupture, was launched.

Replacement of flowmeters due to the diagnostic results of 2003.

When the flowmeter brakes, the operation of the technological channel is interrupted until the shutdown of the reactor, and the flowmeter is being replaced than. Flowmeter diagnostics is being carried out before annual maintenance in order to avoid unpredictable accidents. From now on this examination is based on the methodology, which was earlier developed by laboratory researchers and according to which INPP technical solution is proposed. Performing this work, the laboratory researchers for the first time applying the above mentioned methodology, had carried out a diagnostic measures results analysis and determined which of the flowmeters had to be replaced in both NPP units in order to guarantee a reliable flowmeter system work until the next planned maintenance.

Forecast on the variation of gas-gap in the individual cells of INPP reactors according to control results of 2003.

According to the measures of 2003 (measures have been carried out annually since 1998), new forecasts of gas-gap variation are determined until the planned repair of 2004, and statistical analysis of new data is performed. It is determined that variation of the diameter of technological channel does not change and that varia-

tion is best described by a linear regression. The results had revealed that gas-gap, which was given in the regulation, meets the criteria under the probability bigger than 0.95. Uncertainty and sensitivity analysis of measures results was performed.

Risk-Based Optimization of Diesel Generators Testing Intervals at the Ignalina NPP.

In 2003 continuing the works according to the consulting treaty *Strategy of Negotiations of Integration into EU and National Energy Strategy*, the work has been carried out, which is related to INPP systems' reliability safety, replacing their control and technical maintenance procedures. While cooperating with Risoe National Laboratory (Denmark), testing intervals and breakdown statistics of INPP Emergency Diesel Generators System (EDGS) were investigated; mathematical model of reliability management was created. Breakdown statistics of EDGS was investigated, testing intervals economic effect was evaluated, and EDGS unavailability limit was determined in which the interval among EDGS testings could be increased if not exceeding the limit.

A new work is launched *The Complex for Burning the Fuel Unloaded from Unit 1 to Unit 2 in Ignalina NPP*.

Lithuania is committed to shutdown the INPP Unit 1. Technical and economical calculations show that the utilization of not fully burned fuel, which is left in Unit 1, for Unit 2 would enable to save more than 600 fresh fuel assemblies.

Preparing for a new utilization stage and only one energy unit being in operation, in March 2003, LEI formed an Interna-

tional Consortium with Russian Federal State Unitary Enterprise "Russian Institute for Design and Scientific Research of Complex Power Technology" and Limited Share Holding Company "Power Supply Base" and offered a proposal for complex design and production of Unit 1 fuel burning in Unit 2 reactor. INPP took the offer of consortium and launched the projects that will continue for three years. LEI is the coordinating partner of consortium and responsible for the project implementation.

In 2003 a preliminary technical safety justification report was prepared, in which strength, thermal, radiation protection and nuclear safety calculation in case of normal operation as well as during accidents were presented.

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

The aim of this work, which will last for two years, is to create a software, which would evaluate reliability level of power transmission nets substations. In 2003 statistic and probability analysis of transmission nets condition was performed. Mathematical models of transmission nets breakdown repair flow was described, reliability indicators of net elements, reliability methods of systems, reliability calculation in regard to ageing, were calculated.

International cooperation

In 2003 projects were continued with foreign partners (USA, Western Europe), new treaties signed with international companies, active participation in science programs, funded by international foundations.

EU 6th Framework Programme (FP6).

SARNET Network of Excellent.

The laboratory together with international partners proposed a project for EU FP6, the objective of which was to expand Network of Excellence, which was created to assess severe accidents and control of PWR, BWR, WWER, RBMK water-cooled reactors.

It was participated actively in SARNET (Severe Accident Research Network) events. Participation in this network of excellence will allow Lithuanian representatives to integrate into scientists association of European countries, to obtain information on the analysis of severe accidents in NPP, will have a chance to use ASTEC

code for modelling of such type of accidents.

PHARE projects.

Review of Diverse Shutdown System at Ignalina NPP Unit 2.

The aim of this PHARE LI/TS/15 project is to overview and evaluate design documentation, to perform independent calculations in order to prove the fulfillment of this system to Lithuanian and international nuclear energy standards and to assist VATESI while making certain decisions in regard to the implementation of the above mentioned system. In 2003 project specifications and improved safety justification expertise of documents were performed.

According to changed logic of reactor's safety and management system, INPP independent system models of reactor shutdown were improved, applying German GRS mbH company's codes ATHLET and QUABOX/CUBBOX. Independent thermo-hydraulic and neutron-dynamic calculations were launched.

Enhancement of Lithuanian TSO's Licensing Assistance Capability within Core Integrity, Control Systems Upgrading and Management of Equipment Ageing.

Performing this LT/TS/04 PHARE project, together with *Serco Assurance* Company (Great Britain) Laboratory as a subcontractor worked according to the topics *Reactor Core Safety Surveillance and Evaluation of Ignalina NPP Safety Important Systems Ageing Management*. In the field of neutron-physics calculations, applying WIMS8A code, library of material cross-sections for RBMK-1500 was created, applying QUABOX/CUBBOX-HYCA code, verification and validation of it was performed. Performing works according to the second topic, *VATESI Requirements for Management of Systems and Components Important to Safety of Nuclear Facilities* expertise was performed, VATESI document project on *Guide for Assessment of Implementation of Ageing Management Programme for Systems and Components Important to Safety of Nuclear Facilities* was prepared.

Assistance for VATESI rendering supervision methodology of Western Europe.

Continuing LT/RA-03 PHARE project, Laboratory research was related to the assistance for VATESI international experts, preparing a regulated document on the as-

essment of RBMK-1500 damages due to inter-granular stress corrosion cracking. Prepared project of the regulated document determines inter-granular stress corrosion assessment conditions, in regard to exploitation control effect, violation statistics, mechanical features of materials, stress state, crack growth rate, periodicity and volume of exploitation control.

Projects supported by the USA Department of Energy.

RBMK-1500 RELAP5-3D model development and validation.

In 2003 cooperation with ANL, INEEL and PNNL laboratories was continued. In earlier years while performing projects, RBMK-1500 RELAP5-3D model was created, which enables to simulate reactor core and main circulation circuit of the whole power plant. During the first stage calculation results of LEI were compared to STEPAN simulation (which was carried out by RMC Kurchiatov institute) results.

The comparison of results revealed that RELAP5-3D RBMK-1500 model qualitatively simulates emergency and intermediate processes, which occur in RBMK-1500 reactor, though the final conclusion in regard to its employment to thermo-hydraulic and neutron-dynamic analysis was not made.

In 2003 a broader validation of RBMK-1500 RELAP5-3D model was carried out. For this purpose real INPP events were applied, in which thermo-hydraulic and neutron-physical change was significant. Calculations revealed that results of computer simulations corresponded to measured data and that created model could be applied for transient processes and design base accidents.

Evaluation of strength for the steam distribution headers and their connections.

In 2001–2003 together with ANL laboratory (USA) thermohydraulic analysis of steam distribution headers in case of the biggest design basis accident was performed. In 2003 applying the NEPTUNE code, the biggest dynamic loadings, with the help of which the strength of steam distribution headers and its connection with vertical corridors, was determined. It was also determined that steam distribution headers, existing in 1–5 condensing pools, their vertical nozzles and structural integrity of steam distribution headers supporting walls would not be violated in the case

of the accident, during which coolant is lost. During the biggest design basis accident the fragmentation probability of steam distribution headers is equal to $6.2 \cdot 10^{-6}$.

Analyses of Ignalina NPP RBMK buildings and structures for external loading conditions.

In this continuing project, funded by the USA Department of Energy, strength calculation methodology of structural constructions under dynamic loads was created. It should be noted that while performing dynamic analysis, strain rate was evaluated. Strength evaluation of typical structure of Ignalina NPP was performed by applying NEPTUNE code.

Projects supported by the UK Department of Trade and Industry.

Technical support on issuing a licence for INPP operation – Preparation of regulated documents.

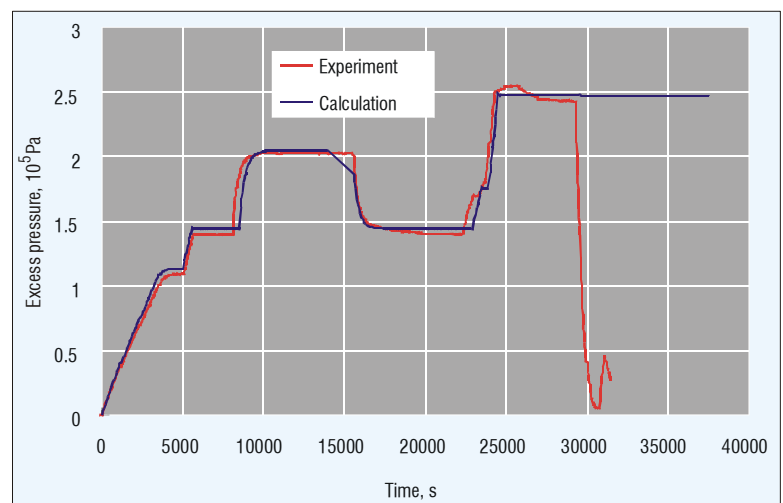
Performing the contract of UK Department of Trade and Industry NSP/03-L9, Jacobsen Engineering Ltd. together with LEI and other performers made a treaty, in which laboratory support was forecasted in preparing VATESI regulated documents. In 2003 the following documents were already prepared – *Requirements for Risk Evaluation and Risk Control, Requirements for INPP Exploitation System Assessment and Requirements for the Assessment of Human Factors*. They are given to VATESI for the final revision.

Preparation of beyond design basis accident management instructions for Ignalina NPP.

Performing the contract NSP/03-L10 of the UK Department of Trade and Industry, Jacobsen Engineering LTD. made a treaty with the Laboratory of Nuclear Installation Safety in order to prepare management instructions of INPP severe accidents, which were prepared for the first time for RBMK reactors. Information will be gathered on INPP systems, equipment and existing accident control instructions, NPP models, which allow to simulate processes that occur during severe accidents. Possible consequences of these accidents will be evaluated, means will be offered how to avoid them or to soften the consequences. On the basis of obtained calculations instructions will be prepared, which will supplement existing Symptom-Based Emergency Operating Instructions.

ISP-47 (International Standard Problem) should be mentioned separately, in which 20 institutions from 13 countries are participating. This project is designed for analyzing the problem of gas mixing in NPP containments. In 2003 during the first stage experiments were carried out in French TOSQAN and MISTRA experimental facilities. The objective of the participating organizations is to create models of experimental facilities while applying chosen codes, and to perform calculations. Simulating an experiment on the TOSQAN facility, experiment participants were given not only the facility description, experiential and boundary conditions but also measurements results. However, this was not the case while simulating MISTRA facility. In the seminar calculation results were compared to the obtained measurements results. COCOSYS code was applied for LEI calculations. A comparison of pressure is given, which was measured by TOSQAN and calculated by LEI. The participation in such project enables not only to evaluate the possibilities of applied codes but show the competence of the participants as well.

In 2003 the following theses were defended: Doctor of Science thesis on *Simulation of the Thermalhydraulic Processes in the Compartments During Loss-of-Coolant Accidents* by E. Urbonavičius, 2 Doctor Habilitus of Science theses *Risk Assessment and Control of the Hazardous Energy Objects by Integrated Methods* by J. Augutis and *Accidents Management for RBMK-1500 Type Nuclear Reactors* by A. Kaliatka; in the field of thermal physics a patent was legitimated on *Method for Initiation of Condensation Implosion Events* (authors K. Almenas, R. Pabarcius, M. Seporaitis; patent No. LT 5087B). Investigation results obtained in 2003 can be traced in 55 scientific articles, 34 conference papers. Researchers of the Laboratory participated actively in different programmes, IAEA technical committee meetings, coordinated meetings. The fact that Laboratory researchers are invited to give lectures at IAEA programmes and participate in nuclear energy specialists meetings of European countries, speaks of their high qualification.



Pressure comparison measured in TOSQAN experiment and calculated by LEI

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Main research areas of the Laboratory :

- Methodology creation of the development of local heat sector assessment and its adjustment, evaluating development demands of macroeconomic indicators of national economics;
- Preparation of software tools for the adjustment of development strategy of local energy sector.

The Laboratory performs two state funded scientific projects:

Creation and justification of macroeconomic methodology for development of municipal energy sector with regard to the tasks of National Energy Strategy. The main objective is the creation and probation of methodology of municipal energy sector development analysis in the context of state macroeconomic indicators. Concepts of development of regional energy sector and design methods development and theoretical grounding prolongation, emphasizing creation of info system of municipal energy sector (SEIS), are launched.

The originality of the work – the analysis of municipality energy sector alternatives in the transitive period of market conditions, which is created on mathematical model basis. Mathematical model of Lithuanian heat sector is based on national economy companies' financial flows variation balance, integrated into W. Leontief matrix model of national economy. IS TAUSA, which is developed in the Laboratory enabled to create a simulation model for the activity of national heat sector, comprising about 90% of technical, operating and economical indicators of district heating systems.

Evaluating local energy sector issues, arising in all Central and Eastern countries, FP6 Project INTEGUMENT was prepared, which received a very high evaluation.

Assessment of socio-economic factors for integration of renewable energy projects into regional development programmes. Main objectives of this project:

- implementing a regular energy sector development, funded by EU Structural funds, to create a methodology, which would enable to evaluate the efficiency of renewable energy sources projects;
- to prepare the energy development methodology, the main aspect of Lithuanian energy economics scientific branch.

In 2003 analysis on energy development external expands structure was carried out. This project is one of the parts of the prepared monograph *The Basics of Lithuanian Energy Economics*.



Clients and workgroup of World Bank project – World Bank representatives consultants from LEI, Finland and Great Britain

In 2003 main contracts of the Laboratory were implemented according to international programmes and projects:

Project BACCHUS – Best Actions for Collaboration in Countries for a High Efficient Use of Energy in Structural Funds.

The main objectives of this projects, performed according to SAVE-II programme were:

- to synthesize the practical examples and spread them in the EU countries – members and candidates;
- to promote personnel of regional development and energy agency to cooperate in the field of sustainable energy development.



FP5 project SAFIRE-LP training seminar in Biržai, which was organised by the consultants from LEI, Great Britain and Poland

Work results were evaluated positively in the European Commission conference *ManagEnergy*. The formation of a new approach was launched in regard to Structural funds, financing sustainable energy projects in EU countries. In 2004 this operation will be continued in INTERREG programme.

MUNEE (Municipal Network for Energy Efficiency) net. Alliance of Energy Efficiency (USA), founded in 1977, after oil crisis, caused by oil embargo. In Lithuania MUNEE programme included the support for Association of Local Authorities in Lithuania, forming energy policy guidelines, exchange of experience, and preparation of a specific energy efficiency development plan for one municipality.

The Laboratory had prepared three commendatory documents for Association of Local Authorities in Lithuania (ALAL), arranged three seminars for specialists of municipalities and energy companies, prepared strategic guidelines for municipal energy sector, that are confirmed in ALAL subcommittee meeting. Energy efficiency development plan was prepared for Birstonas municipality, based on integrated sources design principals. DH boiler-houses reconstruction for wood fuel utilization is already performed.

The World Bank project *Heat Supply for Small Towns in Lithuania*.

With other international support institutions World Bank initiates preparation of energy sector restructuring projects, including modernization of infrastructure of heat supply and demand side, provides information, necessary in reforming district heating systems of small towns, choosing the most economical heat supply alternative. The project covers the first out of three designed stages. In the second and third stages preparation and implementation of commercial and demonstrative projects are forecasted.

The Laboratory together with consultants of new technologies and heat supply

from Finland and Great Britain arranged the seminar. Project objectives were presented for the representatives of municipalities, Lithuanian District Heating Association, government and society. They were also informed on the proceeding of the project and its results.

Current state of heat supply in three municipalities was analyzed in the study, examining heat supply alternatives of four small towns and settlements for the nearest 15 years covering a wide spectrum of alternatives – from renovation of supply nets up to a complete heat supply decentralization, new technologies implementation. Results of the study are planned to be applied in solving heat supply issues of Lithuania and all Central and Eastern Europe region.

SAFIRE-LP (Strategic Assessment Framework for the Implementation of Rational Energy-Local Planning) project. The main objective of SAFIRE-LP project is to prepare means for the improvement of local energy sector planning, which would promote investments in renewable energy sources technologies, compatible with European Commission environmental policy. Data will be applied, which is collected by IS TAUSA.

Joint projects and programs. Laboratory experts actively participated in integrated projects, preparing postlegal acts – *Order for heat purchasing from autonomous producers*, evaluated municipalities possibilities in using international funds, analyzed and presented recommendations for government policy, intended for strategic regulations formation of state energy policy. Together with Institute of Public Policy and Management consulted organizers of *Strategic development plan for 2004-2010 of Taurage region*.

Collaboration Agreement between Association of Local Authorities in Lithuania, Lithuanian Energy Institute and Lithuanian District Heating Association.

According to this agreement:

- laboratory software is further being developed, which is intended for collecting and analyzing information on current energy consumption in municipalities;
- a new concept is prepared for forming municipalities energy sector information system (SEIS), applying SQL database software.

Participation in the process of scientific studies.

In 2003 the laboratory participated in preparing six PhDs; two PhD Candidates finished studies on time and their dissertations were presented for public defense.

Cooperating together with Heat and atom energy department of Kaunas University of Technology in 2003 the first scientific programme in Lithuanian of energy economics was prepared, covering study modules for Bachelors, Master of Science and PhDs.

Two laboratory representatives participate in joint committee work of Lithuanian Energy Institute and Kaunas University of Technology.

In 2003 Laboratory researchers presented papers in seven international conferences, in various journals published 11 scientific articles.

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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 optimization models;
- Environmental impacts of the energy sector, analysis on pollution reduction technologies and implementation and environment protection policies;
- Research of management and marketing in the energy sector;
- 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 foreign countries;
- Development of common power market establishment principles for the Baltic countries.

In 2003 scientific research was carried out necessary for the analysis of energy sector and development of separate energy systems, for the formation of methodological and programme base of forecasting of energy demand and optimization of energy sector development, and for the renewal of statistical data base. Optimization MESSAGE model of energy sector development was successfully applied for Lithuanian conditions while cooperating with international nuclear energy agency (IAEA). This model significantly improved the system of models designed for state energy sector development analysis. Cooperating with experts from Riso National Laboratory (Denmark), forecasting methodology of energy demands was renewed, simulation MAED model was supplemented with macroeconomic analysis models, for this purpose applying TSP code.

A significant report should be mentioned ***Preparation/Implementation of the National Energy Strategy, Integration into West-European Natural Gas System and Gas Supply Reliability Improvement***, which is prepared performing investigations according to the agreement with Ministry of Economy of the Republic of Lithuania.

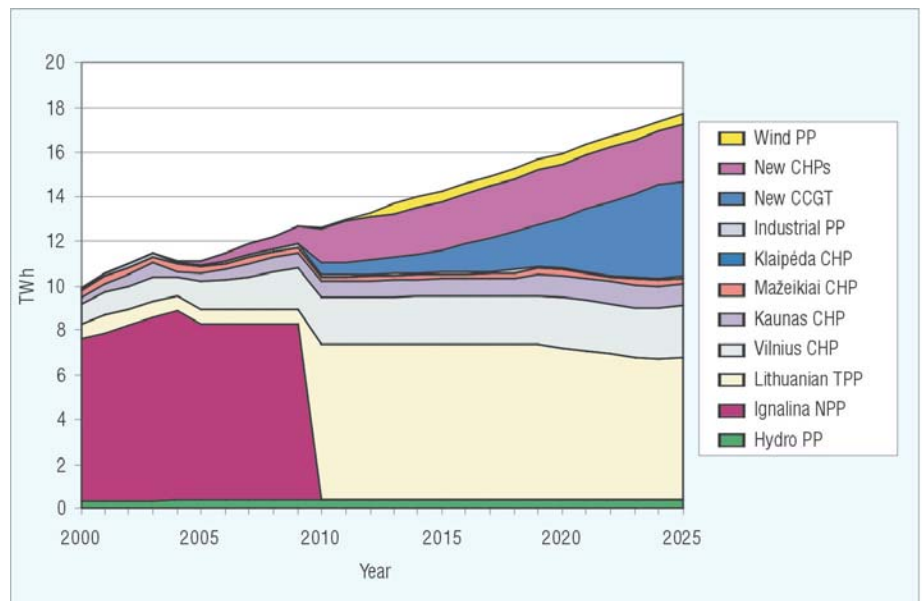
In the first volume of the report **generalized state energy balance investigations** are presented:

- changes in economics and state energy balance are defined for the year 1994-2002;
- the analysis of primary energy and final energy consumption in economy branches is presented;
- changes of energy intensity in Lithuania are discussed;
- aggregated and explicit forecasts of final energy demand (up to 2025) are prepared;
- principals and basic assumptions of energy sector modelling are presented, applying MESSAGE model;
- exhaustive energy development analysis is presented;
- rational energy balance, corresponding to energy development scenario, is presented.

In the second volume of the report **problems of district heat sector** are summarized:

- directions of district heat sector development, corresponding to provisions of National Energy Strategy and requirements of the EU directives, are formulated;
- evaluation of CHP development expedience is performed;
- guarantee of transparency and coherent control for activity of district heat companies is presented;
- financial and legal means for promoting use of renewable and waste energy sources;
- possibilities of environmental means implementation in heat sector are evaluated.

In the third volume of the report **evaluation of security of energy sources (oil and oil products, natural gas)** supply under normal and extreme conditions is presented. Principles of electricity pricing and their development possibilities in Lithuanian energy sector are formulated, considering the requirements of the EU directives.



Forecasted electricity production in Lithuania (basic scenario of the National Energy Strategy)

The Laboratory participates in the project ***Analysis of Policy Instruments and Identification of Tools for the Implementation of Rational Energy Use and Increased Use of Renewable Energy Sources in the EU Candidate Countries*** and ***The European Network for Energy Economics Research***. Significant issues of energy system development and methodological energy demands forecast and aspects of energy sectors optimization were analyzed in various international projects: *Indicators of Sustainable Energy Development* (funded by the International Nuclear Energy Agency), *Enhancement of Use of Local and Renewable Energy Sources in Lithuania* (funded by Danish Energy Agency), *Models for Energy Demand Forecasting in Lithuania*.

The year 2003 was significant for the laboratory researchers: A. Pazeraite defended her PhD thesis on *Formulation of Pricing Methodology for Electricity Transmission Service* (social sciences and management). R. Gatautis, funded by Northern countries fund scholarship, investigated the efficiency of small scale CHP and their mathematical models at Technical University of Denmark. D. Tarvydas participated in the seminar on renewable energy sources development in Austria.

Twenty papers were presented in the conferences in Czechia, Estonia, USA, Kzachstan, Poland, Germany, Romania, and Finland. Laboratory researchers published 22 articles in Lithuanian and international journals. The Laboratory prepared an edition on National Energy Strategy.

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Main directions of research activities:

- Evaluation of effects on water bodies by power industry and transport;
- Creation of database on Lithuanian water bodies (rivers, ponds, the Curonian Lagoon and the Baltic Sea).

Assessment of water bodies state and its fluctuation. Extensive natural fluctuation is characteristic for hydrological regime of rivers and lakes. Economic activity changes water resources state. The environmental changes, which are estimated by modelling the activity of energy and transport objects under specific hydrometeorological conditions, make the basis for environmental impact assessment.

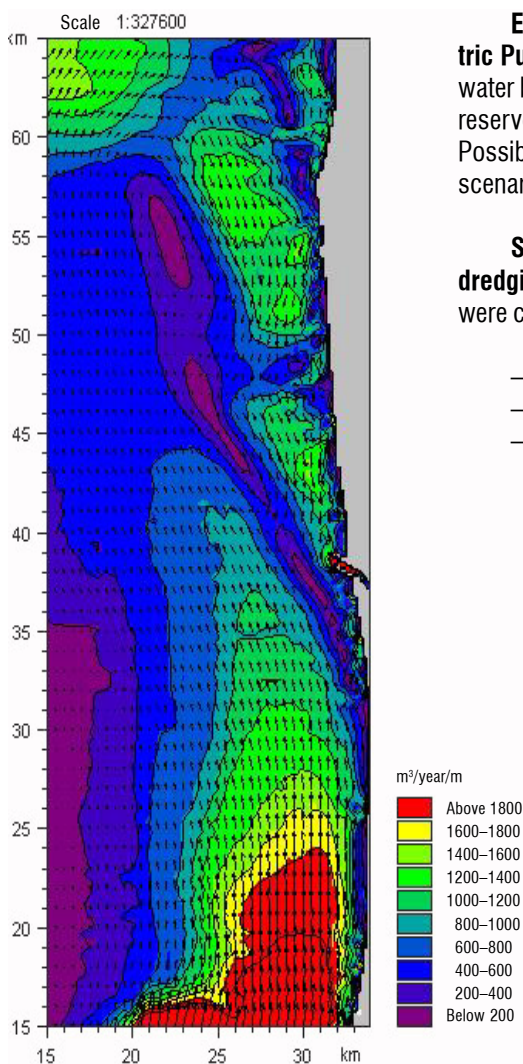
In 2003 scientific investigations carried out in the Laboratory were directly related to the usage of energy and water transport objects and their impact on water bodies. In the Laboratory database was accumulated and the two-dimensional modelling system of water bodies was applied, which allows to solve the following important issues:

- determination of the extreme meteorological, hydrological and hydraulic parameters when there are no direct measurements available;
- transportation of water sediments and formation of deposition and erosion sites;
- determination of operation conditions of the hydro-technical constructions (dams, quays) and seaports;
- substantiation of the mitigation measures for the environmental impact from the proposed human activity.

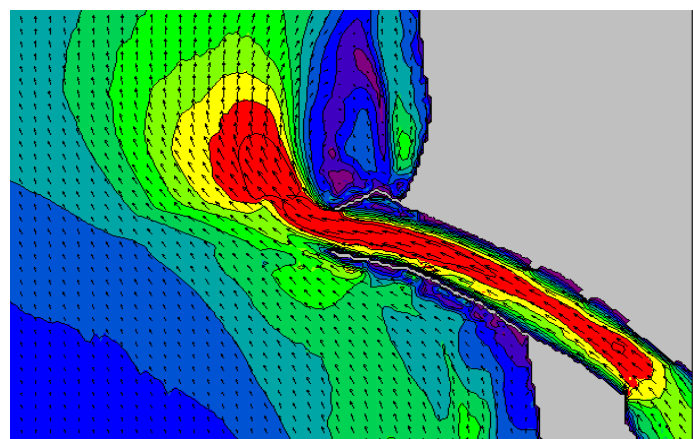
Environmental impact of the Kaunas Hydroelectric Plant and Kruonis Hydroelectric Pumped Storage Plant (HPSP). Power plants change the hydrological regime of water bodies, possible accidents cause danger for people and structures. New rules of reservoir exploitation were prepared after summing up the experience of Kaunas HP. Possible hazard of Kaunas HP and Kruonis HPSP is analyzed after investigating the scenarios of structures' probable break and its consequences.

Solution of the problems of development of Klaipeda State Seaport (fair way dredging). Under the order of Klaipeda State Seaport Authority the following projects were carried out:

- environmental impact assessment for dredging the seaport up to 14.0 m;
- seaport dredging projects;
- proposals for seaport spoil utilization as sand source for beach nourishment.



Sediment transport of the Baltic Sea near-shore



The flow structure of the Klaipeda Strait after reconstruction of seaport gate



Sand spill into Baltic Sea near-shore

On March 7 2003, Lithuanian Science Award of 2002 was officially given to Laboratory researchers: B. Gailiusis, J. Jablonskis and M. Kovalenkoviene for the group of works *Lithuanian Surface Water Resources, their Change and Utilization in the Energy Sector and Water Transport*. This distinction was granted for scientific projects, performed in 1980-2001:

- summary of hydrographical and hydrological data of Lithuanian rivers and preparation of their calculation methodology in the monograph *Lithuanian Rivers. Hydrography and Run-off (2001)*.
- investigation of near-shore of the Baltic Sea and Klaipeda Strait hydrological regime, sediment and sediment transport.
- investigation of Klaipeda Seaport development possibilities taking into account environmental and recreational objectives.
- creation of the Druksiai lake thermal regime database and forecast of lake state;
- investigation on Kruonis HPSP work regime and its impact on Kaunas HP reservoir.

Laboratory researchers participated in NATO/CCMS conferences *Environmental Impact Assessment Methodology* and *Integrated Management of Water Resources*.

In 2003 the staff of the Laboratory presented two articles in international and five articles in Lithuanian journals. Researchers of the Laboratory participated in two international conferences and presented two papers about near-shore of the Baltic Sea hydrological regime, sediment and sediment transport processes.

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Main research areas of the Laboratory:

- Investigation of energy system control and modelling;
- Modelling and optimization of control and data acquisition systems.

The requirements of EU directives to increase the eco-friendly component of electricity in total balance of power by applying renewable energy sources required a more extensive assessment of Lithuanian power system's possibilities to integrate large capacity of wind power plants. Unpredictable variation of their output raises new claims for power and frequency automated regulation and balancing system. For this purpose, the modelling procedures of wind power plants were performed, possible variation of generated power was evaluated for different total capacities of wind power plants and their layout in near-shore zone. Transmission and distribution capabilities of power network were analyzed as well as the wind power plants' impact on voltage quality.

Since large power sources can not be introduced in Lithuanian power system in the nearest future, a considerable amount of different types of wind power plants and other small plants will emerge. Due to this fact investigations on Lithuanian power system's stability and reliability were carried out.

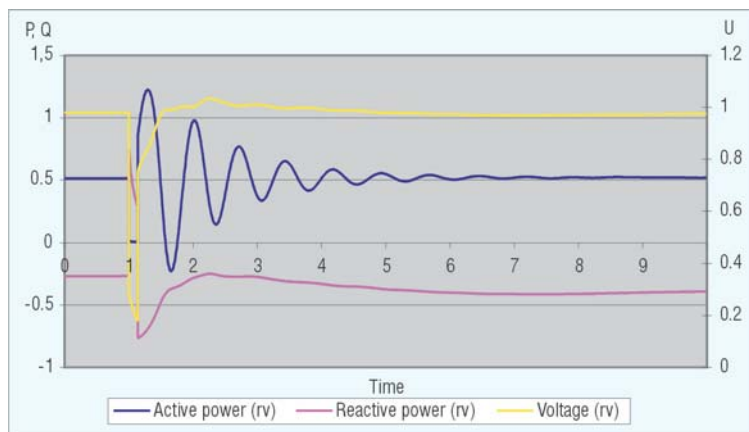
Evaluating possible changes in Lithuanian power system, the Laboratory carried out fundamental and applied research works in the field of energy system control and modelling. The aim of scientific investigations was **to create mathematical models of energy systems and adequate technical means that would enable to optimize energy generation, transmission and consumption processes, to automate their control and enhance energy efficiency.**

Laboratory actively participates in solving other related problems such as reorganizing power sector of three Baltic states, and establishment of the control area of Baltija Integrated Power System (IPS). On solving this issue it is necessary to analyze in detail, and according to many criteria, to evaluate Baltija IPS control area's possibilities to meet the control requirements. In order to achieve this aim multicriteria analysis approach was applied, which enables to select the best option, evaluating the integrated influence of several criteria.

While creating Baltija IPS control area, it is necessary to investigate power and frequency automated regulation system, in regard to the specificity of each power sector of the Baltic states. Due to the fact that IPS is a complex, non-linear and non-stationary system, the investigations of the efficient use of modern automated governors (Fuzzy) are further carried out. Also, issues of choosing the optimal structure of information control systems are solved, evaluating the requirements of growing electricity market and the specificities of operating objects.

Pursuant to the order of Ministry of Economy of the Republic of Lithuania, regulatory and technical problems of informing on activities in energy sector and planning of energy objects were analyzed, drafts of legislation acts, which evaluate EU directives' requirements, were prepared.

One paper was presented in XI international conference on power engineering, Poland, Jurata, 2003. Five papers were presented in Kaunas University of Technology, one article was published in *Energy* journal.



Main curves of Ignalina NPP generator transitional process

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Financial Highlights

The financial sources of the Institute consist of:

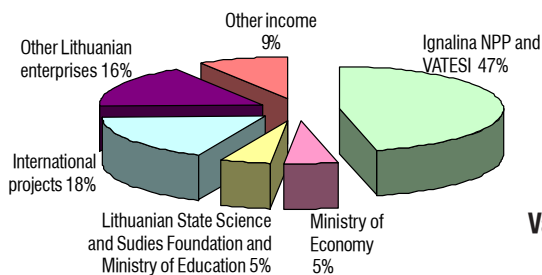
- State budget subsidies;
- Financing for research programmes and education of specialists;
- Financing received from Lithuanian and foreign enterprises and organizations for contract works, realization of products and services;
- Funds received from various international research programmes and funding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

Structure of Income and Total Expenses (LtL'000)

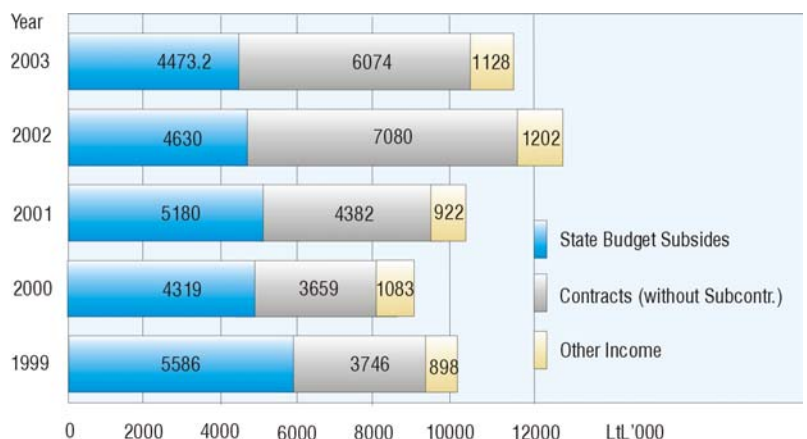
	2000	2001	2002	2003
Income:				
State Budget Subsidies	4319	5180	4630	4473.2
Contracts (incl. subcontr.)	4224	4684	7785	11658*
Other Income	1083	922	1202	1128
Total:	9626	10786	13617	17259.2
Expenses:				
Salaries (soc. ins. incl.)	7002	6362	7181	7783
Operating Expenses	1573	2544	2842	3572.2
Acquisition of Equipment	935	659	1887	571
Subcontracts	565	302	705	5584*
Total:	9435	10178	12615	17510.2
Remainder in the End of the Year	346	954	1956	1705

* – bank guarantee included

Financial Sources of Economical Activity in 2003



Variation of Financial Structure



Main Publications

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2. **Чесна Б.** Теплоотдача и гидродинамика в газоохлаждаемых стержневых теплоделяющих сборках: монография / Под ред. проф. Ю. Вилемаса. ISBN 9986-492-77-7. Каунас: ЛЭИ, 2003. 236 с.: илл. (монография).
3. Advances in Heat Transfer Engineering: Proceedings of the 4th Baltic Heat Transfer Conference, August 25-27, 2003. Eds.: Bengt Sunden and Jurgis Vilemas. Kaunas, Lithuanian Energy Institute, New York, Begell House Inc. 2003. ISBN 9086-400-78-5. 858 p.: illustr.

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6. **Dundulis G., Kopustinskas V., Liaukonis M., Augutis J., Ušpuras E., Hopkinson K., Marsden B.** Prediction of fuel channel-graphite gas-gap behaviour in RBMK reactors // *Nuclear Engineering and Design*. ISSN 0029-5493 / 2003. Vol. 223, p.117-132.
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11. **Poška P., Poška R.** Local turbulent opposing mixed convection heat transfer in inclined flat channel for stably stratified airflow // *International Journal of Heat Mass Transfer*. ISSN 0735-1933 / 2003. Vol. 46, p. 4023-4032.
12. **Pranevičius L., Milčius D., Stankus V., Dudonis J., Templier C., Riviere J.-P.** On the mechanism of synthesis of PbTiO₃ thin films by thermal annealing of Pb/Ti layers in air at atmospheric pressure // *Thin Solid Films*. ISSN 0040-6090 / 2003. Vol. 426, p. 78-84.
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14. **Urbonas R., Ušpuras E., Kaliačka A.** State-of-the-art computer code RELAP5 validation with RBMK-related separate phenomena data // *Nuclear Engineering and Design*. ISSN 0029-5493 / 2003. Vol. 225, p. 65-81.
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17. **Valatkevičius P., Krušinskaitė V., Valinčiūtė V., Valinčius V.** Preparation of catalytic coatings for heterogeneous catalysts employing atmospheric pressure non-equilibrium plasma // *Surface & Coatings Technology*. ISSN 0257-8972 / 2003. Vol. 173-174, p. 1106-1110.
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21. **Džiugys A., Peters B., Hunsinger H., Krebs L.** Evaluation of transport of moving fuel bed on a TAMARA forward acting grate // *Industrial Heat Engineering*. ISSN 0204-3602 / 2003. Vol. 25, No. 4, p. 28-30.
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26. **Konstantinavičiūtė I.** Climate change mitigation policies in Lithuania // *Energy & Environment*. ISSN 0958-305X / 2003. Vol. 14, No. 5, p. 725-735.
27. **Levinskas R., Lukošytė I.** Пассивация низколегированной стали 15X1Ф эмульсией температуростойкого амина // *BAME: Collection of Research Papers of the Baltic Association of Mechanical Engineering Experts*. ISBN 5-94826-071 / Kaliningrad, 2003. № 3, p. 39-42.
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31. **Miškinis V., Deksnys R.** Management changes in the Lithuanian energy sector // *International Journal of Risk Assessment and Management*. ISSN 1466-8297 / 2003. Vol. 4, Iss. 2/3, p. 145-157.
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33. **Tonkonogij J., Pedišius A., Stankevičius A.** Совершенствование эталонных колокольных установок для воспроизведения единиц объема и расхода воздуха // *Industrial Heat Engineering*. ISSN 0204-3602 / 2003. Vol. 25, No. 4, p. 483-485.

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35. **Vilemas J., Miškinis V.** Lithuanian energy: on the way to integration into the European Union // *International Association for Energy Economics (IAEE) Newsletter / Third quarter 2003*, p. 18-21.
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The 80th anniversary of Prof. Dr. Habil., Academician of Lithuanian Academy of Sciences, Algirdas Zukauskas, founder of Lithuanian thermal physics science school, was commemorated at scientific conference *Lithuanian Science and Industry. Heat Power Technologies* (3-4 February 2003) and *4th Baltic Heat Transfer Conference* (25-27 August 2003)



On the 7th of March 2003, Lithuanian Science Award of 2002 was officially given to Dr. Habil. J. Jablonskis, Dr. M. Kovalenkoviene and Prof. Dr. Habil. B. Gailiusis for the group of works *Lithuanian Surface Water Resources, their Change and Utilization in the Energy Sector and Water Transport*



A new Council of the Institute was elected on the 4th of August, 2003. Chairman of the Council – Prof. Dr. Habil. Eugenijus Uspuras

4th Baltic Heat Transfer Conference was organized at LEI on 25-27th of August 2003. Representatives from 16 countries participated in the Conference, 98 papers were presented on thermal physics issues.



Conference opening



Presentation by the Chairman of the Organising and Scientific Committee Prof. Bengt Sundén (Sweden)



Dr. W. Begell, Prof. R. Viskanta (USA) and Prof. Anupras Slanciauskas (LEI) at the Conference

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