



**LITHUANIAN ENERGY INSTITUTE**

**2008**



**ANNUAL REPORT**

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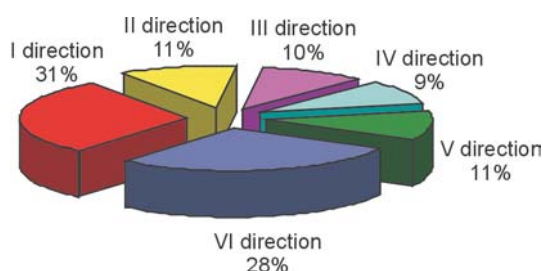
### Scientific Research Activity of the Institute is carried out according to six research directions:

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

## Lithuanian Energy Institute in 2008

*Lithuanian Energy Institute is a state scientific research organization, established for Lithuanian energy and long-term scientific research of international significance and experimental development.*

*The Institute carries out research of hydro and gas dynamics, heat transfer, fundamental and applied research of materials science and nano technologies, which are needed to develop the most advanced and future energy technologies, to justify their safety and reliability, and estimate their impact on the environment. The Institute is also the highest qualification expert in the field of energy economy, metrology and energy system management.*



*Distribution of researchers according research directions*

In 2008 researchers of Lithuanian Energy Institute carried out 17 state funded research projects, seven of which were successfully completed and defended, whereas the remaining ten projects will be continued in the period of 2009–2010. State funded research projects attract particular attention at the Institute, their implementation and achieved results are discussed in the expert commission of scientific works, whereas annual and final scientific research reports are approved at the Institute Council. Information concerning works funded by the Ministry of Education and Science of the Republic of Lithuania is pre-

sented in this publication as well. It is expedient to note that state funded works, such as the development of Lithuanian energy security assessment method and security and reliability assessment of energy supply, new hydrogen technologies, and fuel elements, are especially important to Lithuania.

**1. Security Assessment Methodology Development of Energy Supply to Lithuania** (project leader – J. Augutis); European and worldwide experience has been analysed during the project by estimating energy security. Common energy security assessment methodology has been proposed, principles of this methodology have been formulated and mathematical models have been developed, software has been chosen. RiskSpectrum assessment model of Lithuanian energy system disturbances and outcomes has been developed.

**2. Investigation of Distributed Energy Generation Development** (project leader – V. Miškinis). Assessment of legal, technical and technological conditions of distributed energy generation development has been presented, recommendations have been prepared regarding updating and development of current energy networks (natural gas, electricity nets, and district heating networks), enhancement of competitive ability of new manufacturers in electricity market and rational scenarios of energy sector development.

**3. Analysis of Renewable Energy Sources Use for Energy Production in Lithuania and Development Feasibility Study** (project leader – V. Katinas). Analysis of energy production using RES is carried out. Possibilities of building wind power plants in Lithuanian shore and sea have been estimated. Possibilities of biomass and biogas use in cogeneration power plants have been investigated. Data concerning energetic sprout in other countries have been collected and analysed and their cultivation expedience and perspectives in Lithuania have been estimated. Perspectives of solar energy application for electricity production in Lithuania have been investigated.



**4. Efficient Use of National Balance Control Resources in Lithuanian and Baltic Power Systems** (project leader – V. Radziukynas). Distribution of national balance deviations and their optimal coverage have been investigated. EPS dynamic frequency characteristics parameter estimation methodology has been developed using parameter identification methods. Using developed secondary frequency and power regulator, following fuzzy logics, control efficiency has been investigated. An original optimal balancing mechanism having minimal balancing expenditure function has been proposed.

**5. Research of Condensation Impact on Interface Surface Stability** (project leader – M. Šeporaitis). In this project comparative research of noncondensing and condensing horizontal two-phase flow have been carried out, experimentally and theoretically determined and compared the condensation impact on interphase friction and interphase surface stability. Simulation of condensing two-phase flow in the inclined channel has been carried out, relationship between the inclined channel angle and experimentally determined interphase friction has been estimated. On the project results, an experimental rig has been developed, condensation impact on interphase friction and interphase surface stability has been determined.

**6. Research on Regularities of High-Temperature Spray Pyrolysis Process, Designed for Plasma Synthesis of Coatings** (project leader – V. Valinčius). Experimental gas dynamic device with specific purpose plasma generator has been designed and manufactured, dynamic and thermal characteristics of outflowing gas jet have been investigated, equipment has been installed to investigate plasma jet parameters. Research results of plasma jet velocities, temperature and their pulsations have been obtained, distribution of gas dynamics and thermal characteristics has been determined, distribution of gas dynamics and thermal characteristics at developed coating wall has been determined as well as flow and surface heat-mass transfer coefficients. Movement of dispersed particles has been investigated by numerical and experimental methods and their surface phase conversions at high temperature jet. The impact of various factors on the pyrolysis process and quality of coating formation has been determined.

**7. Research of Increasing Energy Consumption Efficiency in Sectors of Industry and Buildings** (project leader – R. Škėma). Energy management implementation model and prepared computer energy management “E-training” system has been presented to small and medium-sized enterprises. International energy use data monitoring and comparison methodology has been presented and applied at Lithuanian industrial enterprises.

The following state funded projects have been continued:

- **Best Estimate Methodology Application Simulating Processes in Technical, Natural and Social Systems.** Project leader A. Kaliatka;

- **Radioactive Impact Analysis and Optimisation Performing NPP Equipment Dismantling and Managing Radioactive Waste.** Project leader P. Poškas;

- **Impact of Climate Change on The Condition of Lithuanian Water Resources and Hydroenergy Sector.** Project leader B. Gailiusis;

- **Investigation of Liquid and Flow Characteristics on Metrological Parameters of Volume And Rate Meters.** Project leader A. Pedišius;

- **Synthesis of Nanocrystalline Metal Hydrides, Designed for Hydrogen Storage, Applying Ion-Plasma Methods.** Project leader D. Milčius;

- **Experimental and Numerical Modelling Research of Biofuel and Calorific Waste Aiming at Improving Energy Production Technologies.** Project leader A. Džiugys;

- **Heat Transfer and Flow Hydrodynamics Research in Transitional Flow Zone at Mixed Convection and Interaction of Stable and Unstable Air Density Stratification.** Project leader R. Poškas;

- **Planning Principles and Implementation Possibilities of Sustainable Energy Development.** Project leader V. Kveselis;

- **Experimental Investigation of Dissociation Patterns of Zirconium-Base Alloys Designed for Production of Thermal Element Coatings and Pressure Pipes.** Project leader A. Grybėnas.

- **Development of Assessment Methodology of Sustainable Aspects of Energy Resources' Utilization.** Project leader V. Klevas.

Researchers of Lithuanian Energy Institute successfully participated in preparation of projects proposals for European Union programmes projects – 33 project proposals were submitted. *Intelligent Energy – Europe* projects may be emphasized among already implemented projects – 13 of them have been implemented; 10 projects of the Sixth Framework Programme, 6 – COST programme projects. LEI researchers more actively participate in implementing Seventh Framework Programme projects. In 2008 the following Seventh Framework Programme projects were under implementation:

- **Security of Energy Considering Its Uncertainty, Risk and Economic Implications, SECURE)** (LEI representative – J. Augutis). Project objective – develop energy security assessment methodology which would consider all issues regarding energy supply security, including geopolitical changes, price formation, development of energy markets inside and outside EU, terrorist hazards, etc.

- **Energy Technological Foresight and Scenario Development, PLANETS** (LEI representative – D. Štreimikienė). Project objective – determine scenarios of new perspective technology development in EU countries by the year 2050, meeting the priorities of EU energy policy and sustainable development objectives.

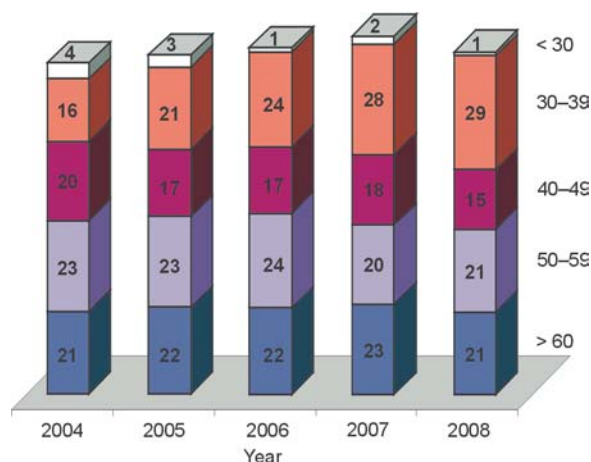
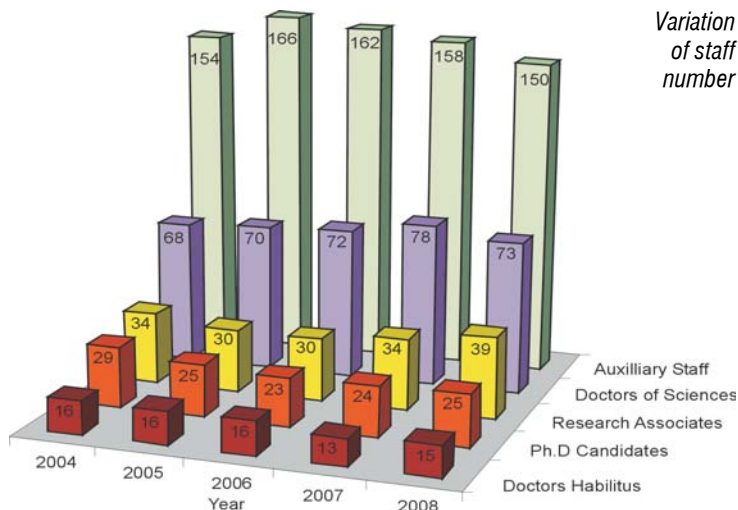
- **Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste, CARBOWASTE** (LEI representative – P. Poškas). Main research objective – irradiated graphite used in Russia, its characteristics and experimental research. In the first stage an integral management analysis of Russian radioactive waste (graphite) was carried out, report on performed investigation was prepared. Nuclear objects present in different Russia's sites were analysed in the report, i.e. nuclear power plants, reactors used for investigations and industrial reactors used for producing plutonium. Detailed information concerning operation of these objects and new nuclear objects

foreseen to be built is given. Graphite characteristics used in Russia is thoroughly analysed in the report as well as performed experimental and numerical research in this field, measuring analysis of ionizing irradiation of graphite present in certain nuclear objects where is given as well technologies applied or planned to be applied in Russia to reprocess such kind of waste.

- **(Integrated European Network for Biomass and Waste Reutilisation for Bioproducts, AQUATERRE)** (LEI representative – V. Katinas). Project objective – inventory biomass resources present in Europe and to determine biofuel production potential and value using Geographical Information System and to create European biomass resources usage maps and to determine environmental impact schemes in accordance with optimal lifetime development cycle scenarios.

- **European Fusion Development Agreement** (LEI representative – E. Ušpuras). Project objective – cooperate with Max-Planck-Institut für Plasmaphysik (Germany) and perform safety assessments of stellarator type thermonuclear synthesis experimental facility installed in the Institute.

No trend in employees variation the Institute was observed, only the number of technical personnel reduced. Dealing with inevitable ageing issues of employees, LEI gives a considerable attention on training and education of young generation, thus a certain number of PhD Candidates are constantly studying at the Institute.



Dynamic of age of scientists

LEI researchers actively participate in the activities of the following technology platforms:

- *Manufuture*;
- *Hydrogen and Fuel Cells (H<sub>2</sub>/FC)*;
- *National Thermal Energy*;
- *National Biomass and Biofuel Production and Use*;
- *Lithuanian National Biofuel*.

In September 2008 reconstruction of LEI Heat Transfer and Nuclear Installation Administrative Building was completed. The objective of the project, value of which is 2 047 229 Lit, is to improve thermal characteristics of the building and more efficiently use thermal energy in public sectors. Later on, after performing the comparative thermal energy consumption analysis, estimating only three last months of the year from 2002, considerable reduction of energy consumption was observed.

In 2008 EU Structural Funds project **Organization of Hydrogen Energy Technologies Training** was completed together with partner Vytautas Magnus University. Educational programme **Energy and Environment** in physics direction Master studies was developed.

In 2008 project **Development and Implementation of Natural Sciences Postdoc's Traineeship System** implemented by Lithuanian Science Council,



Reconstruction of Heat Transfer and Nuclear Installation Administrative Building

where one of 19 partners was LEI, was completed. Project objective – create a model of postdoc's traineeship organization by implementing a competitive mechanism of practices.

LEI researchers together with SC *Naujas Kalcitas* implemented EU Structural Funds project **Scientific Research of Development and Industrial Application of Gasification Technology for High-Calorie Material and Waste to Reduce Fuel Consumption**. Project result – a technology was developed, when gasifying used tyres the obtained gas will be used in the lime production process, replacing 30% of regular fuel.



Establishment of **Centre for Hydrogen Energy Technologies** financed from 2007–2013 EU Structural Funds programme was continued in 2008. Project objective – to create conditions for dynamically complex fundamental and technological research development in the strategic field of EU scientific research and experimental development.

The Institute actively participated in the activities of Valley **Santaka**, national integrated programme **Mechatronics** and in preparation of national science programme **Future Energy**.

Kaunas University of Technology together with Kaunas University of Medicine and Lithuanian Energy Institute at the end of 2006 initiated the establishment of integrated science, studies and business centre – Valley **Santaka** and are aiming at integrating into one area the potential of research, studies and open to knowledge business, developing common use infrastructure and purposefully implementing science research and experimental development activities relevant for Lithuanian economy in the following directions:

- 1) sustainable chemistry (including biopharmacy);
- 2) mechatronics (including biomedical engineering);
- 3) energy;
- 4) information and communication technologies (including telecommunications).

The biggest Lithuanian business groups are contributing to the initiative of Valley establishment: JSC concern *Achemos grupė*, SC *Kauno tiltai* (AB *Tiltra Group*), JSC *MG Baltic Investment*.

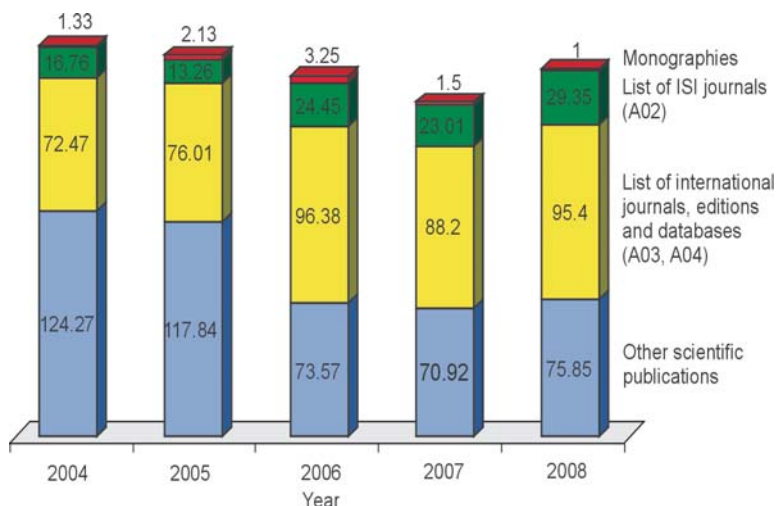
After developing the activity of Valley it is planned to cooperate with partners.

It is planned that future centre will have both centralized common use and network R&D infrastructure: a) base infrastructure will be created for open access centres; b) among planned to be developed open access Valley R&D centres there will be one directly related with the activity of Lithuanian Energy Institute – Future Energy Technologies Science Centre.

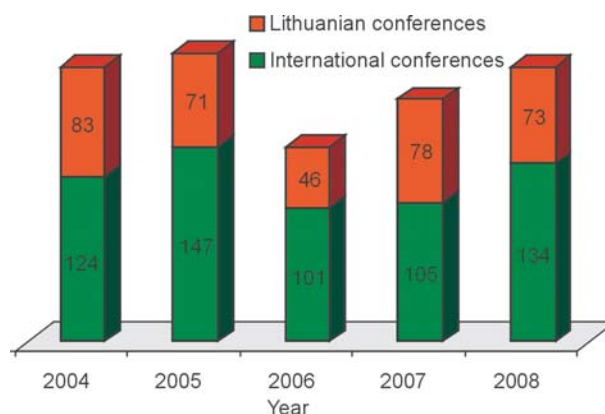
For the second year already Lithuanian Energy Institute has been awarded the golden medal for Lithuanian Industrialists Confederation organized competition *Lithuanian product of the year*. This time – for successfully implemented project **Control System of Leaktightness of Fuel Cladding During Dismantling of Spent Fuel Assemblies in the “Hot Chamber”**.



Researchers from the Laboratory of Heat-Equipment Research and Testing A. Pedišius, J. Tonkonogij, G. Zygmantas and N. Pedišius, were awarded the National Science prize for applied scientific activity work **Creation of Complex of State Flow Standards and Experimental Facilities for Reproducing the Liquids, Gas and Heat Quantity Values and Research-testing Its Measurement Instruments** carried out in the period 1995–2007.



Variation of publication number (authors' contribution evaluated)



Number of papers in scientific conferences

Retrospecting the activities carried out in 2008 and considering recognition shown to the Institute researchers, the whole collective of the Institute with great enthusiasm and energy looks forward to scientific, creative and technical challenges in the future.



Laureates of National Science Prize 2008 (from the left) J. Tonkonogij, N. Pedišius, G. Zygmantas and A. Pedišius

# Activity of Institute's Young Researchers

Since 2003 Lithuanian Energy Institute has a joint PhD studies programme with Kaunas University of Technology in the following research directions:

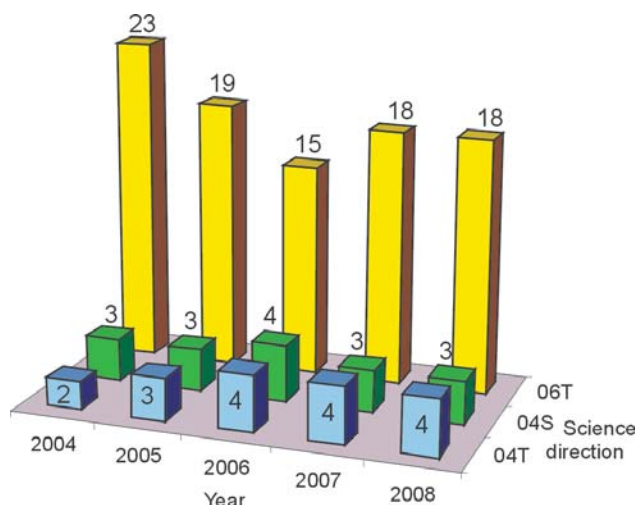
- Economics (04S);
- Environmental engineering (04T);
- Energetics and power engineering (06T).

In the period of 1992–2008 PhD studies were completed by 54, whereas these were defended by 37 PhD Candidates. There were 25 PhD Candidates at the Institute, these were defended by 3 PhD Candidates of joint PhD studies.

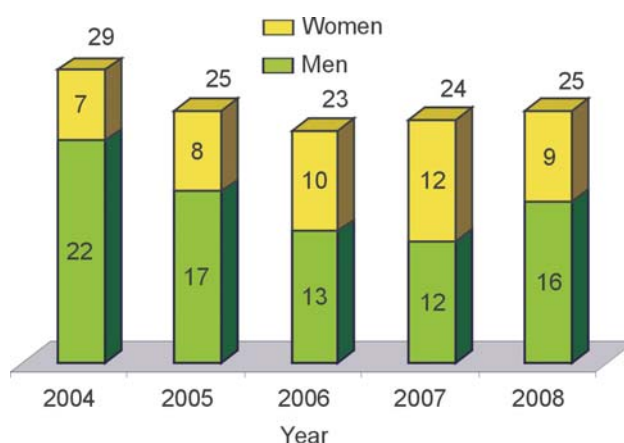
In 2008 Kaunas University of Technology together with Lithuanian Energy Institute granted the Doctor of science degree to the following researchers of the Institute:

- 4 February. Jurgita Simaitytė for environmental engineering and regional management work **Flood Discharge Control Based on Risk Assessment**;
- 8 February. Egidijus Babilas for power and thermal engineering work **Analysis of Hydrogen Distribution in Contaminants of Nuclear Power Plants**;
- 19 June. Vaidas Matuzas for power and thermal engineering work **Probabilistic Ageing Assessment and Management of Energy Installations**;
- 10 November. Violeta Vaitkevičienė for chemical work **Synthesis and Studies of New Macromolecular and Low-Molar-Mass Charge-Transporting Compounds Containing Carbazolyl- and Aromatic Amino Moieties**.

30 June Emmanuel Wirth for physical work **Study of Dynamic Surface Barrier Effects on Hydrogen Storage Properties of Mg-Ni-based Films** was granted Doctor of science degree at Vytautas Magnus University.



Arrangement of PhD Candidates according to science directions in 2004–2008



Structure of PhD Candidates' number in 2004–2008



Engineer of Laboratory of Nuclear Installation Safety and Master Student of Vytautas Magnus University Mantas Povilaitis was granted Lithuanian Academy of Sciences award of scientific works competition of high-school students for work **Modelling of Plasma Interaction with the First Wall of Thermonuclear Reactor** (Supervisor – Prof. Dr. Habil. L. Pranevičius)



Dr. Liutauras Marcinauskas (Laboratory of Plasma Processing) was awarded Lithuanian Academy of Sciences citation for scientific work **Formation of Carbon Coatings and Modification of Surfaces Using Electric Arc Plasma**

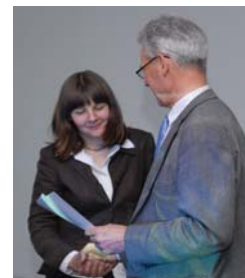




Annually organized *Conference of Young Scientists on Energy Issues* for PhD Candidates and young scientists attracts increasing number of participants. For the fifth year already perspective scientists from Lithuanian and foreign institutes and universities present their ideas and research

results, discuss, prepare papers and have an opportunity to get acquainted with works of other researchers, to gain experience from them and from each other.

In 2008 48 young scientists presented their scientific papers. 30 participants represented Lithuania: 21 – LEI; 3 – Vilnius Gediminas Technical University; 2 – Kaunas University of Technology and Vytautas Magnus University; 1 – Klaipėda University and Geology and Geography Institute. 18 guests came from foreign countries: 7 from A. V. Lykov Heat and Mass Transfer Institute (Belarus); 3 from Riga University of Technology and Tallinn University of Technology; 2 from Physical Energy Institute (Latvia); 1 from Estonian University of Life Sciences, Birla Institute of Technology & Science (India), and St. Petersburg State Polytechnic University (Russia).







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## Main research areas and applied work of the Laboratory:

- provision of metrological support to the Lithuanian energy sector in the field of fluid flow measurements, establishment and maintenance of state flow standards and ensuring measurement traceability to national and international standards; test of thermal equipment and gas appliances carried out with the aim to determine its conformity to the requirements of Lithuanian and European normative documents;
- research of influence of liquid physical properties and flow disturbances on the metrological characteristics of reference and working volume and flow rate meters, operating under different principals; proving the reliability of metrological characteristics of meters calibrated by fluids-substitutes for measuring real flow of technical and nutritional liquids;
- research, testing and conformity assessment of measuring devices of liquid fuel, water, heat and gas, as well as gas appliances and water heating boilers, heated with gaseous, liquid and solid fuel (including biofuel).

# Laboratory of Heat-Equipment Research and Testing

## Accredited services of the Laboratory in conformity with LST EN ISO/IEC 17025 and 17020 standards:

- calibration of measuring instruments and facilities designed for their calibration/verification, tests and conformity assessment of measuring instruments and water heating boilers and gas appliances. In the field of water and heat meters the Laboratory is accredited, identification No 1621;

- testing and conformity assessment of gas appliances and water heating boilers, heated with gaseous, liquid and solid fuel, including biofuel; in the field of gas appliances the Laboratory has been notified and granted the identification No 1621;
- for testing and conformity assessments of water heating boilers the Laboratory meets the requirements of LST EN 305-1:2000.

## Calibration and measuring capabilities of the Laboratory, confirmed and announced by the International Bureau of Weights and Measures (BIMP)

Quantity	Measuring range	Measuring conditions	Expanded uncertainty $\pm\%$	Type of reference facility
Gas volume and flow rate	0.016–6000 m <sup>3</sup> /h *0.005–9700 m <sup>3</sup> /h	Air, 20 $\pm$ 2°C, atmospheric pressure	0.13–0.30	Facility with bell type prover, critical nozzles and reference meters
Gas flow velocity	0.20–60 m/s *0.05–0.2–60 m/s	Air, 20 $\pm$ 2°C, atmospheric pressure	7.0–1.0 *50–7.0–1.0 **12–2.5–0.30	Pitot tube, nozzles, laser and ultrasonic anemometer
Water volume and flow rate	5–500 dm <sup>3</sup> 0.4–30 m <sup>3</sup> /h *5–1500 dm <sup>3</sup> 0.01–100 m <sup>3</sup> /h	Water, 20 $\pm$ 5°C, pressure 0.45 MPa	0.08 0.12	Facility with balances and flow diverter
Volume of oil products	500–5000 dm <sup>3</sup> (1–120 m <sup>3</sup> /h)	Exxsol D80, 20 $\pm$ 2°C, pressure 0.45 MPa, viscosity $\leq$ 20 MPa·s	0.12 **0.08	Facility with reference tanks (vessels) at "start - stop" regime

\* – Extensions of already accredited fields, but not presented for BIMP;

\*\* – planned to submit for accreditation



LDA testing in the Laboratory hydrodynamic facility with the participation of manufacturer German ILA GmbH representative M.Dues



## Experimental research basis

The Laboratory possesses the following aerodynamic and hydrodynamic facilities, equipped with contemporary measuring equipment and calculation technique:

- 4 aerodynamic and 2 hydrodynamic facilities, which ensure the highest accuracy when measuring air (gas) velocity, air (gas), water and liquid fuel volume and flow rate and heat amount in Lithuania;
- 8 facilities to investigate and test liquid and gas meters;
- facility to investigate the efficiency of heat equipment and emissions.

All facilities are in good conformity with international requirements and may be applied for scientific research and assessment of conformity requirements. The Laboratory can also construct and manufacture the required equipment.

## Main results of scientific applied work 2008

### Research of air (gas) velocity, volume and flow rate meters

Transitional regime phenomena influence research in the field of low velocities were continued aiming at ensuring reliable reproduction of air velocity values within the range 0.05–0.20 m/s and validate new calibration and measurement possibilities of standard in data base of International Bureau of Weights and Measures (BIPM).

A facility was constructed and investigated, in which sonic nozzles connected to measurement channel are used to achieve stable velocity values, which ensure stable air mass flow rate at critical flow regime.

Results of theoretical and experimental research of impact of flow pulsations on errors of turbine meters were generalized in the field of air (gas) volume and flow rate measurement, which enabled to determine error variations. These activities, financed by the **Lithuanian State Science and Studies Fund**, were developed in cooperation with Ukrainian researchers. A facility was constructed and installed to perform analysis of inaccuracy causes, which often occur in the natural gas supply pipelines. The equipment was assembled for SC

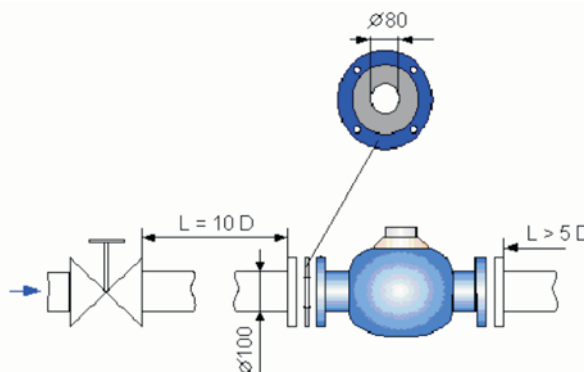
Panevėžio Energija to deal with the situation, conditioned by compressor evoked pulsations.

### Research of liquid (water and oil products) meters

Most of attention was devoted to:

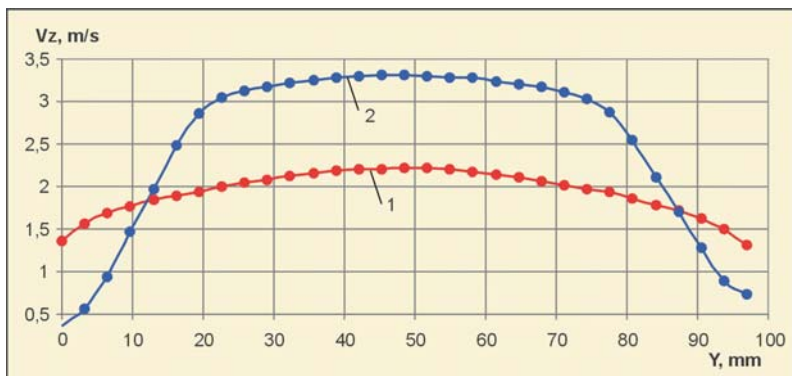
- the impact of hydrodynamic disturbances, evoked by barriers, abrupt cross-section changes and flow pulsations, on the measurement accuracy of most often used meters;
- to estimate the impact of water vapour at increased flow temperature, by reproducing volume and flow rate values;
- application of Laser-Doppler anemometer to measure water flow characteristics;
- generalization of the impact of oil product viscosity.

One of the most significant accomplishments – commissioning of Laser-Doppler anemometer (LDA) and its testing for measuring water flow velocity and its distribution. Composition of LDA submitted by German company ILA GmbH is analogous to the one already used in the Laboratory to measure LDA air flow characteristics of the same company, however higher capacity laser is used. Pilot experiments revealed that LDA enables to accurately measure velocity distributions in pipe's cross-section and sensitively reacts to deformations of velocity



LDA testing scheme measuring velocity profiles in a smooth pipe and after abrupt cross-section reduction





Velocity profiles in meter inflow, measured by LDA: 1 – normal inflow DN100; 2 – inflow diameter reduced to DN80

profile. This confirms a provision to use velocity-area method to calibrate big water meters on the sites of their exploitation.

Another important activity of the Laboratory – research of water volume measurement at enhanced water temperature, which were compared at international level in accordance with EURAMET project No 877 when flow rates are at 6–25 dm<sup>3</sup>/h, whereas water temperature – 50 °C. Research revealed that laboratory equipment and measuring methods are of relevant level so that it would be possible to perform research and tests in accordance with requirements of Directive 2004/22/EC.

Generalized impact of oil products viscosity on metrological characteristics of positive displacement meters is based on theoretical provisions and comparisons with the results, obtained after performing meter testing at the Netherlands national measurement institute laboratory in three flows of different viscosity oil products. In 2008 activities for improving the standard were initiated aiming at reducing the uncertainty of volume values provided by standard.

## Conformity assessment activity

In 2008 the Laboratory initiated the activities important for Lithuanian manufacturers and related to:

- research of water and heat meters and conformity assessments (the notified field);
- research and testing of water heating boilers fired by wood fuel, in accordance with requirements of standard LST EN 305-1:2000.

The first certificates of electromagnetic water meter type examination were issued for SC *Axis Industries* and water heating boilers were tested at Lithuanian SC *Astra* and *Kalvis* and even 10 boilers of Danish manufacturers fired by wood pellets. Such certificates are validated in European countries.

## International cooperation

### Activity in EURAMET and COOMET technical committees

Laboratory implementing functions of state standard laboratory in 2008 participated in annual meetings of EURAMET and COOMET technical committees *Flows* in Berlin and Bratislava, where proposals were suggested to harmonize conditions of air velocity unit reproduction and 5 working themes were excluded

aiming at becoming participant at international projects in accordance with European metrology research programme.

Bilateral measurement comparison with NMI (The Netherlands) is attributed to fully completed international comparisons in 2008, within measuring range 200–2200 dm<sup>3</sup>/min using oil products – diesel, fuel oil and petrol.

Laboratory standard measurement possibilities correlated well with reference values, which were submitted by national laboratories, which organized the comparisons. This shows that correlation of important energy resources flow measurement is guaranteed at international level.

Moreover, the Laboratory completed the cycle of comparisons among Lithuanian laboratories, included into water and gas meter verifications, aiming at ensuring that their services guarantee the accounting accuracy of important resources.

### Baltic Sea Region INTERREG III B Neighbourhood Programme

B belongs to one of the three different strands of the European Community Initiative, part-financed from the European Regional Development Fund. Strand B of the INTERREG Initiative supports translational co-operation to enhance balanced and sustainable development of the European territory. The Baltic Sea Region is one of the 13 European INTERREG III B co-operation areas. The European countries consortium, which encompasses the laboratory as well, won the competition and will participate in implementing this project.

## Perspective activities

Taking into account sudden changes of economy and science demands, the Laboratory accelerates the activities directed towards measurements of low velocities and volumes, in the nearest future orienting towards the issue of micro-flows mea-



## Characteristics of Lithuanian and international comparisons for 2008

Project No, status	Reference laboratory	Fluid, measuring size	Measuring range	Number of countries/ laboratories
EUROMET (M.FF-K3) 514, completed	NMI The Netherlands	Air, velocity	0.2–4.5 m/s	9/9
EURAMET 1006, completed at LEI	CMI Czech Republic	Air, velocity	1000–10 000 m <sup>3</sup> /h	14/16
EURAMET 877, completed at LEI	SP Sweden	Water 50 °C, volume	0.006–0.025 m <sup>3</sup> /h	Is continued
COOMET M.FF-S2 406/UA/07, approved	PTB Germany	Water, volume	0.06–100 m <sup>3</sup> /h	7/7
EURAMET, approved	INMRI Italy	Air, velocity	2–50 m/s	Under adjustment
EURAMET 1046, approved	CMI Czech Republic	Water, volume	1–10 m <sup>3</sup> /h	12/13
COOMET 412/UA/07, approved	SE Ivano-FrankovskSM Ukraine	Air, volume	4–160 m <sup>3</sup> /h	4/4
VMT.S.009 (VS-2), completed	LEI	Water, volume	0.03–10 m <sup>3</sup> /h	1/14
VMT/LNAB (DS-2)	LEI	Air, volume	0.016–100	1/5
LNAB, completed at LEI	KMC	Temperature	0–70 °C	1/8

surement. The first positive results are evidenced by research of air velocity range 0.05 m/s measurement possibilities; comparisons of hot water amount measurements at flow rate 6–25 dm<sup>3</sup>/h, in accordance with EURAMET project No 877; join to the activity of newly developed subcommittee *Microflows*, which belongs to EURAMET technical committee *Flows*; submission of initial research results at the first European conference *Microfluidics 2008* in Italy.

## Personnel

All possible conditions are provided in the Laboratory to perform scientific research and aim for scientific degree. The tasks solved at the Laboratory are widely applied in practice not only in Lithuania but also in foreign countries.

In 2008 28 employees worked at the Laboratory: 11 research associates, 5 doctors and 1 Doctor Habilitus and 3 PhD

Candidates; 12 engineers, 2 of them Master students; 1 technician and 4 high quality skilled workers.

## Conclusions

Results of scientific and applied works of 2008 may be generalized in the following way:

- 7 articles published in reviewed journals, 2 of which with ISI index, 6 papers were presented at conference of important works, 8 papers at international and 9 at Lithuanian conferences;
- Group of researchers (Dr. Habil. A. Pedišius, Dr. J. Tonkonogij, Dr. G. Zygmantas and Dr. N. Pedišius) received Lithuanian Science Award of Year 2008;
- Over 200 calibration and 3000 verifications and tests were carried out in main areas of activity, among them foreign countries – Latvian and Danish contractors;
- Activities were carried in accordance with the following important agreements with State metrology service – to maintain and improve state standard level; to investigate manufactured products of Lithuanian SC *Axis Industries*, *Astra* and *Kalvis* and estimate their conformity to the requirements; with the **Lithuanian State Science and Studies Fund** to prepare recommendation regarding natural gas accounting accuracy;
- Technical expertises of inspection bodies and new measurement devices supplied to Lithuanian market were carried out, it was participated in the working group estimating studies programs of Lithuanian universities and colleges in the field of energy;
- Over 250 thousand Litas were applied for the improvement of experimental equipment and purchase of the new one.

Young researchers of the Laboratory (from left): PhD Candidates I. Briliūtė, A. Bertašienė and E. Maslauskas, Master students M. Kulokas and A. Bončkus, postgraduates of KTU T. Vonžodas and A. Grigula







**Head of the Laboratory – Prof. Dr. Habil. Anupras ŠLANČIAUSKAS**

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### Main research areas of the Laboratory:

- efficiency increase of combustion processes;
- creation and development of burners;
- research of hydrogen separation from organic fuel;
- experimental research of solid waste utilization-gasification;
- numerical modelling of granular media.

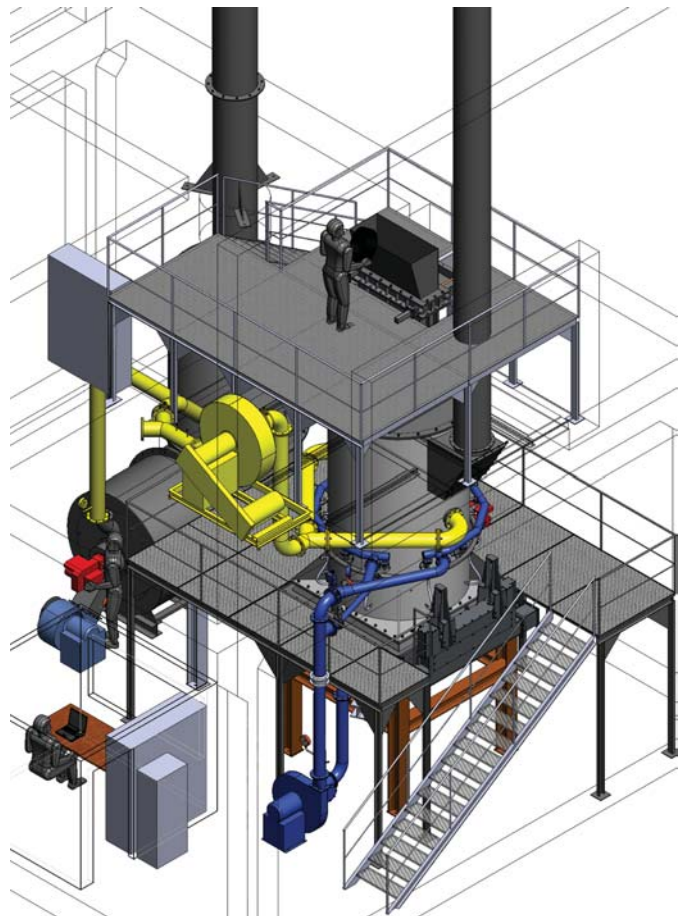
## Laboratory of Combustion Processes

### Gasification specifics of different types of fuel

Gasification specifics of different types of fuel was researched under the project **Scientific Research of Development and Industrial Application of Gasification Technology for High-calorie Material and Waste to Reduce Fuel Consumption**, in accordance with contract with SC *Naujas Kalcitas*. The project scope included the following activities: development of theoretical background and design of the required experimental setups for the technologies; development of the basis of automatic control; elaboration of technology including the gas generation reactors; development of systems for fuel supply and removal of coke and wires; development of gas transportation and combustion system; data collection and processing for the implemented technology.

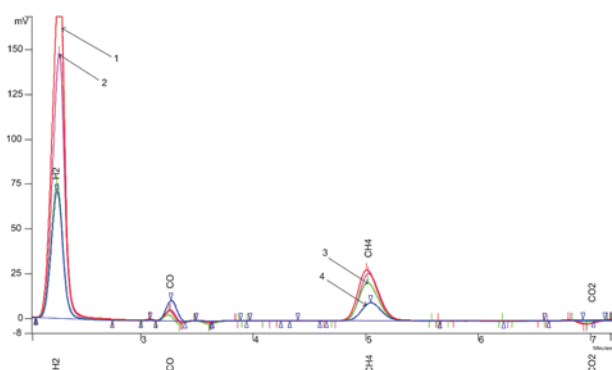
Gasification of high-calorie waste was investigated theoretically and experimentally. The following types of waste that could be potentially used as fuel were analysed: tyres, wood, peat and textile waste (cotton, wool, viscose and mixtures). Gasification tests of high-calorie waste were performed in the Laboratory of experimental research of gasification processes of Lithuanian Energy Institute, using the gasification reactor. Time of emission of volatile compounds from the heated samples was measured experimentally, as well as the amount of resulting tars and carbon residues. From these data, content of volatile compounds in the respective fuel sorts were determined. As the volatile content of textile material was known, theoretical calculations of gasification process were carried out yielding all the required parameters in detail: the required amount of air, the gas yield, the thermal balance of fuel for pyrolysis, the expected chemical composition of gas, how to enhance the gasification process, etc.

It is reasonable to distinguish two cases of the gasification process for two types of fuel – high-calorie fuel (tyres, plastics) and low-calorie fuel (wood, peat, and waste). In the first case, lower amount of air is required to reach the temperature of 1100 °C and to evaporate more volatiles, producing high-calorie



Gasification facility:  
structure of solid fuel gasification reactor

gas: 5000–7000 kJ/Nm<sup>3</sup>. In the second case, the fuel contains more oxygen and an extensive carbon backbone, therefore, it is more difficult to heat, it decomposes slower and therefore higher temperature is necessary. Light gases CO, H<sub>2</sub>, CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub> are produced and the caloric value only amounts to 3000–4000 kJ/Nm<sup>3</sup>. The case of textile gasification has exemplified a characteristic feature of gasification when the oxygen content of fuel has a special importance: as the heated fuel starts to decompose during autopyrolysis, many species of hydrocarbon compounds form and the oxygen contained in the fuel begins to interact yielding high amounts of CO, CO<sub>2</sub> and unbound H<sub>2</sub> besides H<sub>2</sub>O. This is the novelty related to the gasification process, which has not been published yet.



Chromatograms of hydrogen and methane from gasification products of scrap tyres: 1, 2 – samples were taken at steady-state reactor operation regime; 3, 4 – samples were taken at transient reactor operation regime

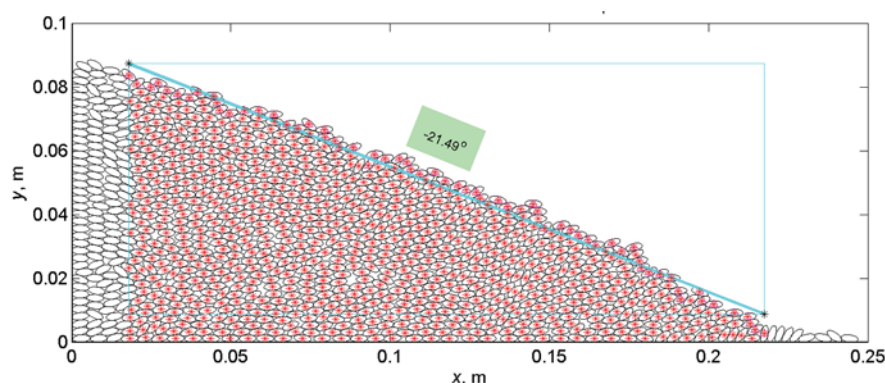
The Laboratory also performs research on incineration and gasification of scrap tyres, and an experimental reactor was designed. Severe problems arise in operation of gas generators since aggressive gases produced during tyre gasification provoke corrosion of steel parts of the generators, therefore, the experts of the Laboratory sought to determine the composition of gas generated during gasification and to test its effect upon the steel samples. The experimental setup of tyre gasification, available at the laboratory of experimental research of gasification process, was used for the tests. Gases produced by tyre gasification were analysed quantitatively and qualitatively by

the gas chromatograph VARIAN GC-3800 and the gas analyser TESTO 350 XL. The metal samples were kept in the ambience of gas produced by tyre gasification for 100 hours, at the temperature of 800 °C. The surface microstructure of the steel samples was analysed using the scanning electron microscope JEOL JSM-5600. X-ray diffraction analysis was performed for the corroded steel samples by the analyser DRON-UM2. The test results suggest that the ambience of aggressive gases produced during the tyre gasification (CO, H<sub>2</sub>S, H<sub>2</sub>, etc.) degrade the steel resistance to corrosion. Effect of these gases on different sorts of steel was identified and the recommendations were prepared for usage of different types of steel in the reactor.

## Applied works for industrial subjects

An experimental device of novel technology was produced and tested under the project **Scientific Research of Development and Industrial Application of High-calorie Materials and Waste Gasification Technology Reducing Fuel Consumption**. Fuel is supplied at the required rate through the valve latches and heated to ignition, and air is supplied in 12 streams perpendicular to fuel flow. The secondary air supply system is used; wire and coke residue is removed by pushing the wires by the hooks of the moving grate, and the coke drops down through the grate openings. The wires and coke are collected into separate closed tanks and the generated gas is extracted by a special-purpose fan at the temperature of 600 °C. The combustion control system was developed: air supply is adjusted according to the temperature of the generated gas, and the fuel supply is automated. The fuel supply and the coke removal unit is the second most important part of the technology. It comprises the hydraulically-operated fuel supply through two latches that separate the reactor space from the ambient air, and a complex implement of a moving grate comprising 11 independently moving bars with attached hooks for wire removal, and for dropping the coke down into the storage. The generated gas is exhausted by a special-purpose fan at the temperature of 600 °C; a special system ensures the constant zero overpressure inside the reactor. The exhaust control system is self-sufficient. Besides these principal technological devices, that are necessary for the experiments from the environmental point of view, the incineration unit for the generated gas, the reactor heating system, and the fuel transportation system are used. In order to test the technologies, the data collection system was developed and the control software was developed.

Emission of nitrogen oxides during fuel combustion is an important issue in power generation. The amount of oxides can be reduced by improving the combustion quality in the boiler combustion chamber. In 2008, under the project **Theoretical Calculations and Experimental Research for Reduction of Nitrogen Oxides and Carbon Monoxide in the GM Boiler at SC Danisco Sugar Kėdainiai**, with partial funding from the Lithuanian State Science and Studies Foundation, the burners of the steam boiler GM-50/14 at SC Danisco Sugar Kėdainiai were rebuilt and the



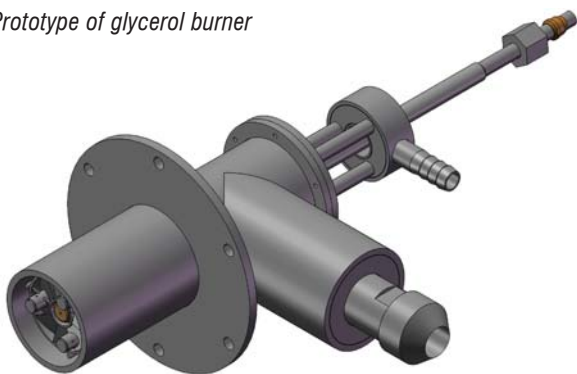
Shape of a pile of elliptical particles and its repose angle determined from simulation



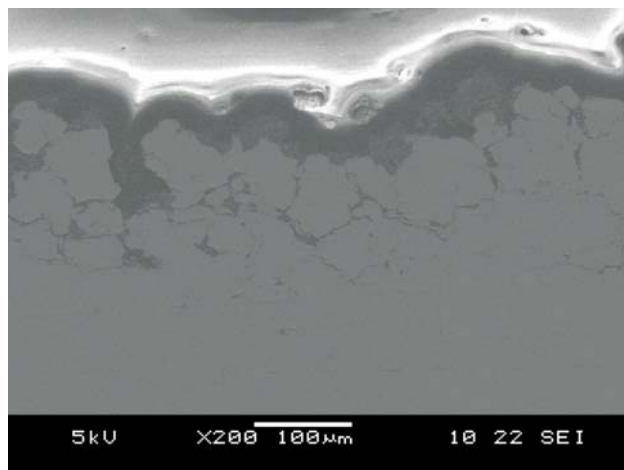
combustion process of this boiler was automated. The works were implemented using the simulation software FLUENT. In order to reduce the computational cost, a symmetric problem was solved for half the combustion chamber with two boilers. The improved burner was designed in accordance with the results obtained. The burning process is regulated by adjusting the fan blade angle and adjusting the gas sprinkler openings depending on the pressure in the gas supply system. Simulation results were compared to the experimental tests of combustion adjustments and a good agreement was found. This work made it possible to reduce the content of nitrogen oxides in the flue gas from 240 mg/Nm<sup>3</sup> to 195 mg/Nm<sup>3</sup> at full capacity of the boiler GM-50/14 operation.

By the contract ***Upgrade of the Burners of the Reforming Furnace 75 for a New Fuel Type, Implementation of Experiments with a Single Burner, their Technical Registration and Adjustment of Combustion Process in the Furnace*** with SC Achema, production of the burners for the primary reforming

*Prototype of glycerol burner*



furnace F201 was completed. During the methanol production, from natural gas and water vapour, hydrogen is produced. The essence of this process is to supply heat to this mixture through the pipes filled with catalysts and to efficiently extract as much



*SEM image of micropolished surface of steel sample after exposure for 100 hours at the temperature of 800 °C in the ambience of gases produced by tyre gasification*

hydrogen as possible. The purpose of this work was to rebuild the old burners and to adjust them to the new type of the gas mixture fuel and the parameters (the temperature, the pressure and the mass flows) of the novel technology designed by the *Khimtekhnologiya* enterprise (Ukraine). The changes in the structural elements and the effect of water vapour and admixtures of gaseous nitrogen upon reduction of nitrogen oxide content were experimentally tested in the furnace. Other experiments were carried out in the facility installed at LEI, in order to select the best shape of the burner nozzle and the spatial geometry of the gas openings of the burner. The results of this work were applied to the design of the burner "Pirna", used in the methanol reforming furnace, whereas the documentation of this burner was prepared and the drawings of the ceramic nozzles were drawn up.

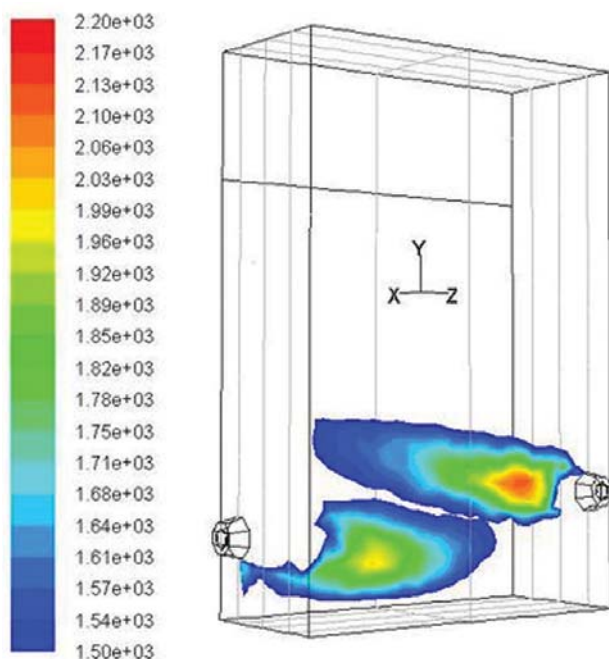
## **Research of utilization of glycerol fraction extracted from biodiesel production**

In 2008 the EUREKA project ***E!3590 USE-GLYCEROL Utilisation of Glycerol Fraction from Biodiesel Plants*** was completed.

The combustion tests of glycerol fraction were carried out in order to develop the burner prototype, to present the recommendations and conclusions regarding glycerol utilization as a fuel for thermal power generation. Throughout the three years period of the project activities, a great deal of experimental research in glycerol combustion was performed, and as a result, the main external characteristics of glycerol spraying (the optimum temperature, pressure, atomised droplet size) were determined using the centrifugal mechanical sprayer, as well as the quality of combustion process and emissions of the main pollutants CO, NO<sub>x</sub>, SO<sub>2</sub>, CO<sub>2</sub> and particulates. Thermal and X-ray diffraction analyses of the solid particles were performed and the crystallographic struc-



*Laboratory researchers at glycerol gasification test facility*



*Simulated temperature distribution in a combustion chamber, at the plane of burners*

ture, thermal properties and the phase change point of the material were determined. An acceptable technology for treatment of solid particles and its efficiency were identified. No production of a potential carcinogenic agent (acrolein) was detected in the combustion products of the glycerol fraction. Together with CSC Tauragės Šilumos Tinklai (Tauragė district heating company), scientific applied research of combustion of glycerol and its mixture with other types of liquid fuel was carried out and the possibility of glycerol combustion in spatial combustion chambers was clarified. The combustion tests performed at LEI and at the company have demonstrated that glycerol can be utilized as a fuel in thermal power production, provided the combustion process is properly adjusted and solid particles are removed from the combustion products. The developed glycerol firing technology enables the biodiesel production plants to combust the bulk glycerol and to produce additional heat that can be utilized for their own needs or sold to nearby heat users.

Under this project, LEI performed also experimental research of glycerol thermal breakdown using its partial oxidation and autothermal conversion. The optimum conditions (temperature, oxygen and water vapour content) were identified to maximize the hydrogen concentration in the reaction products. Further utilization of this type of syngas depends only on the selected production technology of pure hydrogen, as well as on the production technology of methanol, ethanol, dimethyl ether or synthetic biodiesel oil.

An experimental research setup was designed and installed for experimental tests of thermal breakdown of glycerol fraction. The reaction products leaving the reactor are fed into the electrically heated chamber, where a constant temperature is

maintained. The optimum process conditions (temperature, oxygen and water vapour content), maximizing the  $H_2$  gas yield and the catalyst efficiency, were determined experimentally.

Thermodynamic analysis of chemical reactions taking place during glycerol oxidation, performed as a part of earlier research, determined that the principal end products of the partial oxidation reaction is hydrogen ( $H_2$ ), carbon monoxide (CO), carbon dioxide ( $CO_2$ ), methane ( $CH_4$ ), acetylene ( $C_2H_2$ ) and unreacted initial reacting substances. It was determined that the optimum temperature of the autothermal conversion maximizing the hydrogen yield was 1000 K.

## Simulation of granular matter dynamics

A number of models are currently in use to describe the motion of granular matter, of which the discrete element method (DEM) is the most precise. Mixing and segregation is very important for solid fuel combustion. For this purpose, using the software developed earlier, mixing and segregation of granular matter was numerically simulated in order to develop the characterization techniques of these processes and to identify common features. Mixing of round (spherical) particles by a stirring bar was simulated. The parameters, characterising the segregation process, were proposed i.e., its intensity and the final segregation value. During mixing, groups of particles emerge in the granular matter, the motion of which is more or less correlated. In order to examine the emergence and evolution of such groups during the process, as well as their influence on the mixing and segregation processes, appropriate methods should be applied for identifying these groups from the available data of particle velocities and coordinates, calculated during the simulation. For this purpose, community detection algorithms known in the graph theory, that are currently widely researched and applied in many fields, were applied. This technique will be further developed.

Precise approximation of particle shapes is an important task in order to model the properties of bulk materials with sufficient precision. Above mentioned modelling of particle mixing and segregation was based on round (spherical) particle shapes. However, the systems of spherical particles are often inadequate to approximate realistic granular materials. Elliptical shape can be more precise in some cases; however, calculation of the interaction of elliptical particles is rather complex and computationally costly. The task can be simplified by treating the particles as composed of spherical sub-particles, with the total shape close to elliptical one. Under collaboration with Vilnius Gediminas Technical University, numerical experiments of piling of 3-dimensional elliptical particles in a single plane at a vertical wall were performed. The angle of repose and porosity of the resulting pile were determined, as well as an average number of contacts per single particle. It was determined that simulation of ellipse dynamics is slower by a factor of 1.66 than similar simulations of spherical particle dynamics.

During 2008, 1 article was published in the journal indexed in the ISI list, 1 article in international journal and 3 papers at international conferences.



### Main research areas of the Laboratory:

- research of metal ageing processes and properties degradation under the impact of operational factors;
- assessment of reliability of power plant facilities and operating life-time extension;
- development of composites of multifunctional and structural properties from nanoscale materials;
- research of nanocomposite development in cement constructional materials;
- research of composition and properties of ceramics and ceramic coatings;
- testing of materials, assessment and analysis of their qualitative indicators.



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## Laboratory of Materials Research and Testing

### Investigation of hydrogen and hydrides influence on the mechanical and physical properties of zirconium-based alloys

In 2008 the Laboratory continued research on hydrogen and hydrides induced degradation of the mechanical and physical properties of zirconium-based alloys. The Laboratory participated in IAEA coordinated project ***Delayed Hydride Cracking of Zirconium Alloy Fuel Cladding***. The objective of the project is to develop uniform experimental procedures, which will enable to assess velocity of delayed hydride cracking in zirconium-based alloy fuel cladding tubes and to determine the conditions inducing fuel cladding degradation.

Obtained experimental data may be used in developing and validating predictive models of hydrogen induced cracking of fuel cell zirconium-based alloys, estimating hydrogen impact on physical and mechanical properties of alloys. These issues are important in dealing with problems of ensuring safe operation of nuclear power plants, they are also relevant in storage of spent nuclear fuel assemblies.

### Assessment of reliability and operational life-time extension of power plant facilities

In 2008 several projects were carried out in investigating metal ageing processes, which take place in operating facilities of thermal power plants at high temperatures and under the impact of stresses.

The problem of steel operation and its ageing at high temperature is relevant to many power enterprises. Results of these works and created methodology could be employed in Lithuanian power plant as well as in other power plants, in which constructional steels operate under high temperature and pressure conditions. Remaining lifetime assessment enables to optimise activities of renovation of power plant facilities. Implementing

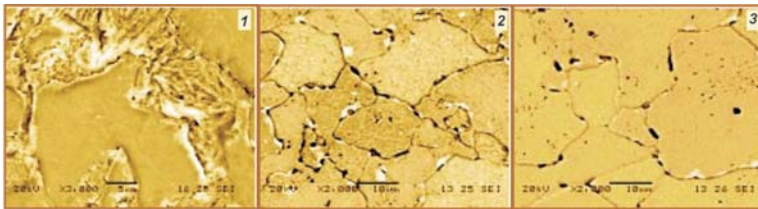
works in this research area a lot of attention is given to fundamental research of physical phenomena in steel structures.

Together with the Laboratory of Nuclear Installation Safety, implementing project ***Justification of the Remaining Lifetime of Direct Steam Cut-off Valve*** with SC *Lietuvos Elektrinė*, state of metal of direct steam cut-off valve case has been investigated. Mechanical characteristics of steel were determined, x-ray investigations were carried out as well as optical, electronic and metallographic analysis, taking into account operational conditions.

Using contemporary finite element computation methodologies and considering changed properties of steel and occurred structural changes, resistance and remaining lifetime of valve case construction under given operational conditions was determined.

Project ***Justification of Service Time Extension of the Servodrives of Ignalina NPP Unit 1 Safety Protection System*** was carried out in the Laboratory of Materials Research and Testing. Specific complex experiments of fast acting protection system servo-drives, calculations and statistical reliability assessment were carried out to determine the real residual lifetime of servo-drives.

**The COST Action 538: High Temperature Plant Lifetime Extension** was carried out with the participation of 17 European countries. Main objective of the activity – development of advanced forecasting model of the remaining lifetime assessment of high temperature power plant equipment. Heat resistant steel 12X1MΦ samples, aged under Laboratory conditions and others operated in the power plant, were investigated using optical, scanning electron microscopy and X-ray diffraction. Variations of carbide content and phase composition were estimated qualitatively and quantitatively during the experiments. It was



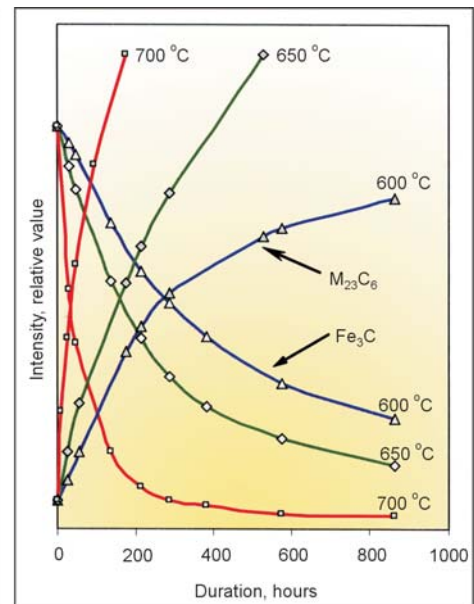
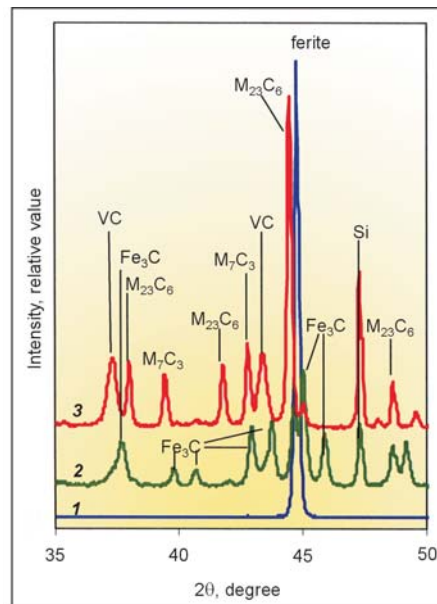
*Micro-structural changes of steel 12X1MΦ, occurring while it is ageing. 1 – Non-operated steel, 2 – heated for 384 h at 700 °C, 3 – operated for 227000 h at 550 °C under 14 MPa*

determined that X-ray diffraction analysis is a fast and informative estimation method of operational conditions of pearlite heat resistant steel.

It was suggested to employ steel ageing at high temperatures under laboratory to simulate processes, occurring while operating it under real conditions.

Due to alloyed element diffusion under ageing of heat resistant steel, phase composition of carbides changes. Changes of composition are determined using X-ray diffraction analysis. Ferrite and cementite ( $\text{Fe}_3\text{C}$ ), comprising the initial steel structure, gradually turn into thermodynamically more stable carbides ( $\text{M}_{23}\text{C}_6$  and  $\text{M}_7\text{C}_3$ ). In accordance with change of these carbides' amount during steel ageing, its operational state is determined.

*Diffractograms of steel samples: 1 – non-etched samples, 2 – non-operated and etched using electrochemical method in hydrochloric acid solution, 3 – operated at 550 °C, 14 MPa and etched using electrochemical method*



*Dependencies of carbides  $\text{Fe}_3\text{C}$  and  $\text{M}_{23}\text{C}_6$  amount in steel on ageing duration and temperature of samples*

## Development of composites with novel functional and structural properties by nanoscale materials

In 2008 researchers of the Laboratory joined activity **COST MP0701 Composites with Novel Functional and Structural Properties by Nanoscale Materials**, participating in the activity of the first working group WG1 *Nanoparticles/Interfaces* (selection of matrix and nanoparticles, production of nanoparticles, surface functionalisation/chemical treatments of nanoparticles).

The objective of participating in the COST activity is to develop preparation methodology of polymer nanocomposite with epoxy matrix and nanosized filler, to investigate the impact of different factors (filler dispersion method, its chemical modification, selection of hardener and compatibility with filler) on intercalation/exfoliation of mineral filler in polymer matrix.

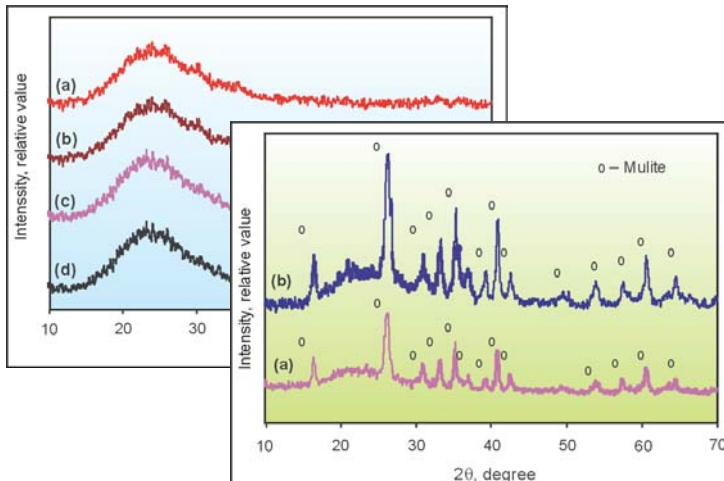
Participating in COST MP0701 activity Laboratory researchers cooperate with researchers from Kaunas University of Technology (Department of Chemical Technology).

## Peculiarities of nano-structures formation in the cementitious building materials: research and technological development

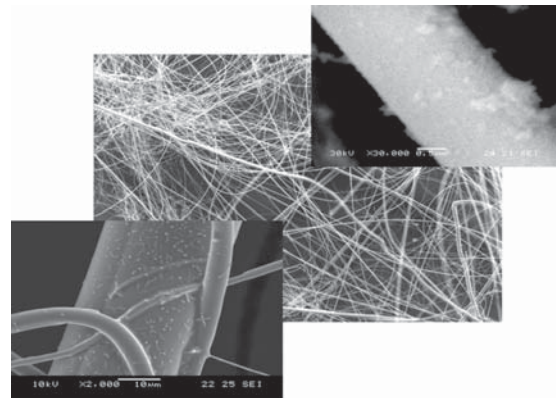
In recent years, working together with the Laboratory of Plasma Processing, a lot of attention has been given to the application of nanotechnologies in cementitious building materials. The project is carried out together with Vilnius Gediminas Technical University (Thermal Isolation Institute, Kaunas University of Technology, Physical Electronic Institute, JSC *Betoneta* and JSC *Statizola*). The objective of the project is development of novel cementitious building materials, the properties of which

are conditioned by nano-structures, developed in their structure. Research is carried out analysing principles of nano-structure formation of cementitious composite materials with nanomodifiers and impact of these composites on product properties. Main work task of the year 2008 was extraction of nanomodifier “micro fiber” in plasmachemical reactor and investigation of fiber’s properties.

The micro fiber is produced from fluid catalytic cracking catalyst waste (ceolits), utilization of which is relevant from ecological and economical point of view. Research revealed that fiber may be used not only in compositions with portlandcement, but also in cementitious compositions designed to be used at high temperatures. Fiber’s thermal endurance is higher than 1200 °C.



*X-ray patterns of ceolite fiber*



*SEM pictures of the fiber*

## Research of structure and properties of ceramics and ceramic coatings

Together with the Laboratory of Plasma Processing **COST action 533** activity **Materials for Improved Wear Resistance of Total Artificial Joints** is implemented. The main objective of the Action is to develop materials for improved wear resistance of artificial joints and enhance durability of artificial joints employing theoretical knowledge and practical experience of scientific participants of the action.

Participating in the activity of the 2<sup>nd</sup> working group **Alternative Hard Bearing Couples for Artificial Hip Joints**, which scientific programme is pointed on the alternative biomaterials, which exhibit better tribocorrosive properties, scientific research is focused on the investigation of the properties of bioinert ceramic coatings formed by plasma spray method on the titanium steel substrates for the development of artificial joints. Performed research revealed that plasma deposited ceramic coatings based on tetragonal zirconia and alumina exhibit good wear resistance and may be a good alternative material for artificial joints.

## Testing of materials and assessment of their quality

Researchers of the Laboratory perform activities providing accredited services, performing material testing and assessment of their quality (the laboratory is accredited for LST EN ISO/IEC 17025). The Laboratory successfully cooperates

with industrial partners, performing research works and providing consultations in the field of product quality assurance.

**The Laboratory is accredited to carry out:**



tests of plastic and pre-insulated pipes,

building mortars, adhesives for tiles, putties,



thermal insulating products, refractory materials and products.

In 2008 researchers of the Laboratory published 7 articles in science journals and 8 in reviewed conference materials, 4 science promotion articles in popular publications. Participated in 14 international and Lithuanian scientific conferences.





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#### Main research areas of the Centre:

- synthesis of hydrogen separation membranes and analysis of their properties;
- synthesis and properties analysis of metals and their alloy hydrides designed for hydrogen storage;
- synthesis of hydrogen fuel cell elements – anodes, electrodes, cathodes – applying physical material deposition methods.

## Centre for Hydrogen Energy Technologies

During the year 2008 state funded project ***Synthesis of nanocrystalline metal hydrides, designed for hydrogen storage, applying ion-plasma methods*** was continued. A great deal of attention was paid to analyse processes of magnesium-nickel alloy surfaces, estimating dynamic properties of surface oxide barrier.

Hydrogen absorption and desorption were analysed separately. There was an attempt to analyse the interaction between Mg-Ni system and Ti additives, which in many other hydride systems (magnesium hydride, sodium alanate, etc.) improved hydrogen sorption properties.

Aiming to achieve project objectives, different composition (Mg-Ni-Ti) films were formed by magnetron sputtering method and their hydriding was carried out under different conditions. Later, films were investigated by in-situ methods, aiming at determining composition and structure of coating elements and hydrogen sorption properties. To understand the processes, researchers of Centre for Hydrogen Energy Technologies performed a mathematical simulation.

Activities in the field of hydrogen energy were also continued in 2008. EU Structural fund project ***Organization of Hydrogen Energy Technologies Training***, implemented by Lithuanian Energy Institute (further LEI) and Vytautas Magnus University (further VMU), was completed. Training programme ***Energy and Environment***, intended for VMU master students

as well as LEI and VMU researchers, working in the field of hydrogen energy research, was developed. The programme provides knowledge necessary to develop and operate the following types of energy: nuclear energy, solar energy (photoelectric and thermal), wind energy, hydro energy, biomass energy (bio-fuel, bio-gas), geothermal energy as well as energy, extracted by using hydrogen fuel cells.

This project had its direct input to obtaining a financial support from European Regional Development Fund. The support has been approved and begun to be implemented – a ***Centre for Hydrogen Energy Technologies*** was to be completely established by the mid of the year 2009.

LEI together with VMU completed implementation of international hydrogen energy PhD studies (HyTRAIN) project. During the first year PhD Candidate Emmanuel Wirth from France came to Lithuanian Energy Institute, Centre for Hydrogen Energy Technologies, where he started his research. Before coming to Lithuania he had defended his Master thesis in the field of chemistry and material engineering. Together with his supervisor, Prof. Dr. Habil. Liudvikas Pranevičius, from VMU, Physics department, and scientific consultants, Dr. Constantina Filiou (JRC Institute for Energy), Dr. Darius Milčius (LEI), Emmanuel proposed a work theme ***Investigation of Dynamic Surface***

#### ***Barrier Effects on Hydrogen Storage Properties of Mg-Ni-bases Films.***

During his first PhD year, Emmanuel actively worked in LEI laboratories, carried out deposition of Mg-Ni film and synthesis of nanocrystalline powders using physical technologies of magnetron sputtering. Afterwards, sample hydrogenation and primary analysis of samples was performed. At the same time Emmanuel actively participated in VMU educational activity: he was one of the participants of project ***Organization of Hydrogen Energy Technologies Training***, during the project seminars Emmanuel presented his work results, discussed them with other participants.

During his second year of PhD studies, Emmanuel went to continue his activities at *Institute for Energy*, Petten, The Netherlands, where using up-to-date equipment performed a thorough investigation of samples synthesised at LEI. Moreover, the student carried out part of the planned experiments at Ion beam physics department of the Rossendorf-Dresden Research Center. In these institutions the young researcher carried out investigations necessary not only for himself, but also enabled LEI and VMU to make contacts with institutions, which accepted him as a student.

In his third year of PhD studies, Emmanuel, together with researchers of LEI and VMU analysed results accumulated in two years and generalized them

by mathematical model. Most of the results were published in three ISI journals and presented in international conferences.

Works by the PhD student were observed at international level – news agency *FACTIVA-Dow Jones & Reuters* submitted an informative report, where it was emphasized that works of Emmanuel Wirth and colleagues are innovative and in the future it may have a huge technological and economical impact on hydrogen storage in the field of material synthesis. Besides publication of results, Emmanuel prepared his PhD thesis, which was defended at VMU on 30 June 2008. The dissertation was acknowledged to meet the international requirements and the PhD Candidate was granted Doctor's degree.

After thesis defence Emmanuel was proposed to participate in the competition of employees of scientific research division of Setaram Instrumentation (France). This company develops, sells and operates the most innovative gas absorption/desorption facilities worldwide. Emmanuel succeeded in the competition and was employed at Setaram Instrumentation. He is the first from all participants, who participated in HyTRAIN project, to have defended doctoral degree, whereas successful employment at international company only confirmed his value as a specialist. Thus it can be observed that the most gifted students not only leave Lithuania to gain the highest level education, but also arrive to Lithuania. Emmanuel's performed scientific work and cooperation with LEI Centre for Hydrogen Energy Technologies and researchers of VMU revealed that there are specialists in the country, who are able to organize and implement scientific research of the highest level in the field of hydrogen storage material synthesis.

In the year 2008 activities were completed in international thermonuclear energy (FUSION) project – **Characterisation of Tungsten Films Used in Thermonuclear Synthesis Reactors**, during which tungsten and tungsten carbide films were formed, thorough investigation of their properties was carried out.

In the year 2008 supplementary Sixth Framework programme specific support action project **HYSIC: Enhancing Inter-**



30 June 2008. Emmanuel Wirth defends his PhD thesis

**national Cooperation in Running FP6 Hydrogen Solid Storage Activities** was completed. During its implementation cooperation with international researchers, working in the field of hydrogen storage, was promoted, exchange of samples, data and knowledge was initiated. During the activities, Mg-Ni film synthesis was carried out at two independent magnetron systems during magnetron cosputtering process. Formed metal films were hydrided in stainless steel container and transparent quartz tube. After hydrogenation, films were investigated thoroughly using an X-ray diffractometer, scanning electron microscope, transmission electron microscope, differential scanning colorimeter, and Furje x-ray spectrometer.

Cooperating activities with partners from Nordic countries were continued within network project **Nordic Centre of Excellence for Hydrogen Storage Materials**. There was an attempt by using **non-equilibrium** technologies to synthesize magnesium and aluminium hydrides, containing a small amount of aluminium and magnesium additives. It is expected that due to experimental magnetron sputtering technologies it will be possible to escape intermixture limits of materials (magnesium and aluminium), developed by traditional equilibrium methods.

The researchers of the Centre participated in investigations of International Energy Agency Hydrogen Implementation Agreement Task 22 – **Fundamental and Applied Hydrogen Storage Materials Development**. In this activity, chemical destabilization of metals and their alloy hydrides was carried out by introducing

new elements into materials, which might impose two affects: i) to form intermediate derivatives during hydride decomposition, thus not allowing the system to get fully relaxed to the lowest energy state, or ii) to form a destabilized hydride during hydriding.

Researchers of the Centre for Hydrogen Energy Technologies actively participated in **COST action 542 Efficient Energy Storage for Mobile and Stationary Equipment**. Main types of supercapacitors and used materials were introduced, research concerning replacement of expensive metal (Pt, Pd) catalysts with Ni / NiO thin layer structures was carried out. Application of industrial thin layer carbon structures, obtained using plasma spray methods and NiOx thin layer structures, obtained using magnetron sputtering methods on graphite GR 280 in supercapacitor electrode synthesis was investigated. Usage of these materials in the future should significantly reduce the price of supercapacitors. Obtained materials and structures were analysed using X-ray diffraction and scanning electron microscopy methods. Measuring scheme of capacitor capacity was constructed. The first experiments of capacity measurement were carried out.

Research results of the year 2008 were published in 13 scientific articles in international journals, 7 international and 1 national conferences and 2 science promoting articles.

Martynas Lelis made his internship at Stockholm University, group of Prof. Dag Noreus, during 7–27 of February 2008.



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### **Main research areas of the Laboratory:**

- development and research of DC plasma sources and arc plasma reactors;
- research of processes and phenomena taking place in reaction arc zone and low-temperature plasma;
- research of dynamics and heat-mass transfer processes in atmospheric and reduced pressure plasma environments;
- plasma and high-temperature gas flows diagnostics and development of diagnostics measures;
- interaction of plasma jets and substances in various plasma-technological processes;
- research and implementation of plasma neutralization process of extra hazardous materials;
- synthesis and characterization of catalytic and tribological coatings in plasma environment;
- research of thermal and heterogenic processes when reacting combustion products outflow the catalytic surface;
- formation and modification of constructional material surfaces in plasma;
- synthesis of micro and nano dispersed granules and mineral fiber from hardly alloyed materials and investigation of properties.

## **Laboratory of Plasma Processing**

Researchers of the Laboratory of Plasma Processing have over 40 years experience working in different fields of development, scientific research and application of low-temperature plasma technologies and are able to successfully simulate new plasma technologies, using plasma equipment, produced in the Laboratory.



*Plasma jet created by atmospheric pressure DC linear plasma generator*

Different composition gas and its mixtures are used as plasma forming gas. Laboratory contains pilot production technological equipment, which is used to change and modify mechanical, tribological, chemical and optical properties of layers of different material surfaces.

Constant updating of technical base, development and disposal of available analytic equipment enables to perform research of plasma sources, diagnostics of plasma flows and jets, analysis of gas dynamic characteristics and heat-mass transfer.

### **Development of plasma sources and research of plasma flows**

Laboratory of Plasma Processing have been developing novel plasma generators with no less capacity than 100 kW. Aiming at developing different construction and capacity linear plasma torches, processes occurring in reactive discharge chambers are considered. This information is obtained using similarity theory, generalizing voltamperic and thermal characteristics of plasma torches, which are determined when electric arc heats various gases under different pressures. The obtained results are compared with other conventional available data and with results of other authors' works.





*Hydrogen plasma outflowing from DC plasma generator*

The following processes occurring in the reaction arc zone are investigated in the Laboratory: heat exchange, electric current strength variation at laminar and turbulent gas flow, its impact on characteristics of plasma flows and jets, impact of radiation at different gases.

Formation of high temperature gas flow, dynamics, heat exchange in different shape of channels and heat exchanger cells are analysed at the Laboratory of Plasma Processing. Operation regime of linear electric arc gas heaters and reactors, their operational characteristics were investigated, conditions of operation duration enhancement were determined, methods of arc turbulence and energy application in plasma devices were investigated. Thermal equilibrium conditions of atmosphere pressure plasma jet were analysed after applying contact and contactless methods. Plasma velocity and temperature profiles were measured by cooling colorimetric probes, their local values were determined and afterwards compared to average values obtained from heat balance equations, patterns of velocity and temperature distribution were determined. Distributions of electron temperature and density were measured employing Langmuir probe with cooling sensor. It was determined that in most cases electron temperature in atmospheric pressure plasma may significantly exceed temperature of heavy particles.

## Research on plasma jet and materials interaction

Aiming at obtaining high-temperature ultra thin fibre, destroying hazardous substances, forming various coatings, synthesizing new materials, the interaction of electric arc and plasma jet with amorphous and dispersed materials is analysed. Physical, chemical and mechanical properties of obtained materials are determined.

Coatings formed employing plasma method are obtained by laminating many dispersed particles, which before confronting the solid surface must be alloyed and plastic. Thus their shape and structure in the coating is very different. The interaction of particles and substrate during contact is defined by flow, deformation, and cooling processes. It has been determined that parameters of similar dispersity of the same kind of material particles are very different.

## Research of plasma neutralization process of extra hazardous materials

Plasma method of extra hazardous materials neutralization is applied to neutralize liquid and gaseous waste, when there is no possibility to neutralize by other thermal method. If temperature is lower than 1300 °C while firing waste in the combustion chamber, new toxic materials may be derived from organic chlorine waste – dioxines, furanes, etc. much more toxic than the initial product. Dioxines is a general name of organochlorine compounds and includes a large number of isomers, called aromatic ethers. The maximal concentration of dioxines is found in exhaust gas of domestic waste and turf firing plants.

From 135 dioxines and 75 furanes 17 are extremely toxic. Their total limiting value is only 0.1 ng/m<sup>3</sup>. Plasma technology of toxic materials neutralization enables to completely neutralize almost all type hazardous substances, an opportunity arises to develop a mobile device. Properties of plasma device, such as very high temperature, short reaction time, opportunity to heat various gases, complete neutralization of hazardous materials, independence from fuel sources (using autonomic electricity generator), enables to use it directly in toxic materials storage sites. After performing research of hazardous waste neutralization in plasma environment it was determined that:

- novel, technologically innovative plasma equipment may neutralize waste and hazardous materials without polluting the environment, whereas combustion process in them may be used to produce energy;
- in plasma environment, at 5000–7000 K temperature, all organic and inorganic materials decompose into atoms, molecules and radicals;
- in all types of waste, remade by plasma technologies, none toxic materials nor secondary hazardous products remain. Final remake products is dark glass or slag, metal and hydrogen induces gas;
- destruction degree of hazardous materials in plasma devices comprises 99.99%.

## Synthesis of coatings in plasma jet

Plasma spray deposition technology developed at the Laboratory allows the formation of catalytic, tribological, protective and hard ceramic coatings used to improve operational properties of surface layers of constructional materials in mechanics, chemistry, energy and medicine. They accelerate resistance to corrosion for 10<sup>2</sup>–10<sup>3</sup> times, significantly reduce friction and enhance resistance to mechanical wear. Using plasma technology, demand for expensive constructional materials diminishes since cheap constructional materials coated with different thickness coatings replace expensive materials consumed in large amounts.

In the plasma device, which supplies nonequilibrium atmospheric pressure plasma jet with unbalanced separate component temperatures, various materials are activated, synthesized and reach the processed surface having different energy. This provides necessary conditions for certain chemical reactions to be blocked in plasma jet and substratum surface.  $\gamma$  phase Al<sub>2</sub>O<sub>3</sub> coatings with extremely developed and active sur-

face were synthesized, and this relevant while developing catalytic coatings. After heating at certain temperature, the coating specific surface was enhanced even more.

At present time coatings of solid carbon derivatives are synthesized in plasma devices. They are called plasma polymers. Plasma polymers – deposited thin films in plasma applied in many fields: microelectronics, biotechnology, semiconductors manufacturing, etc. their low price and good mechanical properties – resistance to corrosion, strength, insignificant specific mass, low wetting angle enable to compete with best up-to-date materials and alloys.

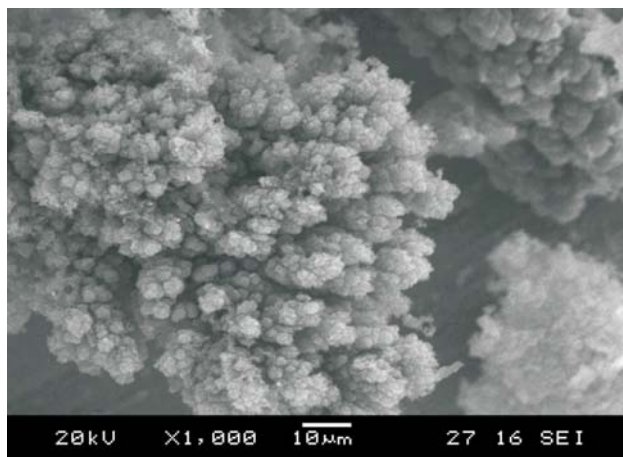
Performing research two plasma systems for the synthesis of hard ceramic and diamond type coating were developed together with new generation modified plasma generators, providing non-equilibrium plasma jet.

Equipment operate in the atmospheric and rarefied gas ambient – nitrogen, argon, hydrogen, acetylene, propane-butane and their mixtures.

### **Melting of ceramic materials and synthesis of high-temperature mineral fibre**

Traditional technology and equipment presently used to produce mineral fibre need continuous operation process, complex and expensive alloying furnaces and insulation materials. Melting raw material in furnaces, afterwards converting the alloy into fibre by mechanical methods, a fibre is derived, filament diameter of which is bigger than  $10\text{ }\mu\text{m}$ . This is not enough in new contemporary heat equipment and technologies. The quality and composition of manufactured fibre is limited by melting-point of raw material: high-temperature thermoinsulation fibre cannot be manufactured by this method.

Plasma technology is the only alternative to obtain a high quality high-temperature fibre. Melting ceramic materials and forming a mineral fibre, an experimental plasma device with high capacity plasma generator has been developed at the Laboratory of Plasma Processing. It enables to form a fibre from



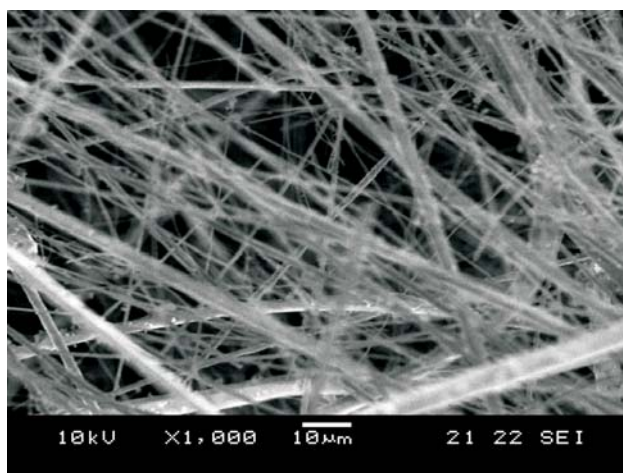
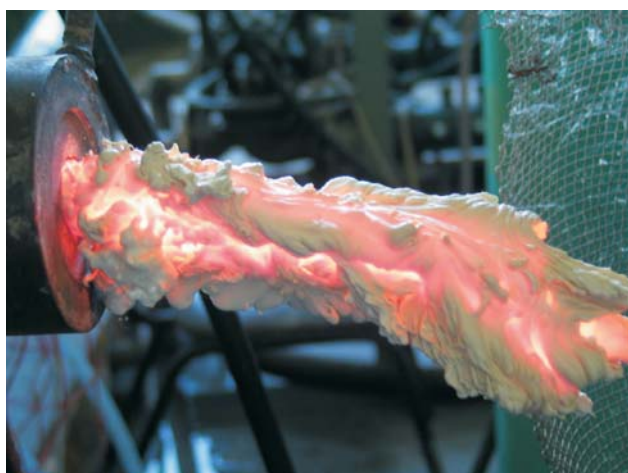
*Structure of carbon derivatives on the stainless steel substratum*

$\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , dolomite, zeolites, etc. dispersed particles, using air as plasma forming gas and auxiliary ( $\text{Ar}$ ,  $\text{N}_2$ , propane-butane) gas mixtures.

### **Other technologies developed at the Laboratory**

The impact of chemical composition, structure, boundary thickness, grain orientation, number of defects, additives of ceramics on its electric conductivity was investigated together with researchers of European countries. Yttrium stabilized zirconium oxide coatings were deposited, their structure and properties were analysed. The dependence of structure, phase composition of obtained coatings and size of crystallites on the parameters of plasma process and conditions of thermal processing was determined.

Plasma nitriding process, which significantly increases the solidity of the surface and substantially reduces the frictional coefficient of the surface, was realized to change the properties of surface layers of stainless steel constructional materials. It was suggested the nitriding process to realize in atmospheric pressure plasma jet, in which the concentration of nitrogen 3-4 orders exceeds the concentration of nitrogen ions



*Aluminium oxide alloy outflowing from plasmachemical reactor (on the left) and fibre formed out of it (on the right)*

in rarefied gas plasma. In such case, the nitriding process would be economical, whereas expensive vacuum technology would not be needed.

Patterns of heat and mass exchange processes in oxide catalytic reactor channels at flow of different composition reacting gas mixtures were analysed aiming at improving catalytic properties of coatings. Information gathered according obtained research results may be used in developing, designing and analytically calculating CO oxidizing catalytic reactors, it may also expand data base of modelling programmes since data is lacking on processes occurring in catalytic reactor. Facility which provides constant characteristics flow of combustion products was developed, novel methodology was developed to investigate catalytic properties and thermal processes of coatings, occurring at the catalytic wall.

State funded work **Research on Regularities of High-temperature Spray Pyrolysis Process, Designed for Plasma Synthesis of Coatings** was completed by the Laboratory in 2008. The problem of plasma spray pyrolysis in the world-wide scientific literature was investigated, experimental gas dynamic device with specific purpose plasma generator was designed and manufactured. In accordance with similarity theory operational characteristics of plasma generators were investigated and generalized, dynamic and thermal characteristics of outflowing gas jet were investigated as well, plasma state was estimated and it was determined that electron temperature of non-equilibrium plasma jet 4–5 times exceed the temperature of heavy particles. Patterns of single phase and two phase plasma jet flow were investigated by numerical and experimental methods. After performing numerical simulation of two phase jet it was determined that under optimal flow parameters dispersed particles reach the maximum temperature at  $x/d = 20$ , whereas velocity at  $x/d = (7-8)$  distance from the plasmatron exhaust nozzle.

Plasma spray pyrolysis process was realized in the experimental device and its basic patterns were investigated. It

was determined that the interaction of plasma jet and dispersed particles lasts for 1 ms, the most rapid phase variation of the particle begins at  $x/d = (3-8)$  from the exhaust nozzle of plasma source.

**Researchers of the Laboratory participate in the following international programs and projects:**

- **COST 533 action *Materials for Improved Wear Resistance of Total Artificial Joints*** (till 2009). Formation of specific coatings, designed for biomedical purposes, is carried out by plasma technologies (in cooperation with scientists of the Laboratory of Material Research and Testing and organizations from 16 European countries). YSZ coatings, designed to produce artificial joints, are developed, in atmospheric pressure low temperature plasma jet applying plasma spray deposition method;
- **COST D41 action *Inorganic Oxides: Surfaces and Interfaces***, till 2010. This action is related with metal oxides coatings synthesis processes and research of their surfaces and internal structure. Its main objective is to improve scientific knowledge on the properties of oxide coating surfaces and structure at microscopic level, applying theoretical knowledge and practical experience to investigate measures and methods, which enable to create the coatings of desirable properties, to control the deposition process. 16 European countries participate in the activity;
- **EUREKA project *E13539 Novel Methods to Produce Mineral Fibre from Local Raw Materials and Waste***, (initiated and coordinate by Laboratory researchers), till 2009. The main goal of the project is to create scientific basis for production of mineral fibre from ceramic materials, to develop experimental equipment, obtain high quality mineral wool, provide research on its properties and application. It is suggested to realise the development of mineral fibre and granules in atmospheric pressure air plasma jet reactor, in which high temperature and high concentration of active ions are achieved. Performed



Examples of Laboratory production at exhibition **Balttechnika-2008**



research reveals that the main factor, which conditions the process efficiency is the flow of atoms and molecules activated in plasma. Developed experimental plasmachemical facility, designed for the research of Si, Mg, Ca and Al oxides and their compounds processes. The fibre, diameter of which is 0.5–2  $\mu\text{m}$ , is obtained in plasma reactor, connected to constant current plasma generator. The cooperation proceeds with researchers from University of Catania (Italy) and JSC *Termotechnika* (Lithuania);

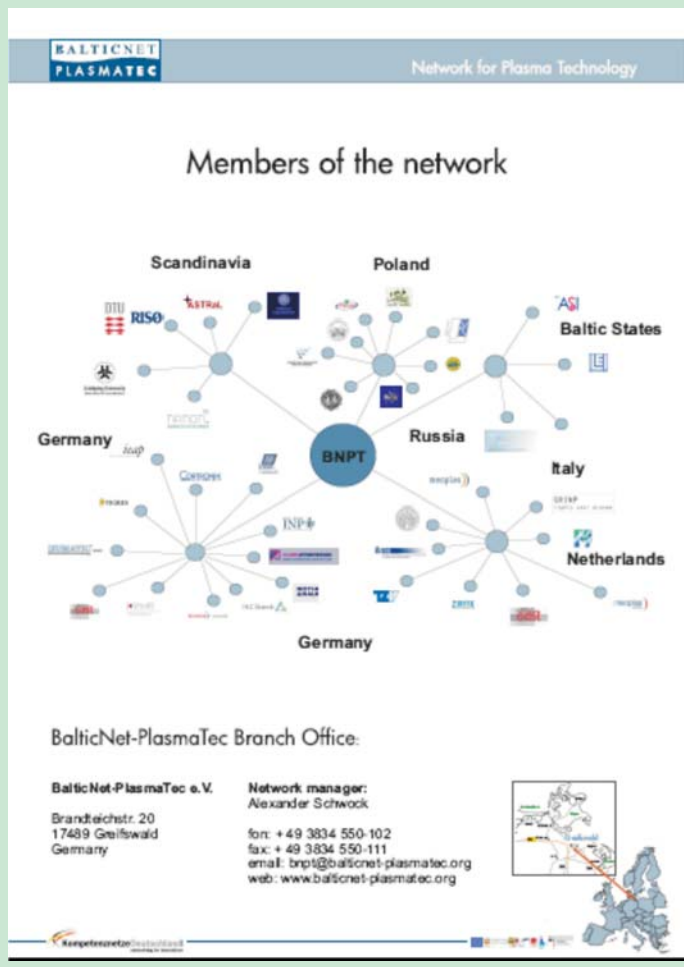


The Laboratory experimental rig and the youth group presenting it: from the left – Dr. L. Marcinauskas, dr. V. Grigaitienė and PhD Candidate M. Milieška

- Bilateral cooperation programme between Lithuania and Ukraine 2007–2008 **Study of Nonequilibrium Properties in Atmospheric and Reduced Pressure Plasma Employed for Surface Modification and Fuel Conversion.** The work is designed for the research of dynamic and thermal characteristics of atmospheric and reduced pressure plasma, used for the synthesis of catalytic and tribologic coatings and solid fuel conversion into gaseous. Plasma state is characterized, measuring

methods of plasma jet parameters are developed, dynamics and heat transfer of plasma jets are investigated, properties of plasma generators and plasma are identified, possibilities are analysed to create specific plasma generators to realize processes of coating composition. Common projects are carried out together with Ukraine Gas Institute (Ukraine, Kiev);

Since 2007 the Laboratory of Plasma Processing has been actively participating in the activity of Plasma Technologies Network of the Baltic countries



- Bilateral cooperation in the field of scientific research between Lithuania and Ukraine 2007–2008. Project **The Creation of Plasma Technology for the Synthesis of Ultradispersed Particles and Deposition of Coatings with Specific Properties.** While performing this project and cooperating with researchers from Odesa National University, technology of dispersed particles synthesis in electric arc and plasma flow is developed, the problem of symmetric ultradispersed particles mixture with plasma forming gas and introduction to plasma flow is solved, porous coatings of high specific surface for micro and nanostructural catalysts, are developed.

In 2008 scientific and technological production of the Laboratory was presented in 8 international and 4 national conferences. The production was demonstrated at exhibition *Balttechnika-2008*, during which the examples of catalytic and tribologic coatings and modified surfaces were presented, new catalytic reactors, filters, and hydrophobic coatings were demonstrated. New plasma technologies of ceramic material melting and fibre production were also presented at the exhibition.

6 science doctors, 2 junior research associates – PhD Candidates, 1 Master student, 1 junior research associate, as well ancillary personnel: 2 engineers and high quality foreman work at the Laboratory. In 2008 the Laboratory researchers published 27 articles and participated in 22 Lithuanian and international conferences.



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# Laboratory of Nuclear Engineering

## Main research areas of the Laboratory:

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



*Experimental investigation of mixed convection in the inclined flat channel – Dr. J. Kolesnikovas (sitting) and PhD Candidate G. Drumstas*

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

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

In 2008 experimental and numerical investigations in vertical flat channel in transitional flow region were continued. The results of experimental and numerical investigations in transitional flow zone for aiding and opposing flows were analysed and correlated. Numerical modelling under different cases of mixed convection was carried out applying FLUENT (USA) code. Obtained heat transfer and flow hydrodynamics results in case of mixed convection for opposing flows fundamentally change the understanding concerning the laminar flow transition to the turbulent under the impact of thermogravitational forces.

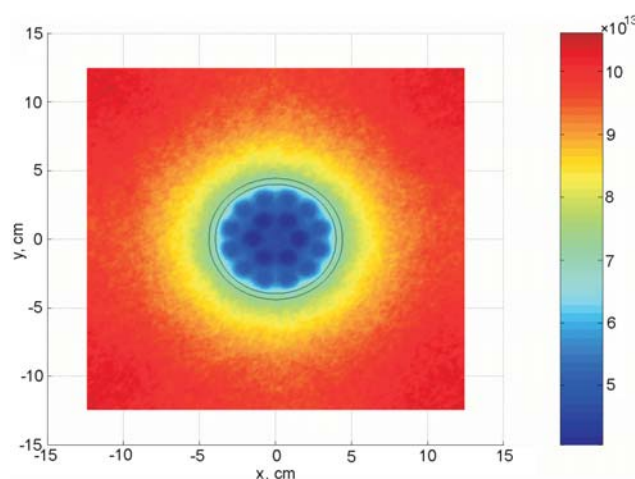
## Management of spent nuclear fuel

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

Implementing research on SNF disposal in Lithuania, the Laboratory experts with the assistance of Swedish experts proposed the generic concepts of deep geological repository in clay and in crystal rocks in Lithuania. The concepts on disposal are constantly revised and optimised taking into account international experience and physical, chemical, thermal and mechanical properties of a specific repository site. While analysing possibilities of SNF disposal in Lithuania, the costs assessment of geological repository installation was carried out and generic repository safety assessment was initiated.

In 2008 research related to radionuclides migration and processes influencing it in the far field of the repository (geosphere) were continued aiming at more optimally evaluating the impact of geosphere on the safety of SNF repository. Research was carried out with the researchers from other countries (the coordinator – IAEA). Data of Veresnia site (Ukraine) was used. Evaluating different flow conditions of underground water in different geological formations, the geofiltration nature of underground water under respective conditions was determined. Preliminary results of numerical evaluation revealed that under given conditions the unsorbed long-lived iodine isotope  $^{129}\text{I}$  dispersed from repository near field environment would reach the river water, however its flow would be 10 times smaller than the flow via the engineering barriers. Whereas the biggest flow values achievement times differ approximately 49 times. This means that radionuclides need time to reach the river water thus they are delayed in geosphere.

Complex researches of the impact of heat and gas dispersion on radionuclides transfer were continued. COMPULINK, CHAN3D, PREBAT-BATEMAN (Sweden), AMBER (UK), and TOUGH2 (USA) codes were applied for the assessment of radionuclides migration.



Radial distribution of thermal neutron flux ( $\text{n/cm}^2 \times \text{s}$ ) simulated by MCNP-5 computer code in RBMK-1500 cell

In 2008 the Laboratory together with GNS-RWE NUKEM GmbH (Germany) consortium continued the project – **The Interim Storage Facility for RBMK Spent Nuclear Fuel Assemblies from Ignalina NPP Units 1 and 2 Supply and Installation (2005–2009)**. The Laboratory prepares environmental impact assessment and safety analysis reports of this SNF storage facility (operational time no less than 50 years) and offers support in licensing the storage facility. In 2008 **Environmental Impact Assessment Report** was approved by the Ministry of Environment and **Preliminary Safety Analysis Report** was submitted to relevant parties for review.

## Radioactive waste management

Since 1994 the Laboratory has been actively involved in the analysis of the radioactive waste management problems at Ignalina NPP. Laboratory experts together with the experts from SKB International (Sweden) carried out a number of projects, including safety evaluation of existing waste storage facilities. Long-term safety assessment of existing radioactive waste storage facilities at Ignalina NPP and Maišiagala was performed, and the possibilities to transform these storage facilities into repositories were analysed. The Laboratory together with Framatome ANP GmbH (Germany) participated in environmental impact and safety assessments for Ignalina NPP cement solidification facility and a temporary solidified radioactive waste storage facility. The Laboratory constantly participates in IAEA coordinated research programmes.

In recent years a lot of attention was paid to site selection for a radioactive waste near surface repository in Lithuania, also to scientific research related with radionuclides migration from radioactive waste repositories and their influence on safety. The Laboratory specialists with the assistance of Swedish experts prepared the set of criteria for choosing a near surface repository site, improved the concept of a near surface repository project, and prepared the implementation programme. The impact of *heterogeneous* waste activity distribution on radionuclides migration from model surface repository was investigated.

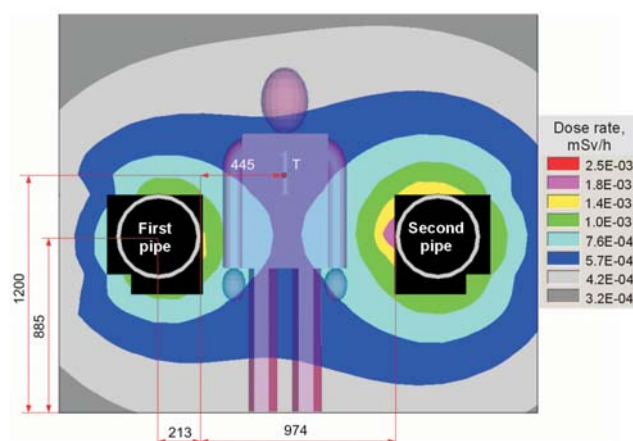


Together with French companies Thales Engineering and Consulting and ANDRA as well as Institute of Physics PHARE project **Safety Assessment and Upgrading of Maišiagala Repository in Lithuania** was implemented. The Laboratory specialists participated in preparing **Safety Analysis Report**, developed the database containing all information on the radioactive waste inventory, which is being stored in the Maišiagala storage facility, and performed a comprehensive nuclide composition analysis.

Implementing the investigation, funded by Science and Study fund, the Laboratory specialists together with the Institute of Physics prepared the report **Research on Radioactive Waste Generation, Radionuclides Migration and Impact to Environment and Public**. DUST, GENII, GWSCREEN (USA), AMBER codes were used for the investigation.

In 2008 the Laboratory specialists continued to implement the project **Reconstruction of Ignalina NPP Bitumen Radioactive Waste Storage Facility (Building 158) into Repository**. A long-term safety assessment of the planned repository was performed. In the research possible engineering solutions of storage facility reconstruction into repository, components of disposal system, i.e. radioactive waste, storage facility and surface engineering barriers planned to be installed over storage facilities and site characteristics were considered. ISAM safety analysis method, AMBER and DUST codes were used in the assessment. Prepared documents were submitted to regulatory institutions in 2007, whereas in 2008 they were coordinated.

In 2008 the Laboratory together with NUKEM GmbH (Germany) continued the project **New Ignalina NPP Solid Waste Management and Storage Complex (2006–2009)**. The Laboratory prepares environmental impact and safety analysis reports for this complex. In 2008 **Environmental Impact Assessment Report** was approved by the Ministry of Environment, whereas two preliminary safety analysis reports: **Ignalina NPP New Solid Waste Management and Storage Complex** and **Ignalina NPP New Solid Waste Unloading Complex** were submitted to regulatory institutions for review.



Radiation fields during dismantling of Ignalina NPP 117/1 building reactor emergency cooling system large diameter pipeline

In 2008 the Laboratory as partner of Lithuanian consortium (JSC *Specialus montażas–NTP*, LEI, *PramProjektas*, JSC *Vilstata*) started to implement a new project **Installation of Very Low-level Radioactive Waste Repository (Landfill)**. *Landfill* repository is designed for disposal of very low-level radioactive waste, generated during Ignalina NPP operation and decommissioning. *Landfill* complex will be comprised of three repository modules and buffer storage where waste will be stored till their disposal. The Laboratory prepared **Environmental Impact Assessment Report** (common for buffer storage and disposal modules) and **Safety Analysis Report** (for buffer storage) and prepared documents were submitted for review to regulatory institutions.

## Evaluation of different factors related to decommissioning of nuclear power plants

In 1998 the Laboratory specialists started a new activity related to the planning of decommissioning of Ignalina NPP. Our experts participated in PHARE project preparing **Preliminary Ignalina NPP Decommissioning Plan**. An extensive database describing the characteristics of the elements of different systems and DEC-RAD software was developed. This software enables to estimate the amount of radioactive waste, which will be accumulated at Ignalina NPP, and also costs for carrying out the presumable operations. In the course of preparing **Final Ignalina NPP Decommissioning Plan**, this code was further developed at the Laboratory and information on radiological and technical data on Ignalina NPP systems was updated. In order to evaluate radioactive contamination level of the most contaminated systems, LLWAA-DECOM (Tractebel Engineering Company, Belgium) code adjusted to RBMK reactors was used. In 2004 the Laboratory specialists for the Ministry of Economy prepared the drafts on **The Ignalina NPP Decommissioning Programme and the Plan of Means of its Implementation for the period 2005–2009**.

The fire hazard analysis for Ignalina NPP Unit 1 and Unit 2 was carried out together with Swedish experts. Fire hazard assessment of newly designed Ignalina NPP SNF storage facility was carried out as well. In 2008 fire hazard analysis was carried out while preparing for **Decontamination and Dismantling of Facilities of Ignalina NPP Building 117/1**.

Since 2002 the Laboratory has been participating in IAEA coordinated research project **Disposal Aspects of Low and Intermediate Level Decommissioning Waste**. The Laboratory performed radioactive deposits formation analysis, also analysed the expected amounts of the radioactive waste at final INPP shutdown. Radioactive residue composition and their activity assessment methodology during the final reactor shutdown was prepared, forecasted quantities of radioactive waste were estimated, preliminary specific activity values for radioactive waste packages with activated reactor components were calculated.

In 2008 research concerning neutron activation of reactor constructions was continued, most of attention giving to reactor constructional elements, other than graphite stack boundary. In order to evaluate the activation of such elements, neutron flows should be simulated using numerical method in the constructions since in RBMK reactors neutron flux are measured only in

the boundaries of reactor graphite stack. Thus the methodology is developed, which enables to estimate neutron flux in the analysed reactor constructions. MCNP-5, SCALE (USA) codes were used for the modelling of neutron flux.

Together with Institute of Physics the Laboratory implemented the project **Development of Radiological Characterization Programme for Equipment and Installations at INPP. General Programme of Radiological Survey** was prepared and approved by regulatory institutions. **Historical Assessment Report of Radiological Situation at INPP** and **Programmes of Detail Radiological Characterizations of Individual Ignalina NPP Units (V1, G1, 117/1)** were prepared as well.

In 2008 new project – **Preparation of Detail Radiological Survey Programmes for Ignalina NPP Blocks B1, D0, D1 and Building No 119 Facilities** has been started. Microsoft Access database was developed, where all data, necessary for describing equipment and schemes with planned positions of radioactivity measurement and sample taking, will be accumulated. Developed codes and collected and analysed data regarding radiological situation at Ignalina NPP are necessary for preparation of the Ignalina NPP Unit 1 dismantling projects.

In 2008 Lithuanian Energy Institute, as a partner of consortium BNG (UK)-LEI-NUKEM (Germany), participated in the new project – **Decontamination and Dismantling of Facilities of Ignalina NPP Building No 117/1**. Researchers of the Laboratory participate in preparing environmental impact assessment and safety justification reports, technical and detailed projects and developing *General Data Set*.

Using CORA/CALCOM (Germany) code, the equipment of building 117/1, waste amounts and their characteristics were analysed and assessment of cost of deactivation and dismantling activities was carried out. Personnel radiation doses were simulated after estimating surface contamination of facilities by VISIPLAN 3D ALARA (Belgium). In 2008 *Environmental Impact Report* and *Safety Justification Report* and *General Data Set* were prepared and submitted to the Ignalina NPP for review.

### Research related with construction of new nuclear power plant in Lithuania

In 2008 researchers of the Laboratory started the activities related with the implementation of new nuclear power plant in Lithuania. Consortium Pöyry Energy Oy (Finland)-LEI (Lithuania) completed important project **Preparation of Environmental Impact Assessment Programme for New Nuclear Power Plant**, where the scope of new nuclear power plant environmental

impact assessment report was determined. In **Environmental impact assessment report**, in cooperation with specialists and experts from Finish and Lithuanian institutions (Institute of Botany, Institute of Ecology, National Public Healthcare Laboratory), deterministic and probabilistic environmental impacts during new NPP construction and operation were estimated. Applying numerical methods and experience while operating Ignalina NPP it was analysed how planned economy activity



During discussion of new power plant environmental impact assessment report – on the left Drs. D. Grigaliūnienė, E. Adomaitis, V. Ragaišis, A. Šmaižys

may impact the following environment components – water, air, soil, biological diversity and public health. A great deal of attention was devoted to numerical simulations of Drūkšiai lake water temperature and radionuclides dispersion, to estimate impact on lake ecosystem and to estimate radiological impact of public health during normal operation as well as during design basis and severe accident. Since planned economy activity may have intercontinental impact, it was estimated how new NPP may impact Latvian and Belarus environment components.

### Main results

In 2008 the Laboratory (26 researchers) continued 2 state funded research projects, carried out 10 applied research projects and earned over 1.8 million Litas. In Laboratory one PhD thesis was defended. Currently there are 4 PhD Candidates in the Laboratory. Researchers of the Laboratory actively participated in different training programs, coordinating meetings, presented 10 papers at international conferences (Belarus, Czech Republic, USA, Morocco, The Netherlands, Ukraine, Germany, and Lithuania), and published 26 scientific articles in Lithuanian and international journals.



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In 2008 researchers of the Laboratory together with Lithuanian and international partners participated in implementation of 33 projects:

- 3 state funded scientific research works;
- 15 international projects (among them 6 projects of EU 6<sup>th</sup> Framework Programme and 7<sup>th</sup> Framework Programme, 4 international scientific research programmes financed from own resources);
- 15 projects with Lithuanian partners.

# Laboratory of Nuclear Installation Safety

## Main research areas of the Laboratory:

- safety assessment of nuclear power plants;
- thermal-hydraulic analysis of accident and transient processes;
- thermal-hydraulic analysis of NPP containment and other compartments;
- simulation of radionuclides and aerosols transport in the compartments;
- assessment of nuclear reactor core modifications and analysis of postulated reactivity accidents;
- safety analysis of thermonuclear fusion reactors;
- analysis of new nuclear power plants;
- reliability estimation and control of energy systems;
- Level 1 and Level 2 probabilistic safety assessment of NPP;
- assessment and prognosis of the NPP graphite stack-fuel channel gap closure dynamics;
- strength analysis of constructions, piping and other elements of complex technical systems;
- single failure analysis and engineering assessment for complex technical systems;
- risk and hazard assessment of industrial objects;
- assessment of energy supply security;
- reliability assessment and modelling of processes in net systems;
- sensitivity and uncertainty analysis of modelling results;
- fundamental research of thermal physics.

## Assessment of energy security

A three year state funded project **Development of Methodologies of Security and Reliability Assessment of Energy Supply to Lithuania** was completed in 2008. Main objective of the project was to create methodology for estimation and assessment of Lithuanian energy security. This methodology included assessment of various external and internal threats to energy system, analysis of their consequences and choice of solutions, which could eliminate and mitigate these threats. From probable threats there were analysed not only technical, but also eco-

nomical (crisis) and geopolitical threats of energy supply disturbances as well as terrorist acts. Threats impact was estimated from economical, social and political point of view.

**UNDERSTAND** project was completed in 2008. The objective of **UNDERSTAND** project was to present a training package to system operators concerning crises management and intersystem co-operation. The aim of the project was to develop and justify a training concept, which could be expanded in further projects striving to retain uninterrupted electricity supply in European electric systems. In this project, which is part of

**Leonardo da Vinci** programme, besides LEI, 9 partners from 8 European countries participated: the leading partner – **Swedish Energy Agency**, SC SecLink (Sweden), Ostrav Technological University VSB (Czech Republic), ABC Dialog (Denmark), National Emergency Supply Agency (Fin-





land), Link Consulting sas (Italy), KCEM (Sweden), Žilina University (Slovakia), University of Cranford (UK), and Ostrav VSB (Czech Republic).



The objective of Seventh Framework Programme project **SECURE (Security of Energy Considering its Uncertainty, Risk and Economic Implications)**, in which 15 partners from 11 EU countries participate, is to develop energy security assessment methodology, taking into account issues of security of energy supply, estimating geopolitical changes, price formation, development of energy markets inside and outside EU, terrorist threats, etc. The project, which is coordinated by Observatoire Méditerranéen de l'Energie (France), is very important and opportune regarding EU energy security.

Cooperation agreement was signed with Joint Research Center Institute for Energy (The Netherlands) to implement project **Lithuanian Energy Security As-**

**essment**, where using experience of Dutch colleagues, security assessment model of energy supply to Lithuania will be developed and assessment of state's energy security will be performed.

### Preparing for construction and operation of new nuclear power plant in Lithuania

On 20-31 October 2008 **Basic Professional Training Course in Nuclear Safety** were organized in Lithuania. Lithuanian State Nuclear Power Safety Inspectorate (VATESI) and IAEA initiated the idea to organize such kind of training. The training courses were supervised by LEI, the director of which was assigned Dr. Habil. Algirdas Kaliatka from Laboratory of Nuclear Installation Safety. JSC *Visagino atominė elektrinė* and Ignalina Nuclear Power Plant also contributed to organizing the training courses. In these courses lectures were given by lecturers and specialists from LEI, Ignalina NPP, Kaunas University of Technology, and Institute of Physics. There were 19 representatives from VATESI, JSC *Visagino atominė elektrinė*, LEI and 20 participants from 13

countries – Armenia, Bulgaria, Czech Republic, Hungary, Kazakhstan, Latvia, Estonia, Poland, Romania, Russia, Slovakia, Slovenia, and Ukraine.

During training courses participants were acquainted with basic nuclear, radiation, environment safety principles, peculiarities of nuclear power plants safety and its assessment. Extra topics were included into the program (development of new nuclear power plant structure; external electricity supply network; dismantling of power plant after its final shutdown), particularly relevant and interesting for the representatives from the Baltic states, who are preparing for constructing new nuclear power plant in Lithuania. While organizing the visit to the Ignalina NPP, the participants had an opportunity to survey the full scope simulator of Ignalina NPP. The participants were divided into three groups and using the simulator, performed operator's actions in case of emergency situations.

"It is important to formulate nuclear safety knowledge in accordance with IAEA safety standards for the countries, which are preparing for construction of



Participants of Basic Professional Training Courses in Nuclear Safety in Lithuania 2008

new nuclear power plants, cooperation of Lithuanian organizations and IAEA are extremely beneficial aiming at continuous development of structures related with nuclear safety”, - stated Maria Moracho, inspector of IAEA Nuclear Installation Safety Department. According to her, it has been decided to organize these training courses in Lithuania since there are a number of specialists of this field, competent experience has been accumulated and relevant infrastructure necessary for such kind of training is available.

“Such kind of courses has been organized for the first time in Lithuania. Besides, these are the very first steps in establishing Basic nuclear safety training centre in Lithuania”, - stated Marius Ginevičius, director general of JSC *Visagino atominė elektrinė*. According to him, after establishing such training centre in the future in Lithuania, specialists from Lithuania as well as other countries could raise there their qualification.



In 2008 Lithuanian Energy Institute continuing activities for project **IRIS** (International Reactor Innovative and Secure) according to the general agreement between project participants and Westinghouse Electric Company LLC the new bilateral contracts were considered. Conceptual IRIS project is already finished and, at present, works of reactor technical systems testing and preparation of reactor project for licensing are carried out (till year 2010). In this stage researchers of LEI begin to prepare methodologies for comparison of new reactors and implement works, related to structural, economical, security and safety analysis of the reactor. Scientific research in this field is relevant for the study of new reactors construction in Lithuania. IRIS project and related research will be completed around 2010 – 2015, i.e. in the time when assessment and licensing issues for new nuclear reactor in Lithuania will be extremely important. In the recent years specialists of the Laboratory of Nuclear Installation Safety have participated in performing IRIS probabilistic safety and economical efficiency analy-

sis and research, devoted to reduce the risk of different external hazards and the uncertainty of obtained results.

New generation reactor development and analysis works, related to IAEA coordinated research programs, are carried out in the Laboratory. One of such programmes is ***Review of Economical Benefit of Evacuation Zone and Safety Measures Around Nuclear Power Plants with Innovative Small and Medium Capacity Reactors in the Regions, where Reactors are Used for Electricity and Heat Generation***. The objective of this project is the assessment of evacuation zone and safety measures of nuclear power plants as well as the analysis of perspectives of secure and efficient small and medium capacity reactors. Performing research there is an attempt to develop an economic efficiency study, where the possibilities of new nuclear power plant use for district heating are analysed. In the project it is analysed what economic effect would be if reactor power plant were used for electricity production as well as district heating. Performed research reveal how the efficiency of new nuclear power plant increases in such case.

In 2008 activity was initiated in accordance with agreement with VATESI – to prepare updated version of nuclear safety regulating legal act ***General Regulations for Nuclear Power Plant Safety***. Survey of international regulating documents (IAEA, WENRA, EUR, EPRI (URD) and worldwide experience (9 countries) was carried out. In accordance with it first version and, after VATESI comments, second version of General regulations for NPP safety were developed. Final document version is to be submitted to VATESI in 2009. This document will be one of the most important legal acts, regulating safety requirements of Visaginas NPP, planned to be constructed in Lithuania.

In 2008 activities were continued in accordance with LEI signed contract with Inspecta Nuclear AB (Sweden) ***LEI Assistance in Performing Expertise of PULS O3 and GREAT Documentation***. In 1980 in Sweden, in accordance with referendum results, a decision was made concerning non-construction of new nuclear power plants and shutdown of operated nuclear power plants. It was forecasted to shutdown the operation of all nuclear power plants in Sweden till 2010, how-

ever, at present time, the opinion of Swedish society and politicians has changed concerning the perspectives of nuclear power development, and thus power uprate programme of operated power plants is carried out.

Researchers of the Laboratory of Nuclear Installation Safety participate in documentation expertise works of PULS O3 and GREAT projects, which are designed for the capacity increase of Oskarshamn (BWR type reactor) and Ringhals 3 (PWR type reactor), operated in Sweden. Main task of LEI researchers in implementing contract with Inspecta Nuclear AB is to review of thermal hydraulic and strength calculations, given in PULS O3 and GREAT projects. Participation in these works is an excellent possibility to get to know the specifics of different type reactors, with Swedish and international requirements intended for design documentation of different type reactors and safety justification. The experience of Laboratory scientists will be applied for construction of new power plant in Lithuania.



#### **Network of Excellence of Severe Accident Research of Nuclear Power Plants SARNET**

Contract on Network of Excellence for Severe Accident Research and Management (SARNET) was continued in 2008. 49 European R&D organizations, including LEI, participated in this project. In 2008 the Laboratory researchers participated in the activities of three working groups:

- ASTEC – adaptation and verification of integral code ASTEC designed for modelling of severe accidents in nuclear power plants;
- CONTAINMENT – analysis of processes occurring in protective shields of nuclear power plants;
- PSA-2 – application of level-2 probabilistic safety analysis for various nuclear power plants, risk assessment and method development of its reduction.

Another part of SARNET project is probabilistic safety assessment consid-



ering potential severe accident scenarios. The model for severe accident (hydrogen explosion and reactor containment damage) research was analysed and developed together with other participants of the project (close cooperation with scientists from Consejo de Seguridad Nuclear and Universite Libre de Bruxelles). Further improvement of developed software and model was carried out for intended works. Sensitivity analysis software SUSA and SIMLAB were applied for the analysis and comparison of results.

In 2008 SARNET project was completed. Activities, designed for the integration of nuclear power plants' severe accident phenomena and control research in Europe, will be continued in network of excellence SARNET II.



#### **Network of Excellence of Nuclear Plant Life Prediction NULIFE**

In 2008 LEI together with partners continued activities in Network of Excellence **NULIFE**. One of the main task is to establish an integral organizational structure – virtual institute capable of performing scientific research of durability assessment in European nuclear facilities industry. Network of Excellence **NULIFE** will enable coordination of scientific research, carried out in Europe, in the fields which require interaction among different ageing processes, environmental impacts and loadings, taking into account safety level of different nuclear facilities. The participants of the project are gathered into a consortium, which is comprised of Contractors from ten organizations and Associated Contributors from 27 organisations, whereas the project coordinator is VTT Technical Research Centre of Finland.

In 2008 researchers of the Laboratory participated in the following working groups: A-1 – assessment of experience and competence of partners (analysing power issues of nuclear plant); IA-2-2 – assessment of structural integrity (final report on RBMK-1500 reactor fuel channel ageing was prepared); IA-2-4 – safety, risk and reliability (researchers presented

their experience in the activities on safety, risk and reliability assessment of nuclear power plants).

The project will be implemented till 2011.



#### **NPP operation reliability characteristics research**

In accordance with agreement between EC JRC IE and LEI in 2008 the research on **Reliability and Data Analysis of Passive Components** was initiated. Activities of the project are related with EC JRC IE coordinated **APSA** research network *Use of Probabilistic Safety Assessment for Evaluation of Ageing Effects to the Safety of Energy Facilities*. APSA research network comprises 14 organizations from different countries and is related to Network of Excellence **NULIFE**. Taking into account impact of equipment ageing on change of their reliability characteristics **APSA** research network is devoted to improvement of classical probabilistic safety analysis (PSA). In the classical PSA, applying an assumption of constant reliability parameters, sometimes inadequate safety assessment is carried out. In order to perform ageing PSA it is needed to have larger amount of data and more detailed models and to carry out inspection assessment. In this research network most of LEI attention is devoted to activities, related to component reliability analysis methods and time dependent reliability characteristic assessment as well as application of such methods and estimates in PSA models. The issues of development and application of reliability database and relevant software (e.g. WinBUGS) were considered too. Since 2008 LEI has been coordinating APSA research network activity – *Ageing data and reliability analysis for passive components*.

#### **Inspection and Qualification Research**

In 2008 LEI being the member of EC JRC IE coordinated **ENIQ** (*European Network for Inspection and Qualification*) con-



tinued its participation in activities of Task Group on Risk, implemented the risk-informed inspection programme development and optimisation activities in Lithuania. ENIQ research network is comprised of 20 different organizations. Activity of this network is related to Network of Excellence **NULIFE** and other 7<sup>th</sup> Framework Programme projects.

#### **Preparation of the Ignalina NPP 117/1 Building Equipment Decontamination and Dismantling Project (B9-0)**

was continued in 2008. The project is implemented by consortium of VT Nuclear Services (United Kingdom), Nukem Technologies GmbH (Germany) and LEI. In the frame of this project, personnel of Nuclear Installation Safety Laboratory was involved in development of the strategy, basic design, detail design and safety justification report. LEI is responsible for supporting of Ignalina NPP during project licensing and implementation stages. The Ignalina NPP 117/1 building equipment decontamination and dismantling strategy was developed and approved by the Ignalina NPP in 2008. As well in 2008 the basic design and safety justification report was developed. The development of detail design for equipment decontamination and dismantling was started in the end of 2008.

#### **Safety analysis of thermonuclear fusion reactors**

In 2008 the activities were continued in accordance with **Association Agreement Concerning the Cooperation in the Field of Scientific Research of Thermonuclear Fusion** signed between LEI and European Commission. Cooperating with Max-Planck-Institut für Plasma-physik (Germany), the analysis of stellarator type thermonuclear fusion experimental equipment W7-X, constructed in the institute, was carried out. The accident assuming rupture of 40 mm diameter pipe of W7-X cooling circuit leading to steam release to the vacuum vessel was simulated. Calculations were carried out using RELAP5, COCOSYS and ASTEC codes. The initial analysis of heat transfer element (Target module 1H) pipe leak



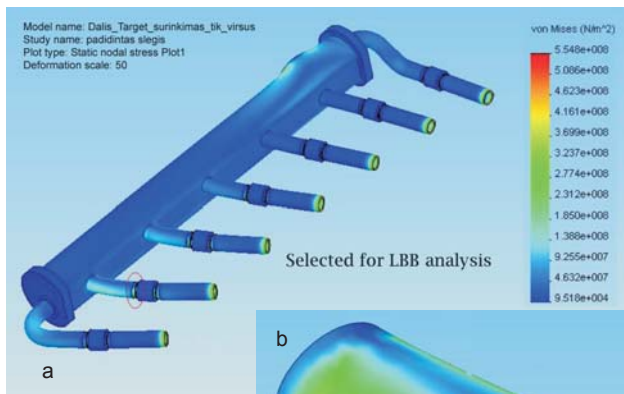


Fig. 1. Finite element model of heat diverting element (Target module 1H) and distribution of stresses

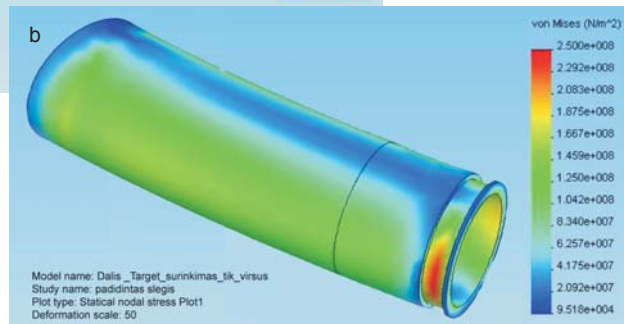
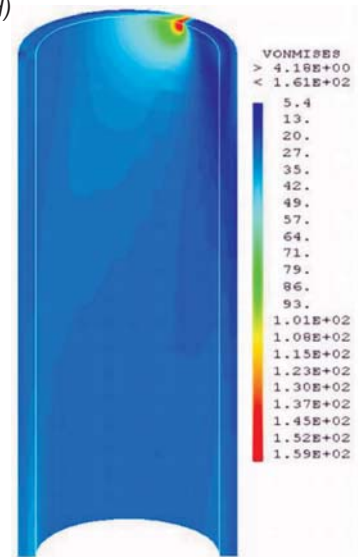


Fig. 2. Finite element model of heat diverting element (Target module 1H) pipe with crack opening and distribution of stresses

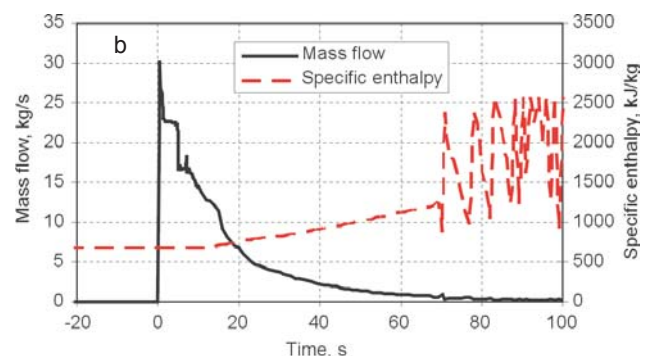
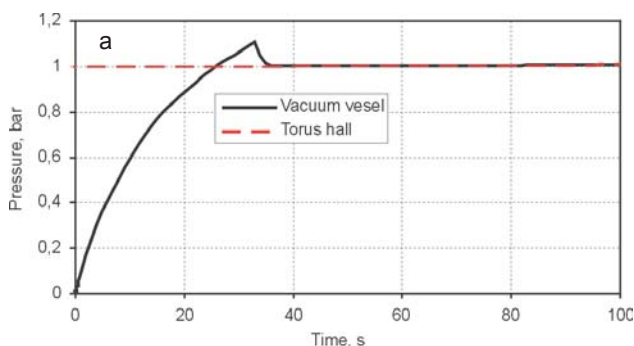


before break was carried out. The pipe region, where crack opening was simulated, was determined after investigating the stress state in the chosen heat transfer element. With this objective the finite element model of this element was prepared, stress analysis was performed (Fig. 1a) and most loaded construction

area was determined. Target module pipe was chosen to analyse leak before break (Fig. 1b). The acceptable and critical crack sizes in the chosen pipe were estimated using R6 methodology. Finite element model of pipe with crack opening (Fig. 2) was prepared using software CASTEM 2000 and crack size was estimated. Cool-

ant release through the crack was estimated using SQUIRT v.2.4.

In 2008 LEI researchers visited Max-Planck-Institut for discussion of the results of analyses and discussed the future programme of activities. W7-X safety analysis activities are to be continued in 2009.



Parameters of coolant flowing to W7-X vacuum vessel, estimated by RELAP5 code (a), and pressure variation estimated by COCOSYS code in W7-X vacuum vessel and torus hall (b)

## Research of condensation implosion

State funded project **Research of Condensation Impact on Interface Surface Stability** was completed in 2008. Numerical and experimental research results of two-phase flow in the inclined channel were obtained during the project: pressure losses, channel inclination angle, and gas velocity profiles.

The analysis of obtained results revealed the drawbacks of experimental facility, helped to decide on the construc-

tions of experimental facility, further improvements of measurement instrumentation and methodology. In the second stage, new improved experimental facility was developed, numerical and experimental research was initiated in the condensing media. Interface surface shear stress was estimated in accordance with the results. It was determined that condensation at two-phase vertical stratified horizontal flow enhances the tangent stress on the interface surface.

Two year cooperation project **Numerical and Experimental Research of**

**Nuclear Reactors in the Field of Heat Transfer** was completed in 2008. The project was implemented with Ukrainian National Academy of Sciences Institute of Technical Thermal Physics. Results of condensation impact on interface surface stability and sensitivity analysis of RBMK-1500 reactor one group distribution collector blockade postulated accident carried out using FAST method are presented in the work. Results may be used for developing thermal-hydraulic facility, designed to ensure passive (opposite to natural) circulation in two-phase thermal circuits.



LEI representatives G. Dundulis (on the left) and T. Kaliatka (in the middle) discuss W7-X facility with IPP representative D. Naujoks (on the right)

## Application of best estimate methodology

In 2008 a three year state funded project **Best Estimate Methodology Application Simulating Processes in Technical, Natural and Social System** was continued. Researchers from the Laboratory of Hydrology and from the Laboratory of Energy Systems Research also take part in this study. The aim of the work is application of uncertainty analysis methodology in the field of social sciences and performing modelling of hydrological processes.

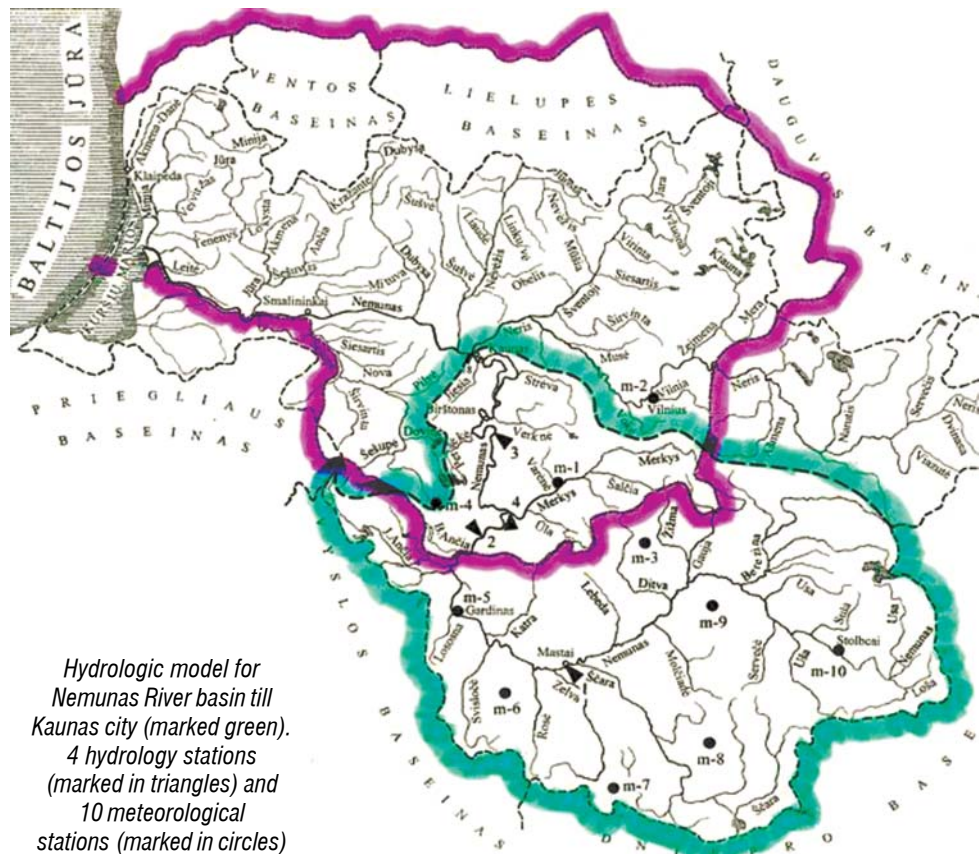
In 2008 forecast of electric power demands was revised. Applying sensitivity and uncertainty analysis methods in social systems (for energy economy tasks), mathematical model of energy system development, applied in developing National Energy Strategy, was reviewed. The changes in energy markets were considered in the model. Also, the

verification of improved FEMAXI-6 code was demonstrated using sensitivity and uncertainty analysis. This code (designed to model processes in fuel rods), was adjusted to RBMK-1500 reactor

needs. Solving natural system tasks (hydrological regime assessment of the Nemunas River), hydrological model for the Nemunas River, which may simulate Kaunas HPP inflow under various natural conditions and in accordance with forecasted climate change scenarios, was developed. Using GLUE (Generalized Likelihood Uncertainty Estimation) method, calibration parameter analysis of the Merkys River (belonging to Nemunas River basin) hydrological model was carried out. Best estimate values of six calibration parameters were determined and value intervals were defined, from which it is suggested to choose parameters to calibrate hydrological model under Lithuanian conditions.

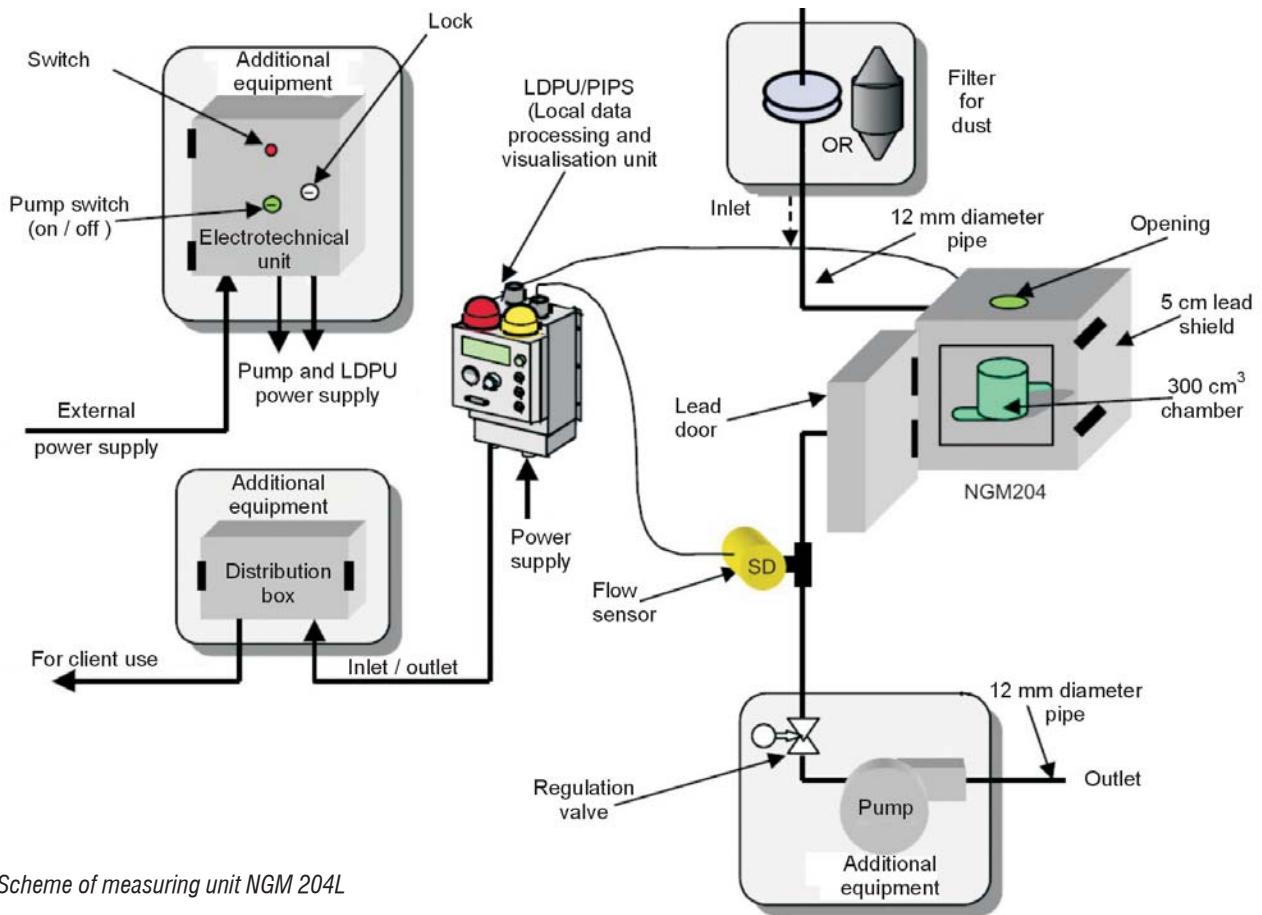
## Activities for the assessment and improvement of Ignalina NPP safety

In 2008 cooperation with Ignalina NPP was successfully continued. Implementing "turn-key" project **Control System of Leaktightness of Fuel Cladding During Dismantling of Spent Fuel Assemblies in the "Hot Chamber"**, the Control system of leaktightness of fuel cladding was developed and implemented at the



Hydrologic model for Nemunas River basin till Kaunas city (marked green). 4 hydrology stations (marked in triangles) and 10 meteorological stations (marked in circles)



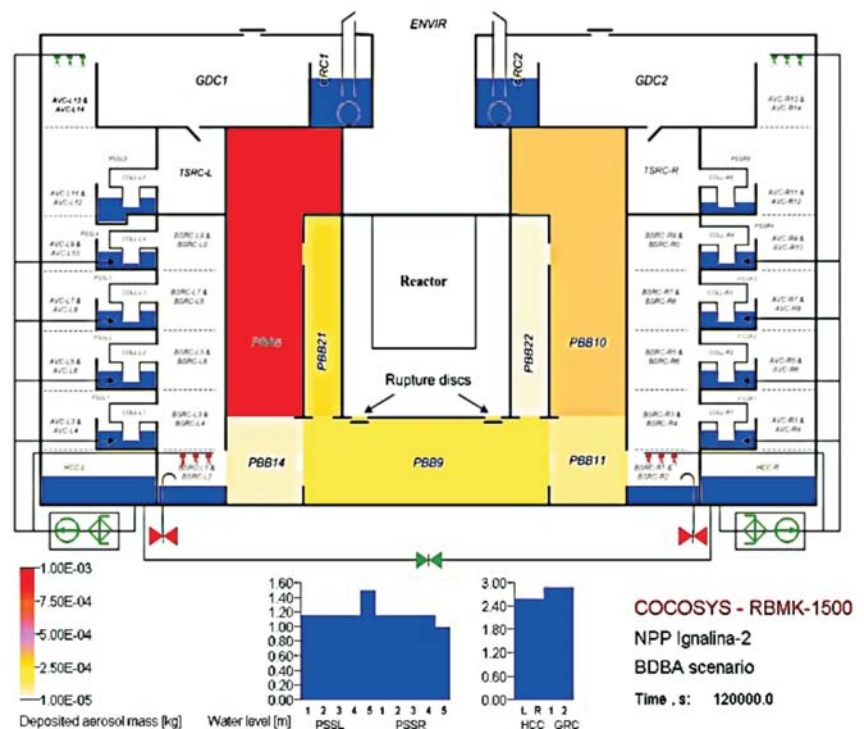


Scheme of measuring unit NGM 204L

Ignalina NPP. Ignalina NPP spent nuclear fuel assemblies from reactor are loaded to spent fuel pools, where they are stored no less than 12 months. Afterwards fuel assemblies are moved to the hot chamber, where they are divided into two parts (two bundles of fuel elements) and are loaded to transportation trays, where only leak tight bundles of fuel elements may be loaded. Leaktightness of nuclear fuel assemblies must be controlled during the whole process in the hot chamber. Ignalina NPP initiated this project, the objective of which was to develop a **Control Method of Leaktightness of Nuclear Fuel Assemblies Cladding**, to justify it and implement control system of cladding leaktightness operating under this method. The project was coordinated by Lithuanian Energy Institute and implemented in cooperation with JSC *Specialus montažas – NTP*. The control method of fuel assemblies leaktightness developed and justified during the project was applied in creating and implementing the system, which enables detection of fuel assemblies with leaky fuel cladding in Ignalina NPP hot chamber both at fuel assemblies reload from the tray and during dismantling of assemblies into two

bundles of fuel elements. Air samples, taken from the hot chamber, access the measuring unit NGM 204L, where activity of inert radioactive gas is measured.

Fuel leaktightness control system was granted the gold medal at Lithuanian Industrialist Confederation organized competition *Lithuanian Product of the Year*,



Distribution of deposited radioactive aerosols in compartments



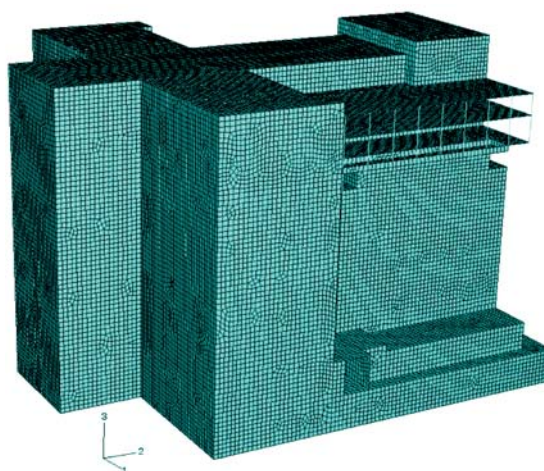
whereas its work efficiency was approved during operation of the system, which started at the end of 2008.

Cooperation project **Analysis of Accident Localisation System (further ALS) of Ignalina NPP** with GRS Company was completed in 2008. The scheme is designed for the analysis of results, obtained applying COCOSYS code. Beyond design basis event (Reactor cooling system pipe rupture with failure to activate emergency core cooling system) analysis was performed and impact of modelling parameters on calculation results was estimated. The following modelling parameters were chosen to perform calculations: control volume centre altitude, compressed air system activation criteria, and initial air and water temperature in Accident Localisation System. While performing the analysis, change of thermodynamic parameters (pressure, temperature, water level in condensed pools, other), hydrogen distribution and radionuclides deposition in compartments and their outflow from Accident Localisation Systems were estimated.

In 2008 agreement was signed with Ignalina NPP regarding **Implementation of Activities of Analysis of NPP A2 Unit 101/2 Buildings Reaction to Seismic Impact**. Implementing this project, the Institute of Geology and Geography and Vilnius Gediminas Technical University participated as subcontractors. Soil and building data was collected for seismic analysis; the seismic hazard assessment was carried out taking into account analy-

sis results of seismic events and seismotectonic conditions in Ignalina NPP region; the soil, the soil – structure interaction and the Ignalina NPP reactor building models have been prepared for seismic analysis of NPP A2 Unit 101/2 buildings.

In 2008 agreement was signed with Lithuanian State Science and Studies Foundation to finance science research project **Modelling and Analysis of Soil and Its Interaction with Ignalina A2 Unit 101/2 Building**, which was implemented together with experts from the Institute of Geology and Geography and Vilnius Gediminas Technical University. The study discusses the seismotectonic conditions of Lithuania. The overview of the corresponding regulations and methods used in the seismic hazard assessment is provided. The experience of other countries and previous studies is discussed. In particular, the application of the probabilistic and deterministic approaches is compared and possibility of application of those methods for the geological conditions of Lithuania is analysed. The case studies of Ignalina NPP show similar estimates of the seismic hazard for both approaches that advocates consistency and applicability of those methods and urges employment of both methods in seismic risk analysis. It should be noted that ob-

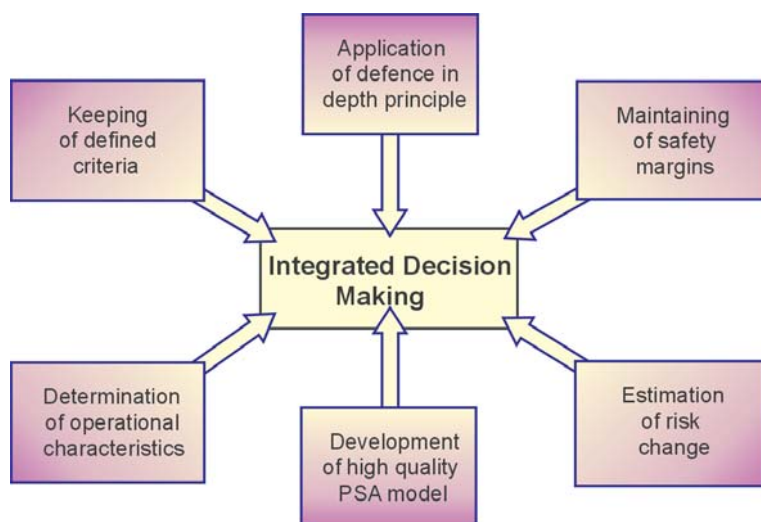


Finite element model of Ignalina NPP reactor building

tained seismic hazard results are well compatible to seismic hazard estimates in Leningrad NPP that is located in a similar geological environment. This study provides a methodological base for seismic risk analysis of Ignalina NPP and will be implemented for analysis of 101/2 building of unit A2 next year. The methodology incorporates ground shaking, building and Soil-Structure Interaction modelling of the seismic impact on the NPP. The finite element approach was applied. The near-field earthquake peak acceleration for safety level SL-2 exceeding  $10^{-4}$  was evaluated as high as  $168 \text{ cm/s}^2$  in Ignalina NPP. It is based on the fact of the presence of the large fault below the Ignalina NPP that is considered as a potential zone for generating an earthquake. This acceleration corresponds to intensity 7.5 (scale MSK-64).

Implementing activities of **Ignalina NPP Probabilistic Safety Analysis** the methodology, designed for the probabilistic analysis of personnel errors, was carried out. Analysis of initiating events as well as probabilistic safety assessment model was updated and uncertainty analysis of modelling results was carried out. Practical application of probabilistic safety assessment and decision making methodology was developed.

The justification of **Hot Shutdown Procedure in Case of Station Blackout at Ignalina NPP** was carried out. The analysis of processes, occurring in reactor cooling circuit, in case of Ignalina NPP station blackout was carried out employing system thermal hydraulic code RELAP5. The optimal operator actions,



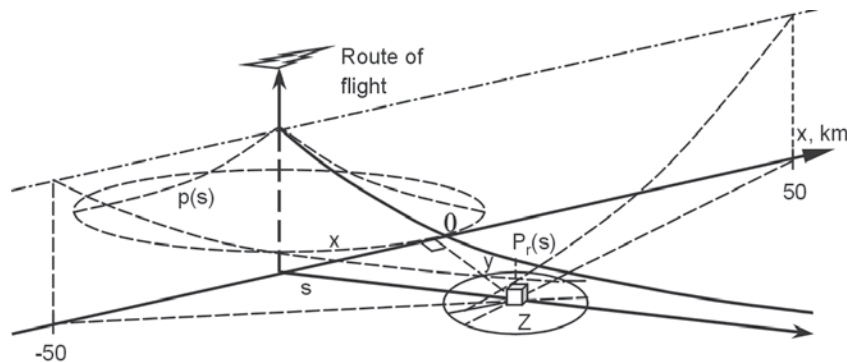
Integrated decision making process

allowing to cooldown reactor reliably in such extreme conditions, were proposed, based on various calculations. It is necessary to point out, that the processes in RBMK reactors during beyond design basis accidents were not investigated in comprehensive manner. Project results enabled to improve Ignalina NPP “hot shutdown” procedure in such way that operators of power plant could successfully control such beyond design basis accident as station blackout (complete energy loss for its own needs).

Other activities related with probabilistic safety assessment were carried out last year: **Probabilistic Safety Analysis of External Events and Events in Shutdown Reactor; Optimisation of Testing Intervals for Safety Important Systems**. Implementing these activities the research methodology was updated, probabilistic analysis models were developed and statistical data research was carried out as well as event scenario analysis and research of testing intervals.

Activities of projects **Justification of Changes, Included into Ignalina NPP Symptom Oriented Emergency Operation Procedures** and **Justification of Changes, Included in Ignalina NPP Accident Classification Procedure** were carried out in 2008. Deterministic analysis of beyond design basis accidents, which do not lead to reactor core damage, was carried out using RELAP5 and COCOSYS codes. Processes, occurring during accidents in reactor core, reactor cooling circuit and in compartments, which surround the circuit, are simulated. Knowing the consequences of specific emergency situation, these accidents are attributed to a certain class of accidents. It is determined what kind of personnel reaction is needed to control a specific emergency or mitigate its consequences.

Ignalina NPP project **Replacement of Flowmeters Due to the Diagnostic Results in Unit 2 in 2008** was completed. In each fuel channel of RBMK-1500 reactor coolant flowmeters are installed. When the flowmeter fails, the operation of corresponding fuel channel is interrupted until the next shutdown of the reactor, when the failed flowmeter is replaced with a new one. Flowmeter diagnostics is performed before annual maintenance in order to avoid failures. In 2008 the continued work analysis of diagnos-



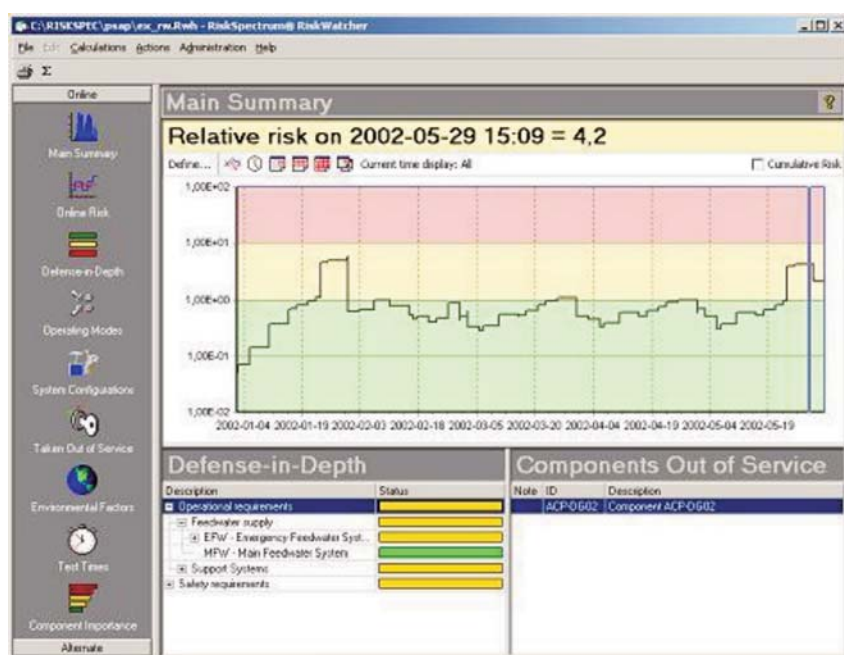
Model of airplane crash on NPP site

tic measures results was carried out and it was determined that 470 flowmeters had to be replaced in Ignalina NPP Unit 2 in order to guarantee a reliable operation until the next planned maintenance. During the analysis the most degraded flow meters were selected. Replacing them the reliability of all flow measuring system was improved.

**The Residual Graphite-fuel Channel Gas Gap Probabilistic Analysis and Forecast at Ignalina NPP Unit 2** was carried out in 2008. The methodology, developed in previous works, was applied in the project to forecast the gas gap of Ignalina NPP Unit 2 and assess the probability of residual gap. Statistical analysis of measurements of fuel channels of

Unit 2 was carried out using measuring data till year 2008, the probability of gas gap disappearance was evaluated and its change was forecasted till year 2010. Calculations revealed that the forecasted probability of disappearance of the gas gap in Unit 2 till year 2010 comply with the requirements of VATESI.

Implementing project **Application of Ignalina NPP Probabilistic Safety Analysis Model in VATESI Activity** the probabilistic safety assessment (PSA) and analysis model was verified and relevant documents feasibility assessment was performed. Software *RiskSpectrum RiskWatcher* was chosen in order to apply Ignalina NPP PSA model for the analysis of unexpected events.



RiskSpectrum RiskWatcher user interface





Gold medal of Lithuanian Industrialists Confederation competition **Lithuanian Product of Year 2008** awarded for development and implementation of project **Control System of Leaktightness of Fuel Cladding During Dismantling of Spent Fuel Assemblies in the "Hot Chamber"**

This software helps working with PSA model and makes possible to adapt it for the development of system for unexpected events analysis. RiskWatcher typically is used as risk monitor for observation of risk dynamics, simulation of possible events scenarios and planning of outages depending on risk estimates. The essence of this software is level 1 PSA model, comprised of set of failure trees and event trees, which define scenarios of investigated events and their consequences. Taking into account the structure and data used at Ignalina NPP PSA model as well as VATESI information, the research on feasibility of data, which is necessary for PSA model adaptation, was carried out.

**The Safety Assessment Expertise of Ignalina NPP Austenitic Du-300 Pipelines Welded Joints with Cracks Left for Further Operation, Volume of in Service Inspection and Period of Inspections** was done in 2008. The review of Ignalina NPP document "Preparation of Reports for Safety Justification of Main Circulation Circuit Du-300 Pipelines of Unit 2, According "Requirements for Assessment of Intergranular Stress Corrosion Cracking Damages in RBMK-1500 Reactors", P-2004-01"" was done. Review comments and independent verification calculations of intergranular stress corrosion

cracking acceptable and critical crack sizes and crack growth in 1.5 year of operation were presented. The results of independent calculations were compared with results presented in report. According to analysis results it was recommended to VATESI to agree the reviewed document according to Ignalina NPP answers to review comments.

Implementing agreement **Review of INPP Documents, Submitted to VATESI, Related with Changes of Reactor Core Configuration, Physical Characteristics and Control, and Other Issues of Reactor Physics and Nuclear Fuel Storage and Management**, Ignalina NPP documents were analysed in order to justify the updated method for operative reactivity margin estimation, the new determined limits for reactor passport characteristics, and safety of regular loading of 2.8% uranium-erbium fuel together with spent fuel rods, transferred from Ignalina NPP Unit 1 to Unit 2. Independent calculations were carried out, on the basis of which conclusion were drawn on the reliability and expedience of presented safety justifications.

According to agreement **Review of Documents of Ignalina NPP SIP-3/2007 41 Implementation**, the Ignalina NPP documents, submitted to VATESI, for justifi-

cation of methodology and equipment, designed to measure hydrogen concentration in top steam reception chamber of Ignalina NPP Accident Localisation System, were analysed. After estimating acceptability of chosen hydrogen concentration measuring methodology, calculations of hydrogen concentration measurement uncertainty were carried out.

In 2008 two Doctoral theses were defended **Analysis of Hydrogen Distribution in Containments of Nuclear Power Plants** (E. Babilas), **Probabilistic Ageing Assessment and Management of Energy Installations** (V. Matuzas).

Research results were presented in science research reports and 63 scientific articles (among them, 15 publications, included in the list of Institute of Scientific Information), 49 papers were presented at scientific conferences. Researchers of the Laboratory participated in the events related to thermonuclear field and presented papers in all main international conferences, where safe operation of nuclear power plants and physical phenomena occurring in them were analysed. Researchers actively participated in different international and national training courses, IAEA seminars, coordinating meetings, activity of FUSION committees and other organizations.





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# Laboratory of Energy Systems Research

## Main research areas of the Laboratory:

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

In 2008 the Laboratory completed state funded scientific research project ***Investigation of Distributed Energy Generation Development***, where issues relevant for the energy sector development were analysed. The following issues were discussed in the project:

- common overview of distributed energy generation (merits and drawbacks of small capacity energy generation resources, issues of connecting them to the network);
- characteristics of distributed electricity generation in Lithuania and factors affecting introduction of small scale producers into the market and demands of applying management tools;
- analysis of directive on the promotion of cogeneration development, issues of connecting cogeneration power plants to the network, ways of removing development barriers;
- recommendations for overcoming technical, business and regulation barriers of distributed energy generation development;
- power sector development model, developed by applying MESSAGE software and supplemented by new linear programming solutions, which enable modeller to perform rather exhaustive and correct simulation of operation regimes of wind power plants and hydro power plants;
- modelling principles of heat supply schemes in the sec-

tor of private houses and wider utilization of renewable energy sources and generalized results of optimisation calculations;

- analysis of probable international climate change regimes after the Kyoto protocol, assessment of their impact on the amounts of greenhouse gas emitted into the environment and characteristics of indicator system of sustainable energy development;
- principles of natural gas supply modelling and assessment of pressure in critical points of the Lithuanian gas supply system, obtained by applying STANET software package.

In the completed state funded scientific research project ***Development of Methodology for the Evaluation of Safety and Reliability of Energy Supply to Lithuania*** energy safety estimation methods were developed, mathematical models were formed and interruptions of the Lithuanian energy system were simulated.

State funded scientific research project ***Application of Best-estimate Methodology for Process Modelling of Technical, Natural and Social Systems*** was further continued together with colleagues from the Laboratory of Nuclear Installation Safety and the Laboratory of Hydrology. In this project, the principles of best-estimate methodology application were discussed, the revised assumptions on electricity demand forecasting and ex-

pected changes in electricity demand in different branches of Lithuanian economy were presented.

## Scientific research works for the national economy

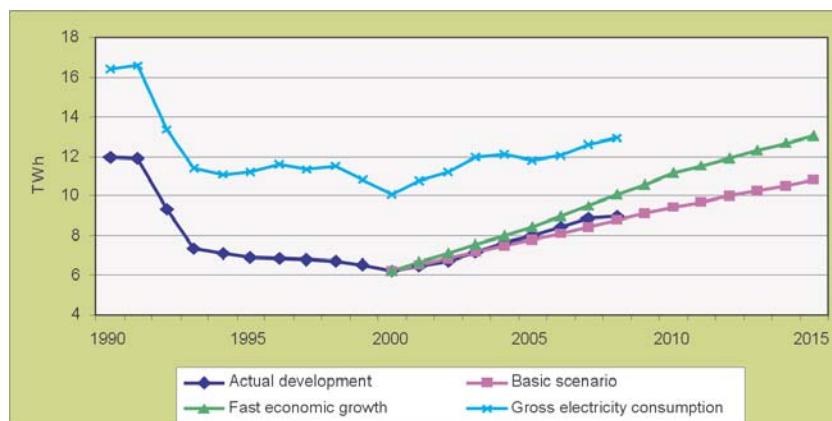
The Laboratory continued its successful cooperation with the Lithuanian Ministry of Economy. The Laboratory won the tender and carried out applied research project **Analysis of Technical and Economic Indicators of the Lithuanian Energy Sector during the Period of 2000–2007, Comparison of the Respective Indicators of the EU Member States and their Publication**. In this project, the development trends of the Lithuanian energy sector and its branches for the period 2000–2007 were analysed, a comparative analysis of major economic and energy indicators of other EU member states was carried out, general production and consumption balance of different fuel and energy forms in Lithuania for the period 2000–2007 was presented. The indicators that define the Lithuanian energy sector development were compared with respective indicators in Latvia and Estonia, the publication *Lietuvos Energija 2007* was prepared.

Significant task had to be solved with approaching shutdown of Ignalina NPP. In accordance with agreement with SC *Lietuvos Energija*, scientific research project **Assessment Study of the Consequences of Ignalina NPP Operation Shutdown on Lithuanian Economic Safety from the Year 2010** was carried out. Analysis of the current status of the Lithuanian energy sector was presented, threats of Ignalina NPP shutdown and scenarios of the energy sector development were analysed in the project. Based on modelling of various scenarios and performed analysis of obtained results, expected changes in electricity

**the Lithuanian Energy Sector after the Year 2009** was carried out. The following results of performed analysis were presented in the project: balance of electricity generation capacities and demand by the year 2020; forecast of electricity consumption in branches of the country's economy; fuel availability and its possible structure; electricity price; environment pollution change and other indicators of the energy sector.

Research results were used by the Commission of the Government of the Republic of Lithuania to analyse energy supply issues after the year 2009 and estimate country's possibilities to take the responsibility regarding climate change mitigation and change in the amount of emitted greenhouse gas after shutdown of Ignalina NPP.

Continuing cooperation with SC *Lietuvos Energija*, scientific research project **Updating of Perspective Development Mathematical Model of the Lithuanian Power System, Taking into Account New Trends in the Baltic Region and Investigation of Capacity and Energy Balances for the Period 2010–2050** was completed. In this project the following results were presented: analysis of gross domestic product changes and electricity consumption tendencies in the Baltic countries and Poland; updated mathematical model for analysis of the power system development; modelling principles of electricity and heat supply from combined heat and power plants in Estonia, Latvia, Lithuania and Poland, as well as modelling of high voltage electricity transmission network and medium voltage transmission-distribution grid; modelling peculiarities of interconnections with power systems of the third countries; forecast of fuel and energy price variation; balances of electricity and capacities in Baltic countries and Poland and scenarios of the amount of CO<sub>2</sub> emitted into the atmosphere.



Forecast of final electricity demand and actual development

generation and fuel, used for production of electricity and heat, as well as primary energy balance were summarized, forecast of electricity production price and impact of electricity price increase on country's gross domestic product and inflation were presented. Measures were proposed to mitigate negative consequences of Ignalina NPP shutdown, detailed characteristics of Ignalina NPP safety status was presented.

In accordance with agreement with the Lithuanian Ministry of Foreign Affairs, scientific research project **Assessment of**

## Participation in the international programmes

In 2008, two EU Sixth Framework Programme projects were completed: **Coordination Action to Consolidate RTD Activities for Large-scale Integration of DER into the European Electricity Market (SOLID-DER)** (experience accumulated in the EU countries was generalized in the project, advantages of distributed generation sources as well as issues of their connection to the networks were revealed, recommendations were provided how to overcome economical, technical and regulation barriers and how to integrate more quickly small scale plants into power system) and **Cost Assessment of Sustainable Energy Systems (CASES)** (in this project, applying EcoSence model, external energy generation costs were determined for main Lithuanian, Latvian and Estonian power plants). Important EU Seventh Framework Programme project **Probabilistic Long-Term Assessment of New Energy Technology Scenarios PLANETS** was launched. The objective of this project is to determine scenarios of new most attractive technologies development in the EU countries by the year 2050, which satisfy the priorities of the EU energy policy and objectives of sustainable development.



*Seminar Role of Distributed Energy Generation in the EU and Baltic Countries*

Relevant questions regarding Lithuanian energy sector development, including aspects of wider use of renewable energy sources, were analysed in the following international projects of *Intelligent Energy – Europe*: **European Tracking System for Electricity (E-TRACK-II)**, **Determination of Milestones of European Policy Future of Electricity Production Using Renewable Energy Sources (FUTURES-e)**, **Sustainable Energy in New Building-market Introduction of Feasibility Studies (SENTRO)**, **Investments in RES Heating Systems through Direct Tax Measures (REFUND +)**, and **Policy Development for Improving RES-H/C Penetration in European Member States (RES-H Policy)**.

Two projects were prepared in accordance with agreements with the EU Energy and Transport Directorate: **Analysis of Achieving National and Community Objectives for Year 2010 of Directive 2001/77/EC (PROGRESS)**, **Employment and Economic Growth Impacts of Sustainable Energies in the European Union (EMPLOYRES)**.

Project **Strategies of Greenhouse Gas Reduction and Scenarios of Energy Development** coordinated by the IAEA was continued. International climate change regimes after the Kyoto protocol were analysed and requirements of greenhouse gas reduction for Lithuania for the period 2020 and 2050 in accordance with different international climate mitigation regimes were determined in the project. In 2008, new project **Comparative Analysis of the Storage of Nuclear Waste and Carbon Dioxide (CO<sub>2</sub>)** coordinated by the IAEA was launched.

Experience gained in the Laboratory was used at the international level in preparing:

- Specialists from Ethiopia and South Africa to model scenarios of the energy sector development (Dr. A. Galinis participated in IAEA training courses as an expert del-

egated by this Agency, responsible for application of MESSAGE model to solve tasks of long-term energy planning);

- Report on Lithuanian greenhouse gas inventory in the energy sector for secretariat of the United Nations Framework Climate Change Convention (UNFCCC) and progress report of implementation of Kyoto requirements;
- Implementing strategy of sustainable development for Kazakhstan (Dr. D. Štreimikienė was responsible for selecting measures for sustainable development strategy);
- Centralized review of greenhouse gas inventories in Russia, Ukraine, Finland and Italy (Dr. I. Konstantinavičiūtė).

On the 22<sup>nd</sup> of April, at the premises of JSC *Lietuvos Energija*, the Laboratory organized a National seminar **Role of Distributed Energy Generation in the European Union and Baltic Countries**, which was attended by the specialists from Denmark, Spain, Latvia, and representatives from 17 Lithuanian energy companies and organizations. This seminar was organized on the basis of Sixth Framework Programme project **Coordination Action to Consolidate RTD Activities for Large-scale Integration of DER into the European Electricity Market**.

Dr. Dalia Štreimikienė was granted the professor educational title of social sciences by Vilnius University.

In 2008, researchers of the Laboratory participated in the conferences in Germany, Japan, Latvia, Malta, Spain, Turkey, USA and other countries, where 25 papers were presented. Researchers of the Laboratory published 16 scientific articles in Lithuanian and international journals and proceedings of international conferences (5 of them are indexed by Information Sciences Institute).





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### Main research areas of the Laboratory:

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

# Laboratory of Regional Energy Development

## Research of regional energy issues

In 2008 state funded scientific research project **Planning Principles and Implementation Possibilities of Sustainable Energy Development** was launched. Principles and implementation experience of sustainable regional energy development, issues of Lithuanian regions and urban energy sector and planning condition are analysed in the project.

Sustainable energy development in regions is one of European energy policy elements, related to implementation of sustainable society development conception, which will enable to achieve target objectives – security and reliability of energy supply, availability for all social layers and meeting the responsibilities in the field of climate change prevention.

Previous means cannot ensure the implementation of these objectives, further on energy dependence of countries on imported sources is increasing, structure of consumed energy sources slowly changes, and hazard prevails that obligations will not be met in the field of climate change prevention.

From social point of view development trends of Lithuanian regions (districts) have been negative. Regional differences increased despite declared activities. Data of recent years indicated a certain shift in trends – economical and social differences do not increase among regions.

State funded scientific research project **Development of Assessment Methodology of Sustainable Aspects of Energy Resources' Utilization** was completed in 2008. The objective of it was to develop the methodology of economic, social, environmental, reliability aspects of energy sources to justify and evaluate the perspective of sustainable energy development. While implementing the project, the following tasks were tackled:

- Connections of decision-making among energy development, economy growth and social and energy supply reliability issues (positive impact) and secondary negative impact regarding environmental pollution and market perversions in various enterprises, cities and re-



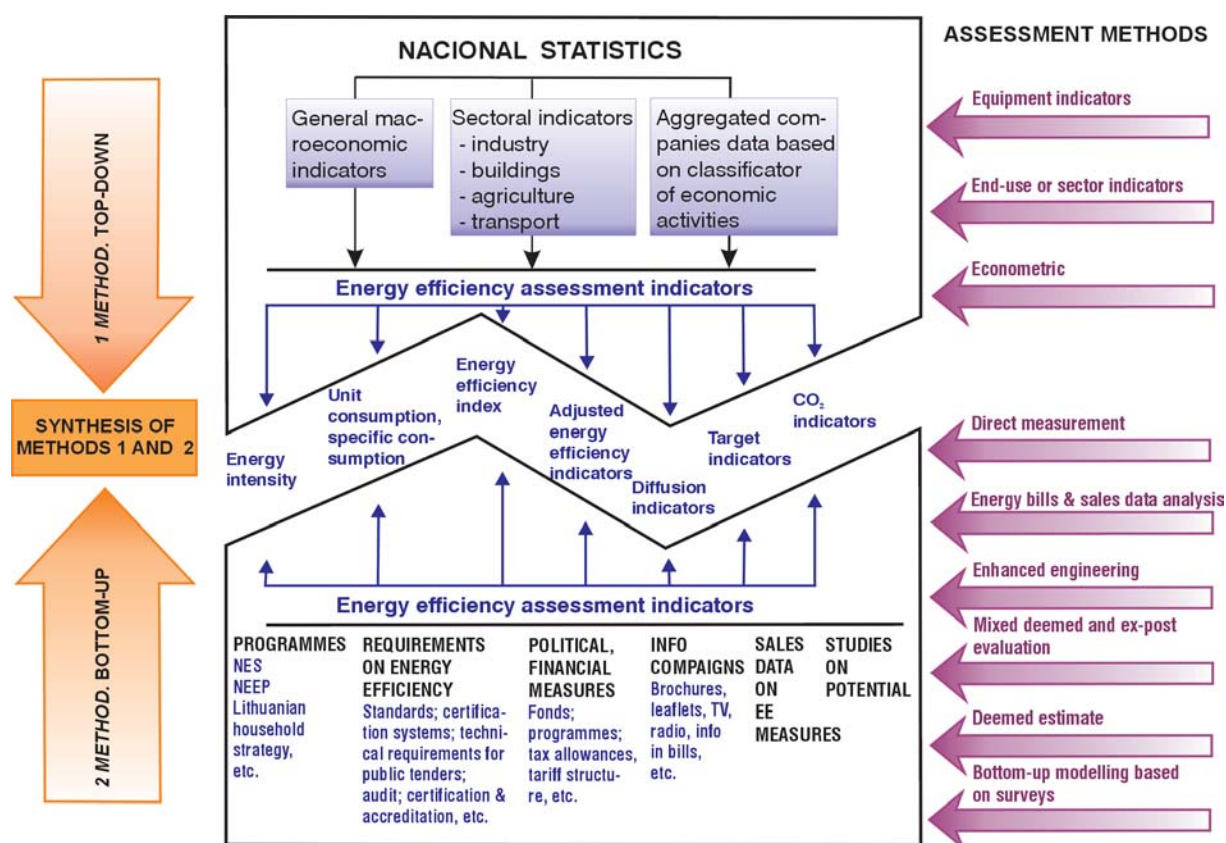
*Elements of conception "sustainable development"*

gions were estimated;

- Propositions of economy theory on issues of energy source reliability supply were discussed;
- One of the most contemporary questions on economical theory was answered: why means of economical policy should be taken to promote consumption of renewable energy sources.

In accordance with agreement with the Ministry of Economy of the Republic of Lithuania project **Development of Monitoring the Increase of Efficient Energy Use** was implemented by the Laboratory researchers. The objective of the project was to perform applied scientific research and prepare projects of legal acts (methodologies), designed to estimate growth of efficient energy use and saved amount of energy due to application of means, which increase efficient energy use in different branches of country's economy sector and fields of energy activity. After reviewing Lithuanian legal documents, which regulate energy generation, efficiency of supply and consumption, it may be stated that common documents (laws) very generally define conception of efficient energy use and do not regulate monitoring system in Lithuania.

Developed monitoring system of efficient energy use increase in Lithuania may beneficially overtake certain principles



Basic functioning scheme of monitoring system

and methodologies, for example, assessment and verification of renewable energy sources and combined energy and heat production projects, uncertainty assessment, and other assessment methods.

Summarizing previously presented analysis, monitoring scheme of energy consumption efficiency was developed by integrating two main methods – “from individual to common” and from “common to individual” and choosing relevant methodologies.

Monitoring system of efficient energy use increase is developed in accordance with National Efficient Energy Use Increase Programme 2006–2010, where organizational, legal, economical educational and informative means are foreseen to increase efficiency of energy sources and energy use.

In international cooperation context, besides efficient energy use monitoring inside the country, the execution of country’s responsibilities in accordance with **Directive 2006/32/EC on Energy End-use Efficiency and Energy Services** is as much important.

## International projects

In accordance with bilateral cooperation programme in the field of scientific research, project **Comparative Analysis of Heat Sector State and Problems of Ukrainian and Lithuanian Municipalities** was carried out. Project partner – **Institute of Technical Thermal Physics of the National Academy of Sciences of Ukraine**. The project is devoted to compare heat economy sectors of municipalities of two post-Soviet countries – Ukraine and Lithuania, to estimate outcomes and per-

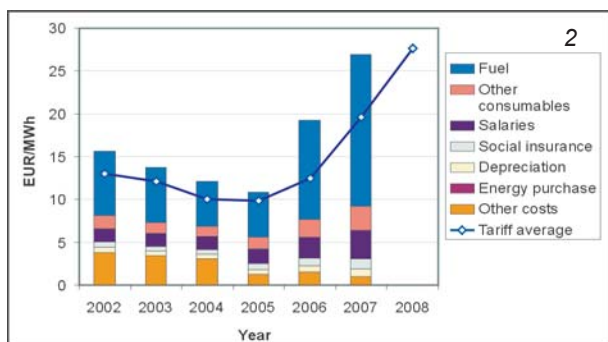
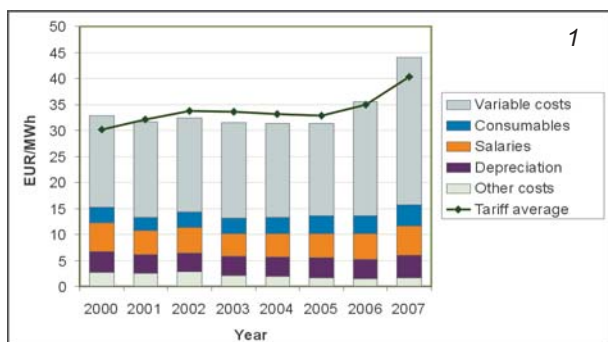
spectives of reforms, implemented in most problematic energy sectors.

Results of the analysis enable to state that reforms of municipalities’ heat sector while transferring to market economy principles in Ukraine are still in initial state and obvious deviations from market economy are observed. Comparing with the situation in Lithuania, essential differences in institutional basis of activity regulation of this sector and information environment have been revealed while forming market relations.

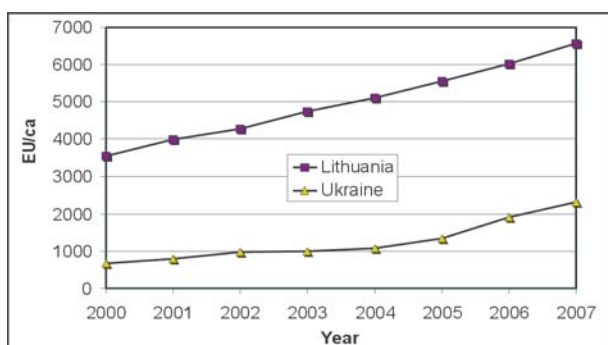


**6<sup>th</sup> Framework Programme Project EIFN (Energy Innovation Financing Network)** in the framework of INNOVA programme was completed. A wide network of energy enterprises and institutions as well as financial agencies, which will help to implement the EU innovations and energy policy, offering financial services in energy sector, making practical and effective decisions, which would enable the access of innovation agencies to financing sources in energy sector, was developed. While implementing the project LEI participants submitted to energy society possibilities of this project and INNOVA network in seminars and local conferences.

Final report of international RUSE project – **Redirecting Urban Areas Development towards Sustainable Energy** (under



Structure of heat cost price in Lithuania (1) and Ukraine (2)



Growth of gross domestic product per habitant in Lithuania and Ukraine

**INTERREG-IIIC programme**) was completed. The aim of the project is to support new EU countries in directing energy policy towards sustainable development, using the Structural Funds. This support is provided at urban development level, by rendering the experience of 15 old EU members in various aspects of energy sector. Collected material is analysed, summarized and published at [www.ruse-europe.org](http://www.ruse-europe.org), used in publications and submitted to new EU member states.

Aiming at achieving the objective, the consortium comprised of 20 partners, where LEI was one of 4 main partners, organized a four year activity. Collected material was summarized and published at [www.ruse-europe.org](http://www.ruse-europe.org).

Final report of **Sustainable Energy Investments for Consistent Urban Environmental Management (SEIPLED)** project was prepared. Scientific and practical task is solved in the project on how to relate implementation of renewable energy (in this case application of biogas technologies) with common energy and economy policy, whereas national role, while organiz-

ing and giving financial support, ground on overall positive effect, which would be the outcome of practical implementation of projects.

Environmental requirements which are getting stricter conditioned development of production sector in all EU countries. Achieving two objectives – to reduce environment pollution and generate energy, biogas production enterprises have been established in all EU countries. Stockbreeding organic waste is main source of biogas production raw materials in Lithuania and EU. Biogas, obtained during anaerobic organic material separation may be used a energy source to produce electricity and heat or as gaseous fuel. Thus development of biogas electricity sector is related to present state and perspectives of country's stockbreeding.



**REDUBAR (Investigations Targeted to the Reduction of Administrative Barriers for the Use of Gaseous Fuels Produced Decentralised from Renewable Energy Sources)** project was implemented in the framework of *Intelligent Energy – Europe*. Coordinator of the project – Gas-und Umwelttechnik GmbH (DBI), one of the largest German gas institutes.

At present biogas in Western Europe biogas is usually used in their production site to generate electricity, whereas heat obtained during production process is not practically used. This project is initiated aiming at higher energy efficiency using biogas. Objective of the project is to analyse and submit recommendations eliminating administrative and technological barriers and developing legal means to use biogas for heating, airing and electricity generation.

Implementing the project, legal regulating bases (laws, rules, technical regulations) of the countries, which participated in the project, were overviewed and analysed; standards and regulations, related to necessary quality of biogas, wishing to transport them via natural gas networks, were analysed; a thorough analysis of valid technical standards and instructions was carried out, it enables to group them according influence and importance; positive practice of biogas transportation via natural gas networks was analysed and described. Barriers which emerge during the project and impede biogas spraying process were analysed. Theoretical modelling was carried out aiming to find out possible barriers if each part of the chain (supply, production, improvement of biogas quality, consumers and investors) would operate individually; mathematical and financial model was designed to compare the power plants, fired by biogas and natural gas.

In 2008 researchers of the Laboratory published 1 article in ISI journal (*Renewable and Sustainable Energy Reviews*), 1 article in peer reviewed journal. Researchers of the Laboratory presented 6 papers at Lithuanian and 2 at international conferences, the papers were published in conference material.

Researchers of the Laboratory perform scientific research and advisory activities and provide services in accordance with agreements with Lithuanian public institutions, enterprises and organizations.



## Main research areas of the Laboratory:

- analysis of the use of renewable energy sources (RES) for energy production and assessment of utilization development in implementing the decisions of the European Parliament and the Council directives;
- research, modelling and prediction of wind flow variation on the Baltic coast in Lithuania;
- analysis of RES use for electric power production in Lithuania and research of development possibilities;
- economical and environmental efficiency research of biogas and biofuel production and use;
- research of solid biomass use for energy production;
- promotion of state-of-the-art technologies using local and renewable energy sources, research of environmental issues; preparation of accredited training courses, development of RES database, services and consultations for users.



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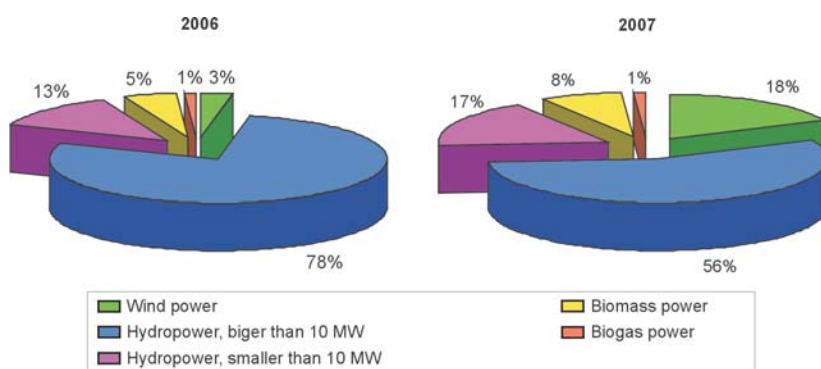
# Laboratory of Renewable Energy

Research related to the development of the use of renewable energy sources for energy production is carried out in the Laboratory. New technologies and perspectives of their application in Lithuania are analysed, data are collected on RES consumption, and milestones are foreseen for further RES penetration into state's energy market aiming at optimally ensuring the implementation of the requirements of the European Parliament and of the Council directives.

In 2008 state funded project **Analysis of Renewable Energy Sources use for Energy Production in Lithuania and Development Feasibility Study** was completed. Investigation revealed that energy production in the country when using RES mainly depends on hydroenergy, wind energy and biomass fuel sources. It was determined that hydroenergy sources of small rivers are insignificant, whereas the ones of big rivers (the Nemunas and the Neris) are forbidden to be used due to environmental requirements, thus most of attention is to be devoted to the development of wind and biomass energy.

Importance of biomass fuel, as an energy source, worldwide and in Lithuania was estimated in the Laboratory. It was observed that an acute competition regarding main biomass type – wood – occurs among energy and industry sectors, which will strengthen in the nearest future. Assessment was carried out on how energy production efficiency in cogeneration biofuel power plants is affected by available fuel combustion technologies. The intercomparison of direct fuel combustion in furnaces of different types is presented. In accordance with indirect fuel combustion technologies (in gasification or pyrolysis reactors biofuel is transformed into gaseous or liquid fuel) possibilities to use more diverse and efficient equipment, for example, gas turbines, microturbines or fuel cells, are overviewed.

Enhancement of wood resources by cultivating willow plantations is meaningful. Information on specific requirements attributed to energetic willows and peculiarities of cultivation of willows and other energetic plants was collected at the Laboratory. Worldwide experience in cultivating willow plantations with commercial purposes was overviewed, and economical aspects of cultivating willow plantations were discussed. Possibilities for solar energy use for electricity production in Lithuania were analysed, a 15-year progress in photovoltaic (PV) module production was reviewed. Assessment of up-to-date production technologies of solar PV modules was carried out by emphasizing that PV module production sector is one of the most dynamic business sectors in the EU. Research revealed that expansion of PV module use worldwide is conditioned by PV module produced energy price, which for several times exceeds standard electricity price. Technical and economical feasi-



Structure of electric power production from RES in Lithuania in the period of 2006 and 2007

bility assessment of energy production in wind power plants was carried out. Estimation and prediction methodology of wind energy parameters was developed.

## Wind flow variation research, numerical simulation and application of prediction methods in Lithuania

Statistical analysis of wind speed and direction measurement data is carried out at the Laboratory, wind resources are estimated on Lithuanian land and offshore, short-term wind power prediction model is developed at the Laboratory. Wind speed distribution map of Lithuanian coastal region was developed. It was determined that wind power parameters of the Baltic Sea Lithuanian offshore and coastal region are similar to the wind power parameters of Germany, Poland and other European countries, where the average wind velocity at 50 m height in coastal region reaches 6–7 m/s, whereas at the sea – approximately 7–7.5 m/s.

Computation methodology of wind power parameters, based on WAsP software was developed. It was determined that the power output of offshore wind turbines is approximately 35% bigger than that of the onshore wind turbines with the same rotor diameter. The optimum distance from the coast to install offshore wind farms at the Baltic Sea Lithuanian nearshore is 6–10 km. However, due to bigger investment costs electricity production price of the offshore wind turbines is approximately 24% bigger than that of the onshore ones.

Cooperating with Wind Energy Department of DTU Risø National Laboratory (Denmark) detailed analysis of Lithuanian coastal region wind resources was carried out and methodology for selecting wind farm construction site using WAsP software was developed. Numerical roughness and terrain maps of Lithuanian coastal region surface, which enable to estimate wind speed distribution in a region, were developed in accordance with Digital Data Base of the Lithuanian Space Imagery Map LTDBK50000 at scale 1:50000.



*Researchers of the Laboratory in wind farm in Kretinga region*

Wind resources were estimated using wind measurement data in the region, taking into account the terrain, land surface roughness and natural and urban obstacles.

It was determined that the most favourable conditions for wind farm construction are a 20 km area in Lithuanian coastal region and in Tauragė region. Employing data of numerical weather forecast model HIRLAM (used at Lithuanian Hydrometeorological Service), short-term (up to 54 hours) wind speed and wind power variation prediction methodology designed for Lithuanian wind farms, was developed, the impact of terrain, surface roughness and atmosphere stability conditions on the accuracy of forecasts was estimated.

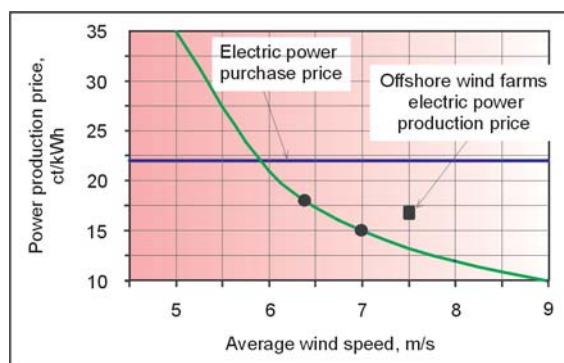
## Economical and environmental efficiency research of biogas and biofuel production and use

### Biogas

With growing importance of renewable energy sources in the country's energy sector, works related with an exhaustive analysis of biogas power objects' activity, necessary for estimating efficiency of power objects and optimisation, without which it would be complicated to forecast further development of biogas production and consumption sector, have been carried out in the Laboratory. Implementing EU projects, feasibility studies of biogas production and their use in transport are carried out.

### Biofuel

Persistent increase of mineral fuel prices oblige to tackle acute issues of biofuel industry development. Issues of further biofuel use in transport are solved, considering other alternative possibilities of biofuel use, such as liquefied oil gas, suspended natural gas and biogas. The Laboratory participates in the activity of National Biofuel technological platform.



*Dependence of electricity production price of wind power plants on average wind velocity: • – onshore wind farms in coastal region*

combustion in different types of boilers are collected and analysed.

At present time RES comprise approximately 9.3% from the primary energy consumption in Lithuania. Biggest share of RES (approximately 91.66%) accounts for solid biomass, mainly wood, thus most of attention is given to issues related to wood fuel production and use. Research is carried out by implementing different EU programs.

### **Sixth Framework Programme project *Co-firing – from Research to Practice: Technology and Biomass Supply Know-how Promotion in Central and Eastern Europe* (COFITECK)**

The objective of the project is to contribute to optimisation of fuel mixtures firing technologies and biomass fuel supply chains.

Three informative statements, introducing with biomass mixture firing technologies for energy production, were prepared. Processes occurring in biomass preparation boilers were analysed, successful experience examples were reviewed and emerging problems were discussed. In other three informative statements possibilities of biomass production and supply in firing fuel mixtures were emphasized. The brochure *Overview of contemporary fuel mixture firing technologies* was translated into Lithuanian.

When implementing the project, seminars were organized, where the interested parts were introduced with up-to-date technologies in the field of fuel mixture firing in EU countries and experience, accumulated in different Lithuanian enterprises, was shared among participants. Issues of biomass production and supply in Lithuania were discussed as well.

### **Seventh Framework Programme project *Integrated European Network for Biomass and Waste Reutilisation for Bioproducts***



*Publications of the COFITECK project: Biomass Mixture Firing Technologies in Producing Electric Power and Biomass Supply Possibilities for Fuel Mixture Firing*

The objective of the project – to promote cooperation of science research centres, business and other partners in the field of biomass and waste reutilisation. During the project there was an attempt to review biomass sources available in Europe and identify potential and value of biofuel production. Using the Geographical Information System maps of Europe biomass source use were developed and schemes



*The moment of seminar*

of economical factors and environmental impact in accordance with optimal lifetime development cycle scenarios (LCA) were determined. LCA is a standardized computation method, which estimates the impact of a product on the environment in all stages of production process. The following objectives were achieved while implementing the project:

- the efforts of the European research centres, business representatives and politicians in the field of biomass use by implementing new technologies were united;
- information was collected on the best cases of biomass use in Europe, which is foreseen to be used in publication *The White Book*;
- possibilities of up-to-date means were overviewed by estimating possibilities of different types of land areas for cultivating biofuel, using new types of plants in various countries, estimating social and economical factors in different environment;
- biomass and biofuel production coherence was estimated according availability, production, price and environmental criteria, and optimal biomass production scenarios were predicted using LCA computation models.

The following **Intelligent Energy – Europe** projects were implemented in the Laboratory in the year 2008:

- **Market Development of Gas Driven Cars Including Supply and Distribution of Natural Gas and Biogas (MADEGASCAR 2007–2010);**
- **Regional Bioenergy Initiatives Increasing the Market for Biomass Heating in Europe (REGBIE+ 2006–2009);**
- **Monitoring and Control of Energy Consumption in Municipality Public Buildings over Internet (ENERinTOWN 2006–2008);**
- **Solutions for Biomass Fuel Market Barriers and Raw Material Availability (EUBIONET III 2008–2011).**

Cooperating with research centres of Germany, Denmark and Poland, investigations of bioenergy development perspectives in Europe regions were carried out. Main objective of performed projects is to provide considerable input to the implementation of EU tasks in energy sector pursuing that share of RES in the region and in the total EU energy balance would satisfy the indicators of directives and other regulating documents.



Investigation of natural gas and biogas use possibilities in autotransport is carried out during implementation of project **MADEGASCAR**. Use of compressed natural gas and biogas in comparison to traditional fuel enables to reduce environmental pollution significantly. However use of compressed natural gas exhibits specific peculiarities of storage, distribution and use, which have not been investigated thoroughly. Pursuing this objective it is a must to analyse biogas production technologies and peculiarities of their use in autotransport, comparing with use of natural gas.

During implementation of project **REGBIE+** assessment of biomass sources in various EU regions is carried out, as well as in Lithuanian, Kaunas district. Possibilities of biomass use in energy production are analysed by estimating experience of other countries (Sweden, Germany, Austria, etc.). Capacity of presently operated boilers in our country exceeds 550 MW, whereas consumption of wood fuel comprises 80% from available scopes of renewable energy sources. Therefore it is necessary to predict different promoting means, new technologies of biofuel preparation and firing by searching for more efficient heat production methods. Researchers of Lithuanian Energy Institute together with specialists from other countries implementing this project deal with above mentioned issues, exchange with up-to-date achievements in the field.

In 2008 project **ENERinTOWN** was completed. Its objective was to reduce energy use in public buildings of municipalities by creating a constant monitoring system via internet when data is recorded for emphasizing energy consumption tendencies and comparing similar buildings. Energy consumption monitoring system was implemented in 12 public buildings of Kaunas, Kėdainiai, Vilkaviškis and Šakiai municipalities, seminars were organized for municipalities' energy specialists, publication *Manual for equipment purchasing and buildings design taking into account efficient energy use* was prepared.

The objective of **EUBIONET III** is to enhance biomass fuel use in EU countries by searching for ways to overcome market obstacles. Analysis of biofuel use, future perspectives and basic obstacles is carried out, national biomass programs are analysed, biomass fuel potential is estimated, most of attention giving to agriculture waste and assessment of potential of new biofuel types. Price mechanisms are analysed, biomass fuel

certification and sustainable development criteria are determined.

## Science promotion activities

In 2008 the Laboratory implemented science and technologies promoting project **Think about Energy in Different Way**, the objective of which was to promote scientific ideas and the society to be interested in sciences, to perform scientific activity by organizing different science promoting events, to promote science representatives to actively participate in informing the society on the issues of science promotion. The project was funded by the Ministry of Education and Science of the Republic of Lithuania. When implementing the project the following events were organized:

- seminars for teachers of natural sciences, students, pupils and other interested persons, on the topics of efficient energy use and renewable energy;
- excursion to objects of biomass fuel preparation and use;
- computer animation and graphics creative works competition for Lithuanian pupils, which integrates pupils' plentiful information technologies capabilities with knowledge and new ideas on efficient energy use and renewable energy;
- poster competition for Lithuanian teachers during which works were created as possible methodological means for the presentation of the project's topics to the school-children;
- educative quiz *What do You Know About Energy* for Kaunas district pupils;
- final project conference.

Promoting the project and science, publications *Renewable Energy Sources*, *Climate Change: Reasons and Consequences* were prepared and issued, methodological material was prepared by researchers from higher education institutions.

In 2008 researchers of the Laboratory published 5 articles in scientific journals and 9 in other reviewed science publications, 2 science promotion articles in popular publications. Researchers of the Laboratory participated in 5 international and in 5 Lithuanian science conferences.



Participants of the project **Think about Energy in Different Way** in a willow plantation and wood pellet production enterprise



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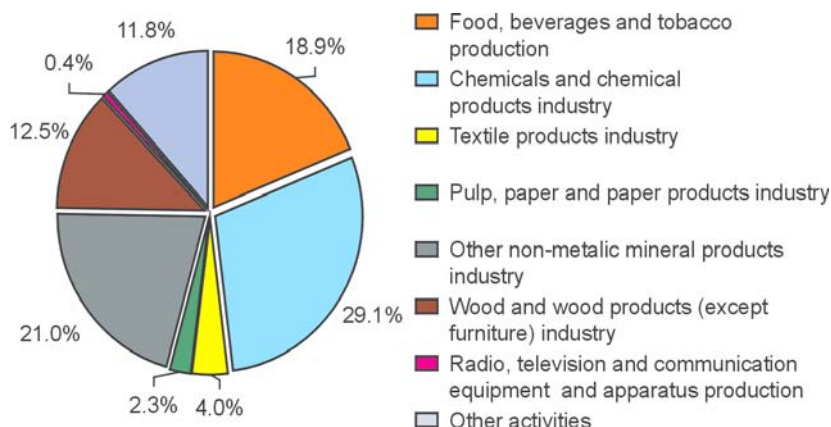
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### Main research areas of the Centre:

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

## Energy Efficiency Research and Information Centre

Sustainable energy development and energy saving is the most important direction in energy sector both in Lithuania and in the European Union. At present, after the structure of final energy consumption has changed in Lithuania, households, industry, commercial and public service sectors cover almost two-thirds of the total final energy consumption. In these sectors the potential of increasing energy consumption efficiency is the biggest. It could be used by implementing up-to-date energy management systems, energy efficient techniques and technologies, and by improving organizational and legal measures.



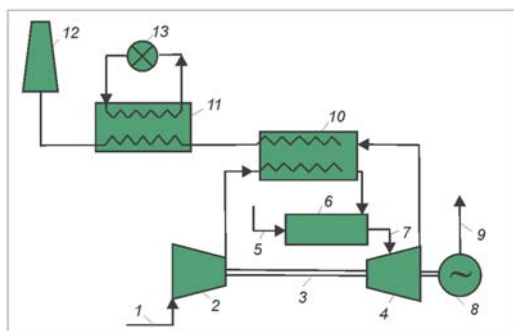
*Distribution of final energy (heat, electricity, natural gas, liquid fuels, wood and coal) consumption according to activities in 2007*

In 2008 the state funded scientific research project **Research of Increasing Energy Consumption Efficiency in Sectors of Industry and Buildings** was completed. It provided the analysis of industry structural changes and energy consumption in industry for the period 2005–2007.

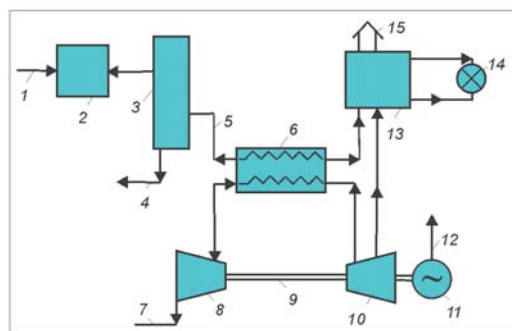
The biggest branch of manufacture of food and beverages industry, consuming approximately one third of total industry

energy input, was analysed in detail. One of efficiency assessment indicators of energy consumption in industry is the comparison of enterprises' energy consumption to produce one production unit with analogous enterprises' energy consumption in Western countries. Data on energy consumption efficiency in chosen enterprises of manufacture of food and beverage industry were collected and compared with analogous enterprises in

	Year					
	2002	2003	2004	2005	2006	2007
<b>Energy intensity</b> (TOE/million LTL of GDP)						
Total	77.2	72.0	69.8	67.5	66.4	64.1
Industry	71.5	65.0	60.5	60.0	59.2	56.0
<b>Work productivity</b> (GDP/1hour of work, LTL)						
Total	18.4	20.0	22.0	23.8	27.1	30.6
Manufacturing industry	17.8	20.1	24.9	26.0	29.2	32.0



Principal scheme of cogeneration power plant with microturbine (fuel – gas, diesel): 1 – environmental air, 2 – air compressor, 3 – barrel, 4 – turbine, 5 – fuel, 6 – combustion chamber, 7 – combustion products, 8 – generator, 9 – electric power, 10 – recuperative air heater, 11 – residual heat exchanger, 12 – chimney, 13 – heat consumers



Principal scheme of cogeneration power plant with microturbine (fuel – biomass): 1 – supplied biomass, 2 – fuel storage, 3 – gasifier and combustion chamber, 4 – removed ash, 5 – combustion products, 6 – air heater, 7 – environmental air, 8 – air compressor, 9 – barrel, 10 – turbine, 11 – generator, 12 – electric power, 13 – residual heat exchanger, 14 – heat consumers, 15 – chimney

Western countries, using the comparison methodology and experience of such countries. In accordance with obtained results, recommendations on enhancing possibilities and perspectives of energy consumption efficiency in the chosen industrial branch were presented. Energy management implementation model and prepared computer energy management “E-training” system were presented for small and medium-sized enterprises.

Taking into account the Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market, possibilities assessment of implementation of low capacity (30–250 kW) microturbines in industrial and building sectors was carried out, whereas in several chosen objects also technical and economical justification of their implementation.

Possibilities of enhancing energy consumption efficiency in dwelling houses were estimated in the work. Detailed statistical data were collected on energy consuming facilities in dwelling houses, energy consumption efficiency, and possibilities of enhancing efficiency by changing existent equipment with new technologies. Obtained data were compared with analogous data of Western countries. Legal basis and obstacles, which prevent from enhancing energy consumption efficiency in dwelling houses, were estimated, and means were proposed for improving the situation.

When implementing *National Energy Efficiency Enhancement Programme* (2006–2010), the expert investigation on the causes of the accident, which occurred in water supply system

of the pension-house (in Birštonas town), which belongs to JSC *Senjorų Rezidencija*, was carried out. Activities of boiler-houses, operated by Smalininkai technology and business schools, JSC *Jurbarko Komunalininkas*, public institution *Eržvilko Pirminės Sveikatos Priežiūros Centras*, and public institution *Juodupės Komunalinis Ūkis* for the period 2007–2008 were estimated and forecasted realization prices of district heating were determined. Technical and economical justification of heat network connection of Anykščiai town boiler-house in Pušynas and Šaltupiai streets was carried out as well as expert assessment of Geothermal heating system, installed in *Teisėjų Mokymo Centras* in Sanklodžiškiai village (Molėtai district).

## Participation in international projects

### Dissemination, Extension and Application of the Motor Challenge Programme

This *Intelligent Energy – Europe* project was implemented together with partners from 15 European countries for the period of 30 months. The project supervisor was French National Energy Agency.

The objective of the work was to estimate the efficiency of electric motor usage in industry of individual countries and propose means to enhance their usage efficiency. At the moment electric motors consume approximately 70% of total electricity consumed in industry.

In accordance with the project programme, LEI is devoted to investigate efficient electric motor usage in Lithuanian water supply enterprises. In Lithuanian enterprisers energy saving potential is very big.

Energy audits were performed in chosen water supply enterprises. During audits electricity consumption parameter measuring methods were used and methods were developed to estimate the obtained measuring data. Obtained results according the common data comparison methodology were compared with the results of other countries. Preliminary energy consumption saving potential in water supply enterprises



## THE MOTOR CHALLENGE PROGRAMME

The Motor Challenge Programme is a European Commission voluntary programme through which industrial companies are:

Aided in improving the energy efficiency of their Motor Driven Systems and

Reducing CO<sub>2</sub> emissions



was determined. In individual enterprises it accounts for 50% of the presently consumed energy.

According research results means were determined and suggestions were submitted to water supply enterprises how to enhance usage of present electric motors by implementing new technologies and updating control of electric motors.

*Energy Efficiency Research and Information Centre* has become the representative of European efficient electric motor utilization programme in Lithuania. For the present time 30 new Lithuanian industrial enterprises have joined the Programme with the objective to enhance efficiency of electric motors used in enterprises.



*EU Green Light programme's winners*

### **Implementing EU-Appliance Policy in Central and Eastern Europe**

*Intelligent Energy – Europe* project was carried out by partners from 9 EU countries for the period of 30 months. The project leader was *Efficient Energy Center* of the Czech Republic.

Main objective of the project was to estimate energy consumption in dwelling houses in EU countries, to estimate energy consumption efficiency, propose means to reduce energy consumption in dwelling houses. This project is relevant to Lithuania since two-thirds of electricity is consumed in premises.

In accordance with the project, Lithuanian legal acts, regulating energy consumption in buildings, were assessed, energy audits were carried out in selected buildings, main energy consumers in dwelling houses were determined by using scientifically justified and specifically prepared methodology. Energy consumption efficiency of domestic electricity appliance was estimated. After performing energy audits, energy saving potential in dwelling houses was determined, and means were proposed for enhancing energy consumption efficiency.

Detailed information on electricity consumption in dwelling houses and prepared methodology, which will enable to

estimate energy saving possibilities and technical and economical efficiency of implemented saving means, will enable habitants to efficiently consume energy in dwelling houses.

### **The European Green Light Programme in New Member States**

*Intelligent Energy – Europe* project, duration of which 28 months, was implemented by partners from 9 EU countries. The project leader was *Efficient Energy Center* of the Czech Republic.

The objective of the project was to estimate electricity application for lightening urban areas and public buildings, and suggesting means how to reduce electricity consumption for lightening needs.

When implementing the project, presently used lightening technologies were estimated as well as possibilities for reducing energy consumption, new lightning technologies, which enable to significantly reduce presently consumed energy amount designed for lighting town areas and public buildings, were proposed.

*Energy Efficiency Research and Information Centre* was appointed a representative of the **European Green Light programme** for Lithuania.

The Green Light programme was established with the initiative of the European Commission on 7 February, 2000. When implementing the project approximately 40 different Lithuanian organizations joined the program (universities, municipalities, schools, sport halls, Kaunas airport, etc.).

The programme is independent and enterprises, organizations, which have implemented, are updating or are to update lightening systems of their buildings or territories, may independently join the implemented program. The European Commission does not directly give financial support for updating lightning systems, however it pro-



*Distribution of domestic fridges manufactured by SC Snaigė according energy efficiency classes*

vides a big amount of information to specialists in the field of lightening on new and developed modern lightning systems, best experience of other countries in implementing updating of lightning systems.

Kaunas town municipality was very active in implementing the project, therefore, for the first time in the history of Lithuania, it was granted the European Green Light award for 2008 for active participation in updating lightning of Kaunas town streets.

### ***Sustainable Energy Actions for Europe's Cohesion***

*Intelligent Energy – Europe* project, duration of which 36 months, was implemented by partners from 12 EU countries. The project leader was German *Renewable Energy Sources Center*, established in Munich.

The objective of the project was to estimate development possibilities of decentralized energy production resources of regions of eight chosen EU countries by employing EU Structural and Cohesion Funds. When implementing the project, with the help of project partners (EURADA, REC, UNEP, URBIS and others), the EU policy, which promotes development of regions by reducing differences of economical development among individual country regions and promoting development of renewable energy sources in regions, was analysed and estimated. One of the chosen EU regions was Kaunas region. The energy strategy was prepared for it. Main objective of Kaunas region Energy Strategy was to estimate the current situation of energy sector in the region, to estimate the potential of renewable energy sources, to present a vision of energy sector development, to give examples of the projects, which could be partially funded from EU Structural Funds.

The energy strategy for Kaunas region was prepared in accordance with the ***Lithuanian National Energy Strategy***. Main regulations of Kaunas region strategy satisfy the regulations of Lithuanian National Energy Strategy. Additional data on Kaunas region energy sector are presented in the Kaunas Region Energy Strategy.

Main factors, affecting stable energy activity in Lithuania (at the same time in Kaunas region), are the following:

- I Prevailing import of primary energy resources from Russia, dependence of Lithuanian gas supply and energy systems on Russia's energy systems and nonex-



*Granting of award for Kaunas city municipality*

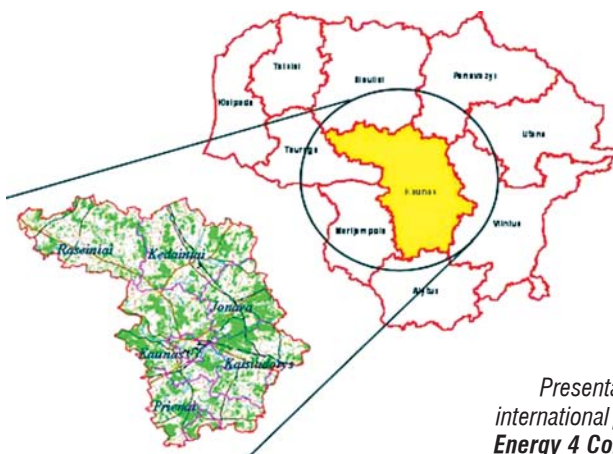
istence of connections with Western European energy systems;

- II Ignalina NPP shutdown in the year 2009, which will negatively affect the structure of energy resources, primary energy balances, and energy price for the period 2010–2015.

Enhancement of energy production and consumption efficiency, wider application of renewable energy sources may significantly mitigate a negative impact on energy sector activity and development in Kaunas region.

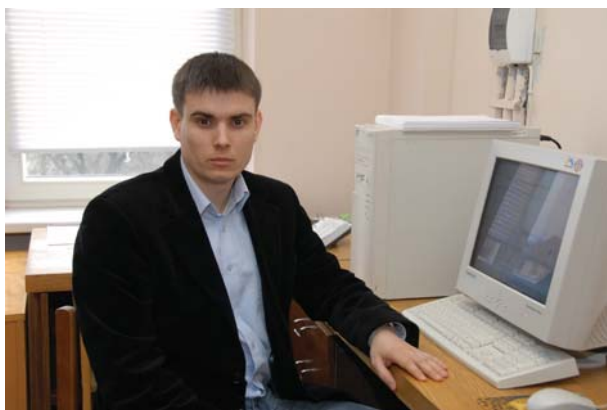
Aiming at successfully implementation of innovative energy projects, a coherent cooperation of all interested organizations, such as district's administration, municipalities, energy enterprises, communities of dwelling houses, banks, and others, is needed. When implementing the international project, a unified methodology for preparing strategies of region energy sector was proposed, which was used in preparing energy strategies of eight chosen EU countries' regions. Ideas and proposals of different organizations were assessed and generalized in the above mentioned strategy by identifying directions and priorities of energy sector development. Project results were presented at eight national seminars, a common publication was prepared and translated into 8 foreign languages.

In the period 2007–2008 6 seminars (2 international ones) were organized, research results were presented in 12 scientific articles, 8 papers (2 international ones) were presented in scientific conferences.



*Presentation of international project  
**Energy 4 Cohesion***





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#### Main research areas of the Laboratory:

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

## Laboratory of Systems Control and Automation

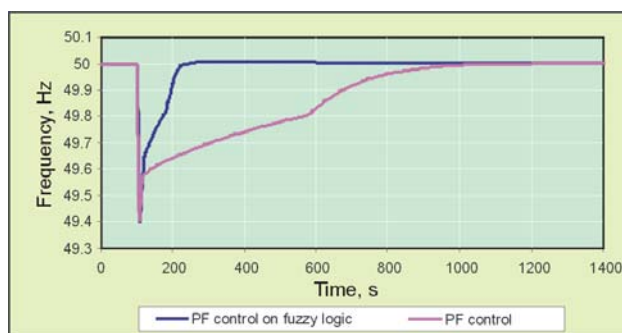
With rapid development of information and communication technologies (ICT), more control and protection automatic equipment, including intelligent electronic devices, is introduced into electric power systems (further EPS). EPS control algorithms are getting more complexity as they must ensure coordinated operation of all those devices for EPS to run in the scheduled mode and properly interact with other EPS. New approaches are undertaken, e.g. GPS (Global Positioning System)-based wide area protection system. It is endeavoured to process more information (telemetry data, tele signals) from different EPS points in real time in order to: 1) generate control solutions that adequately correspond to the EPS status and send the respective commands to remote EPS controllers; 2) select optimal setpoint of automated devices. Here the target is to achieve optimal ratio of the centralised and decentralised control. Flexible alternating current transmission systems (FACTS), i.e. power electronic controllers, are introduced to increase the transferring ability of the network and improve EPS stability. The enhanced control increases cost-effectiveness of EPS, reduces emergency risk, allows for disturbance localization in the national system and enables to avoid its spreading within inter-connected system.

Laboratory of Systems Control and Automation **carries out research and offers services** in the following fields:

- evaluation and analysis of EPS parameters;
- mathematical modelling of EPS, power networks and control systems;
- investigation of advanced EPS control methods, new automatic control devices and ICT applications;
- investigation of EPS control issues and development of control algorithms (related to frequency, active and reactive power control, static and dynamic stability, loss reduction, power quality, emergency prevention, aspects of electricity market);

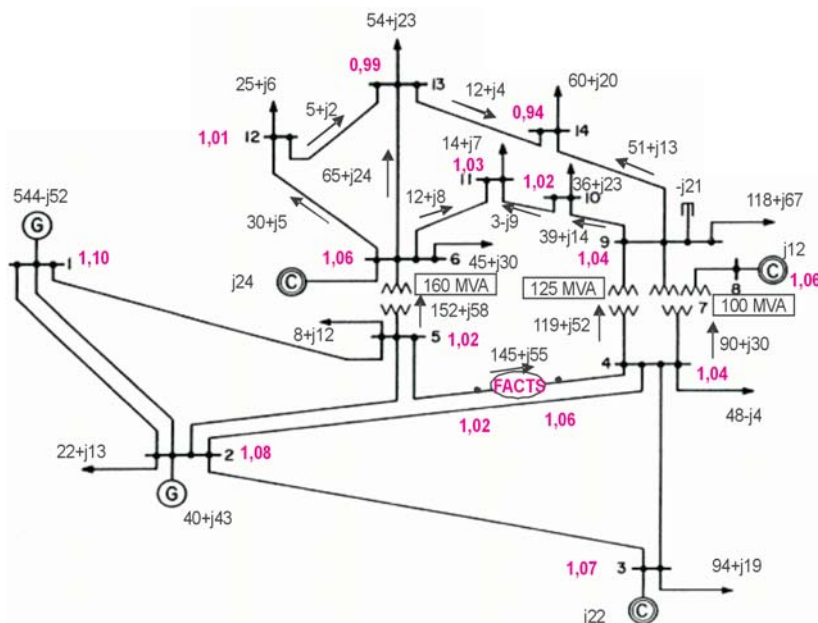
- EPS and network extension modelling and technical policy formulation;
- cost-effectiveness of power consumption, control and development of EPS and power networks;
- research and assessment of EPS reliability, security and risks;
- optimization of EPS operation under market conditions, development of competitive mechanisms of balancing, system operator and ancillary services;
- assessment of EPS control needs related to integrating into EPS wind power plants, other power plants on renewable energy sources, small-scale generators.

In 2008 Laboratory completed a three-year state-funded project **Efficient use of National Balance Control Resources in Lithuanian and Baltic Power Systems**. This project corresponded to research area *Modelling of complex systems, development of technical measures of their management methods and control*. During the project time, efficient use of national balancing resources was analysed aimed at developing effective meth-



*Isolated Baltic EPS frequency variation curves, when power changes by 200 MW*





Calculations of load flows in IEEE 14 bus test system with FACTS controller in branch 4–5

ods for improvement of EPS operation states and optimal choice and control of generation reserves. Therefore the possibilities of smart control of available generation resources were investigated, including application of advanced approaches and methods (such as FUZZY logics) to provide better automated generation control.

Influence of EPS states on system reliability was analysed as well. Herein the causes of accidents, which cut electricity supply to large regions, and their prevention opportunities were gone through. It enables more thoroughly to assess a risk of scheduled EPS state and choose adequate risk reduction measures.

The effectiveness of parametric identification and spectrum analysis methods was investigated. It would enable to make more precisely and readily the estimates of EPS dynamic frequency characteristic parameters. Secondly, it assists in getting more information on probable frequency variation process during large emergencies. Finally, it can contribute to the selection of system structure ensuring enhanced system robustness against disturbances.

Since the magnitude of EPS imbalance depends on the scale of wind power generation in EPS, the needed reserve capacities have been found for different combinations of wind power generation and disturbances in EPS.

In 2008 researchers of the Laboratory performed a number of research projects for customers in the Republic of Lithuania. In accordance with the contract with SC *Mažeikių Nafta*, one of the largest oil refineries in Central Europe (10 million tons crude oil per year), the following projects were carried out:

- Analysis of legal conditions for the connection of new electric equipment of SC *Mažeikių Nafta* to power networks;
- Development and reconstruction plan of SC *Mažeikių Nafta* power network;

- Economic efficiency calculations for the development of SC *Mažeikių Nafta* power network.

During implementation of project **Analysis of Legal Conditions for the Connection of New Electric Equipment of SC *Mažeikių Nafta* to Power Networks**, the legal and technical opportunities of SC *Mažeikių Nafta* to connect new electric equipment to transmission networks were examined as well as consistency of legal acts of the Republic of Lithuania regulating the connections and their respect to the interests of a new customer. Recommendations of project experts on connection of new equipment to power networks were presented to SC *Mažeikių Nafta*.

During implementation of project **Development and Reconstruction Plan of SC *Mažeikių Nafta* Power Network**, several alternatives of development and reconstruction were proposed, their advantages and disadvantages analysed and preliminary economical comparisons of these alternatives carried out.

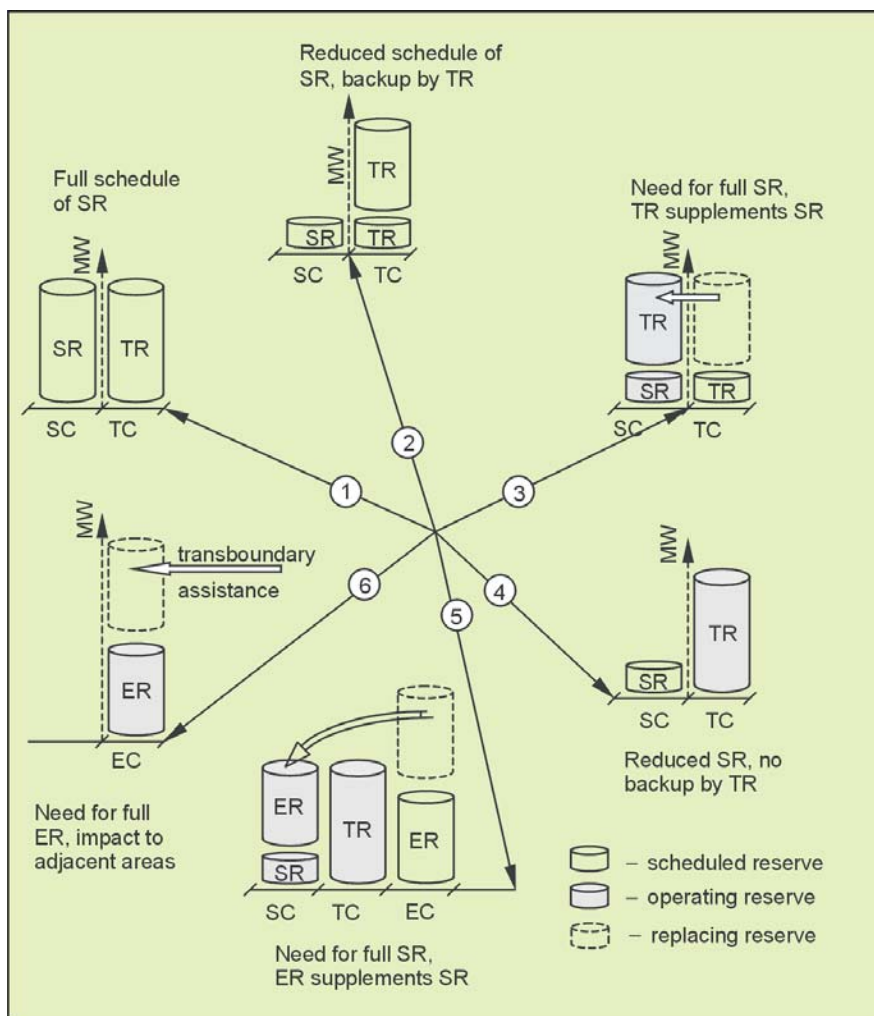
During implementation of project **Economic Efficiency Calculations for the Development of SC *Mažeikių Nafta* Power Network**, overall cost-effectiveness of development alternatives was determined taking into account not only capital investments, but also operation cost of “new network” and electricity losses.

In accordance with the contract with SC *Lietuvos Energija*, the part of project **Investigation of Dynamic Regimes of Perspective Lithuanian Power System Scheme for 2025** was accomplished and the following interim results were presented:

- *Scheme of Lithuanian Power System Development till the Year 2025*;
- *Development of Mathematical Model of Lithuanian Power System for 2010, 2015, 2025*.

During implementation of project **Scheme of Lithuanian Power System Development till the Year 2025**, the perspective scheme of Lithuanian power system the year 2025 was developed. It contains options of deployment of new generation sources as well as options of development of 110–330 kV transmission network up to 2025, with full pictures for intermediate points 2010 and 2015. The options are based on forecasts for generating capacity needs and maximum loads in Lithuanian system.

During implementation of project **Development of Mathematical Model of Lithuanian Power System for 2010, 2015, 2025**, the numerical model of Lithuanian power system (110–330 kV transmission networks) was prepared to perform various electric calculations. The model reflects three time horizons of 2010, 2015 and 2025. New generators and network equipment were taken from the abovementioned project **Scheme of Lithuanian Power System Development till the Year 2025** and introduced to the model. The model is designed for static, dynamic and short circuit calculations.



Management of reserves at reduced secondary regulation reserve. SC, TC, EC – secondary, tertiary and emergency control. SR, TR and ER – secondary, tertiary and emergency reserve

In accordance with the contract with JSC Šilutės Šilumos Tinklai, the project **Expertise of Cogeneration Power Plant Connection to Power Networks** was carried out. It has examined the fairness and validity of the connection-to-grid technical conditions (issued by the network operator), technical connection project and connection cost.



“intersystem” cooperation problems in crisis management process, to identify the education needs and to develop a package of attractive education programs for European electricity suppliers, transmission and distribution network operators as well as education institutions that prepare electrical engineers.

The second international project **Bulk Electrical Energy Transport in Europe** explains the specificities of power system

operations and discusses the most advanced technologies and their advantages and disadvantages, reviews the issues related to operation and development of power systems and highlights the milestones in the development of power systems in the future ensuring:

- really functioning electricity market based on strong interconnections;
- extension of usage of renewable energy sources;
- high reliability of power supply.

Results of the project are dedicated to European institutions (e.g. European Commission), which are responsible for power sector. The project is co-ordinated by the European Academies Science Advisory Council, which is comprised of national science academies from 26 EU member states. This Council enables its members to undertake joint actions in submitting proposals to EU policy makers.

In 2008 results of research were published in 1 article in the journal indexed the list of ISI, 1 article in international journal. Researchers of the Laboratory presented 2 papers at international and 1 at Lithuanian conferences.





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### Main research areas of the Laboratory:

- analysis of climate change and river run-off variation;
- investigations of safety and reliability of power plants and transport objects and their impact on water environment;
- collection of data of Lithuanian water bodies (rivers, ponds, the Curonian Lagoon, and the Baltic Sea).

## Laboratory of Hydrology

State funded project ***Impact of Climate Change on the Condition of Lithuanian Water Resources and Hydroenergy Sector*** (2007–2009) has been implemented at the Laboratory of Hydrology. Global climate change will inevitably cause drastic fluctuations of hydrological regime and changes of water resources. According to climate change scenarios, increasing air temperature, changes in precipitation and total evaporation will have an extraordinary effect on the annual distribution of river run-off and will cause changes of extreme run-off elements (floods and droughts). In Lithuania, as well as in other EU countries, it is necessary properly exploit renewable energy resources, as this will allow reducing negative consequences of the climate change (greenhouse effect). Hydroenergetic resources of rivers are one of the most widely used renewable energy sources, directly depending on the parameters of river run-off. Due to climate change processes, river water resources will have a direct impact on hydroenergy production as well as on the safety of embankments during extreme natural phenomena.

In the year 2007 researchers of the Laboratory determined trends of meteorological and hydrologic parameters change in Lithuania and compared the results with obtained parameter trends of the Baltic and Nordic countries. In the year 2008

Nemunas run-off formation model was developed using state-of-the-art software HBV, developed by Swedish scientists. Using this model, Nemunas run-off forecast was carried out in accordance with different climate change scenarios, whereas Kaunas hydropower station operation was analysed by estimating Nemunas run-off forecasts.

The investigation of Lithuanian water bodies has been performed using numerous hydrographic, hydrologic, morphologic and other data, collected by the Laboratory of Hydrology since 1961. The main task of environmental protection – the assessment of impact of economical activities on the environment and justification of environmental protection measures are solved employing state-of-the-art modules (hydrodynamic, wave, advection-dispersion and sediment transport) of modelling system MIKE 21 of Danish Hydraulic Institute.

Using collected data base the following tasks are solved at the Laboratory:

- environmental impact assessment of anthropogenic activities on water bodies and justification of environmental protection measures;
- climate and run-off variation analysis and its impact on water resources;
- hazard and risk analysis of hydrotechnical constructions;
- investigation of quays interaction with water flow and selection of optimal constructions;
- determination of environmental conditions using water bodies for different objectives;
- modelling of mixing and dispersion of pollution under critical conditions in water bodies;
- sensitivity and uncertainty analysis of two-dimensional hydrodynamic models input parameters.

### Research objects and tasks

The most significant research objects of the Laboratory are as follows: the Baltic Sea, the Kaunas Sea, Drūkšiai Lake, the Curonian Lagoon, the River Nemunas and other Lithuanian



*Klaipėda State Seaport*



ivers. These water bodies are under extreme nature phenomena expressions (storms, excess rainfalls) or are affected by intensive anthropogenic activities.

### International co-operation

Since 2007, together with Nordic countries, a joint project ***Climate and Energy Systems***, funded by the Nordic Energy Research, has been carried. Researchers from Norway, Sweden, Finland, Denmark, Iceland, Lithuania, Latvia and Estonia participate in the project. The main purpose of this research work is to assess the impact of climate change on energy sector. Scientists of the Laboratory participate in the activities of the research group of the statistical analysis of climate and river run-off.

In the year 2008, the following investigations were carried out: annual, seasonal and flood discharge trend analysis of Lithuanian rivers for the periods 1920–2003, 1941–2003 and 1960–2003. Obtained results were compared with the results of analogous research, carried out by Nordic countries. The following common trends were determined: winter river run-off increased, spring floods emerged earlier and maximum flood discharges decreased.

### Research of Lithuanian rivers

Good situation of Lithuanian water bodies is closely related to hydrographic, hydrologic, water economy and environmental research. Only after evaluation of characteristics of water bodies in different physical geographical regions, sustainable development of water ecosystems is possible.

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



Neris River

Aiming at more efficient use of water and flowing water energy, embankments are constructed at river valleys. However such appeasement to man's demands negatively affects the environment. After flooding a river, the most significant abiotic parameters of hydro ecosystems change suddenly: hydrologic and thermal regime, chemical composition of water and the amount of sediment in a flow.

Investigations reveal that below the embankment all ecologically important indicators, which influence river flow and water quality, are more or less affected. The impact mainly depends on morphological parameters of embankment, construction and operating regime. Obtained data may be used to assess environmental impact, determine the most favourable installation conditions of designed ponds and the most relevant operation regime so that anthropogenic impact on river would be mitigated as much as possible.

### Co-operation with state and scientific institutions

The Laboratory of Hydrology closely cooperates with the Institute of Environmental Engineering of Kaunas University of Technology, have joint doctoral studies, since 1995 have been publishing scientific journal ***Environmental Research, Engineering and Management***. The Laboratory together with Institute of Geology and Geography, Institute of Botany and Institute of Ecology of Vilnius University, Vilnius Gediminas Technical University, Klaipėda University and Lithuanian University of Agriculture carry out complex environmental research. In accordance with agreements between the Ministry of Environment of the Republic of Lithuania and Lithuanian Energy Institute, expertises of plans, programmes and projects are prepared by the Laboratory.

### Major applied research works

The Laboratory carries out applied research works and prepares hydrotechnical construction projects according to agreements with enterprises and organizations:

- in accordance with agreement with SC *Rėkyva* reasons for lake water level variation and water balance changes were investigated;
- in accordance with agreement with *Klaipėda State Sea-port Authority*, environmental impact assessment reports of Malkų embayment deepening and Klaipėda harbour northern part seaway widening and deepening were prepared;
- in accordance with agreement with the Ministry of Environment of the Republic of Lithuania environmental conditions, the objective of which is to regulate operation of small-scale hydro power plants, were prepared;
- in accordance with agreement with *Klaipėda State Sea-port Authority*, possibilities of constructing Klaipėda deep-sea harbour were analysed;
- studies on potential use of Drūkšiai lake water for the new NPP and boat quay at Smeltė peninsula were prepared.

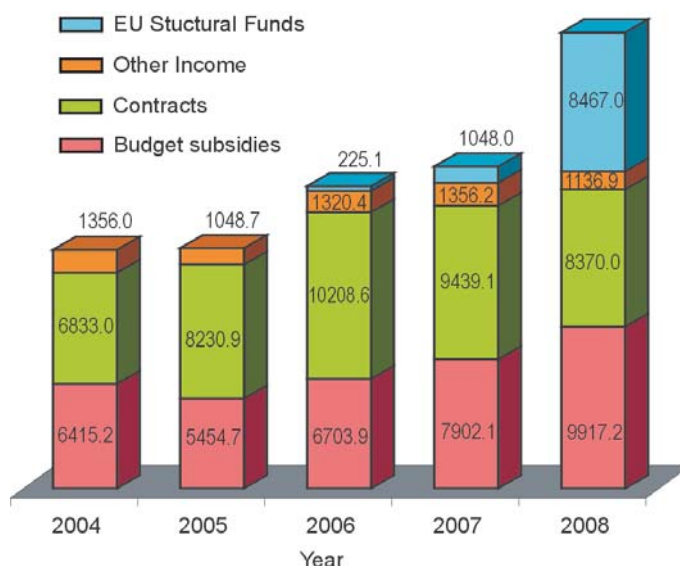
Researchers of the Laboratory participated in 6 international conferences, published 8 scientific articles in Lithuanian and international journals.

# Financial Highlights

## The Financial Sources of the Institute Consist of:

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

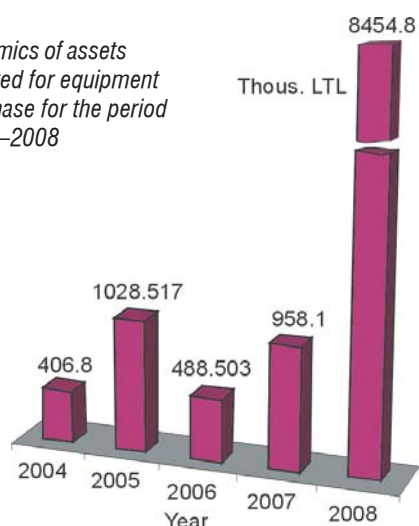
## Variation of Income Structure (Thous. LTL)



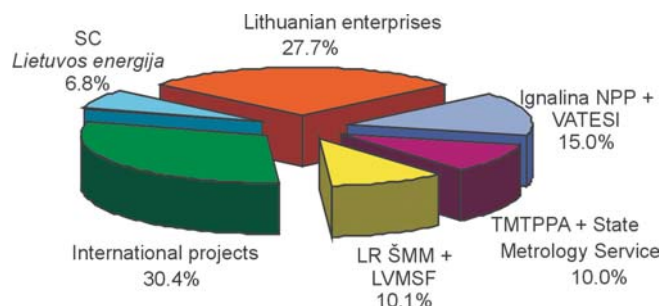
## Structure of Income and Total Expenses (LTL'000)

Year	2004	2005	2006	2007	2008
<b>Income:</b>					
State Budget Subsidies	6415.2	5454.7	6703.9	7902.1	9917.2
Contracts	6833.0	8230.9	10208.6	9439.1	8370.0
SF Support			225.1	1048.0	8467.0
Other Income	1356.0	1048.7	1320.4	1356.2	1136.9
<b>Total:</b>	<b>14604.2</b>	<b>14734.3</b>	<b>18458.0</b>	<b>19745.6</b>	<b>27891.1</b>
<b>Expenses:</b>					
Salaries (soc. ins. incl.)	8667.0	9345.5	10709.1	12919.9	15650.0
Operating Expenses	3699.7	3559.0	4696.6	4881.8	5059.0
Capital Funds	1564.3	1548.4	1185.5	2010.4	9757.3
<b>Total:</b>	<b>13931.0</b>	<b>14452.9</b>	<b>16591.2</b>	<b>19812.1</b>	<b>30466.3</b>
Long-Term Projects Assets	2378.2	2878.0	4744.8	4678.1	2102.9

Dynamics of assets devoted for equipment purchase for the period 2004–2008



## Income of 2008 from Local and International Projects



VATESI – State Nuclear Power Safety Inspectorate  
TMTPPA – Agency for International Science and Technology Development Programmes in Lithuania  
LR ŠMM – Ministry of Education and Science of Republic of Lithuania  
LVMSF – Lithuanian State Science and Studies Foundation

# Main publications

## Books, monographs

1. Šilumos energetika ir technologijos-2008 // Konferencijos pranešimų medžiaga. Kaunas: Lietuvos energetikos institutas, 2008. ISBN 978-9986-492-99-3, 341 p.
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*Comprehensive list of publications is faced on Lithuanian Energy Institute webpage:  
http://www.lei.lt → Information → Publications → 2008*



# Lithuanian Energy Institute events in 2008



4 January. Prof. Jurgis Vilemas was granted the award of Kaunas city mayor the Brick of Kindness at Kaunas city hall



25 January. Visit of USA embassy representatives



31 January. Conference devoted to commemorate the 85 year birth anniversary of academician Algirdas Žukauskas



6 March. Mantas Povilaitis was granted Lithuanian Academy of Sciences award of scientific works competition of high-school students for work "Modelling of plasma interaction with the first wall of thermonuclear reactor"



6 March. Dr. Liutauras Marcinauskas was awarded Lithuanian Academy of Sciences citation for scientific work "Formation of carbon coatings and modification of surfaces using electric arc plasma"



19 March. LEI participates in the event of Kaunas University of Technology career days



14 April. Dr. Inga Konstantinavičiūtė received official acknowledgment from Inter-governmental Climate Change Organization (together with Albert Arnold (Al) Gor) for contribution to work, awarded with Nobel prize



18 April. Second Euratom/LEI association meeting



31 March. Lecture of Dr. Karl Gross "Hybride Development for Hydrogen Storage"



22 April. Visit of Vytautas Magnus University students in LEI

29 April. Laboratory of Heat-Equipment Research and Testing announced as accredited institution

12 May. Lecture by Prof. Claude Templier on the interaction of electrons with materials



14 May. LEI at Vytautas Magnus University career days



24 May. LEI participates in international exhibition "Kaunas 2008"





29 May. 5th annual conference **CYSENI 2008**



and Republic of Lithuania common financing assets was implemented

1 September. Project "Reconstruction of LEI Heat Transfer and Nuclear Installation Administrative Building" supported by EU Structural Fund



2 September. General meeting of Institutes' research associates



10 September. IAEA national seminar "How to Write Competitive Proposals for Research Funding"



22 September. Seminar "Sustainable Energy Strategy in the Baltic States"



25 September. LEI Committee election



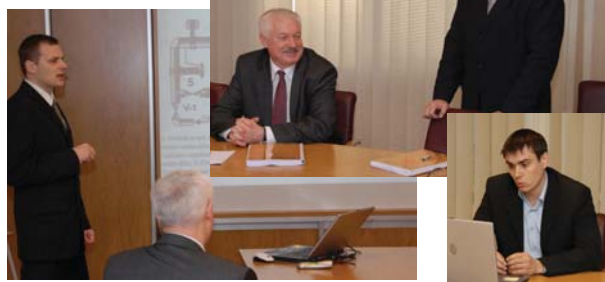
16 October. LEI Young Researchers Association organized seminar "Up-to-date thermal energy issues"



4 November. Regional nuclear safety professional training courses for the first time organized in Lithuania



10–14 November. Defence of state funded projects



20 November. Anniversary of Prof. J. Vilemas active and long-lived activity in the management committee of International Energy Agency Hydrogen Implementation Agreement



27 November. Information day of 7th Framework Programme



22 December. LEI was awarded by Lithuanian Industrialist Confederation competition "Product of the Year 2008" gold medal





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