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WORK OF THE INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY OF THE BULGARIAN ACADEMY OF SCIENCES IN 1980

By B. Betev, B. Aneva and G. Vojkov
B.A.S. Institute for Nuclear Research and
Nuclear Energy

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THE BULGARIAN ACADEMY OF SCIENCES

Institute of Nuclear Research and Nuclear Energy

WORK OF THE INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY OF THE BULGARIAN ACADEMY OF SCIENCES IN 1980

Compilers: B. Betev, B. Aneva, G. Vojkov

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INTRODUCTION

This report reflects the work of the Institute of Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences in 1980. For each problem group it contains indications about the problems, about the main results, about publications and about additional activities of the co-workers: international links, links with practical work, scientific-pedagogical work etc. We intend to publish a similar report every year.

Since this is the first survey of its kind, we decided that it would be useful to give some general information about the Institute. It was set up in 1972 together with the Institute of Solid State Physics as a result of a split in the former Physics Institute of the Bulgarian Academy of Sciences. Nuclear research was carried out previously in this general institute, which was founded in 1946, and still earlier in the Physics and Mathematics Faculty of Sofia University. The present Institute is a constituent part of the United Centre of Physics and is under its direct authority.

The Institute is a general rather than a specialized institute of nuclear science. If we wanted to give a brief description of its work, we could say that three main types of research are carried out in it: theoretical (elementary particle theory and nuclear theory), experimental (dealing with high- and low-energy physics) and applied science (concentrating on nuclear power, nuclear methods and instrument making). The organizational structure of the Institute, which is shown in Table 1, corresponds to these types of research, but naturally there are other groups doing closely related work having various objectives and involving different approaches. A centre for the Application of Radioactive Methods and Instruments has been set up in the Institute and this does not have its own separate structure - all the experimental and applied teams participate in its work to some extent.

The Institute has two comparatively large experimental facilities: the IRT-2000 nuclear research reactor of Soviet design and the Station for Cosmic Ray Research on Mount Musala (2924 m above sea level) - the highest in the Balkan peninsula, which was originally set up in view of the need for Bulgarian-Hungarian co-operation in this field. The Institute has several TRAI computers in operation and for solving more complex problems uses the machines at the computer base of the United Centre of Physics and also at the United Centre of Mathematics and Mechanics and other computer bases. The Institute has an ILU-4 mass separator, a D-150 SAMES neutron generator, a DN-520 neutron diffractometer, several small beta- and gamma-spectrometers and viewing tables for bubble chamber photographs, and a large gamma-irradiation chamber designed and built at the Institute.

The Institute is linked (integrated) with the nuclear physics departments of the Physics Faculty of Sofia University and also with several departments in Plovdiv University and the Higher Pedagogical Institute in Shumen. It is concerned with work optimization, burial of waste from the Kozloduy nuclear power station and also - together with other institutes and firms that manufacture nuclear instruments - with the supply of radioisotopes and the provision of irradiation services at the reactor or in the gamma chambers.

The Institute plays a large and active part in the work of the Joint Institute for Nuclear Research at Dubna and also in the work of the Interim International Body for the building of the WWER-1000 reactor in Budapest, in the committees of the Council for Mutual Economic Assistance, in the International Atomic Energy Agency, and in the International Centre for Theoretical Physics at Trieste. There is co-operation with a number of institutes in the USSR and in other countries of the socialist community as well as with several institutes in countries of the West. All these links enable the Institute's staff to keep their work fully up to date and to contribute both to fundamental nuclear science and to its innumerable possible applications.

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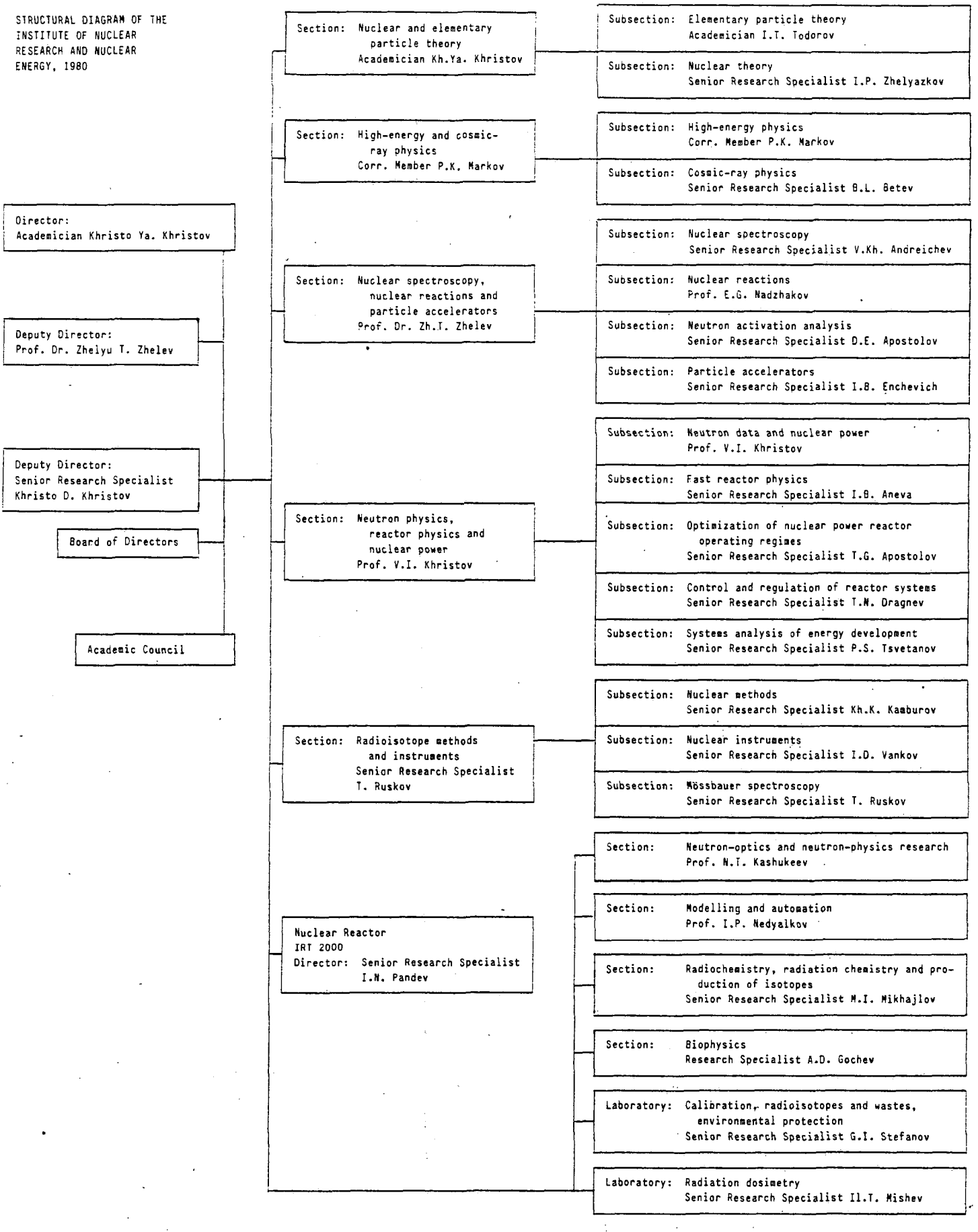
This material has been compiled by an editorial board comprising:

Senior Research Specialist, Boto Betev; Research Specialist, Bojka Aneva and Research Specialist, Georgi Vojkov.

STRUCTURAL DIAGRAM OF THE INSTITUTE OF NUCLEAR RESEARCH AND NUCLEAR ENERGY, 1980



NEUTRON PHYSICS, REACTOR PHYSICS AND NUCLEAR POWER

The section of neutron physics, reactor physics and nuclear power covers the following problem areas:

- Neutron data and nuclear power;
- Fast reactor physics;
- Optimization of power reactor operating regimes;
- Control and regulation of reactor systems;
- Systems analysis of energy development.

In 1980 research in these areas was concentrated on the following subjects:

- Theoretical and experimental investigation of non-steady-state neutron transport;
- Study of rare nuclear reactions with neutrons;
- Formulation of program complexes for calculating the neutron physics characteristics of fast reactors, optimization of such programs, the creation of a unified nuclear data system and of a universal program library;
- Measurement and evaluation of neutron constants for more precise reactor calculations;
- Measurement of neutron spectra in fast reactor systems;
- Reactor-physics research on the VBEhR critical assembly and similar devices;
- Systems analysis of the long-term evolution of thermal and electric power generation requirements in Bulgaria.

Most of this work was carried out in close co-operation with the Institute of Nuclear Research of the USSR Academy of Sciences, the Joint Institute for Nuclear Research at Dubna, the Kurchatov Institute of Atomic Energy, the Institute of Physics and Power Engineering at Obninsk and the Interim International Body on WWER Physics. The 3R-6 critical reactor assembly and the "Fakel" electron accelerator, among other installations, were used.

The basic facilities on which research is carried out are the IRT-2000, the D-150 kV SAMES neutron generator, the fast mechanical neutron selector, the single crystal fast neutron scintillation spectrometer, the streamer electron-positron pair spectrometer and the "Romashka" multiple-section scintillation detector for measuring the multiplicity of gamma rays.

SUMMARIES OF CERTAIN SCIENTIFIC RESULTS

Theoretical and experimental study of neutron albedo using the pulse method in multilayer spherical and cylindrical-symmetric systems

V. Khristov, A. Stanolov, K. Ilieva, L. Aleksandrov, M. Drenska, N. Stancheva, V. Gadzhokov

Bilateral co-operation between our Institute and the Nuclear Research Institute of the USSR Academy of Sciences has included theoretical and experimental research on non-steady-state neutron transport in spatially heterogeneous media.

Experimentally, damping of the neutron flux from a pulsed source has been observed in a water moderator of a given volume with a large cavity, and the quasi-exponential damping constant has been determined.

Relationships between the damping constant for the neutron flux from a pulsed source and the neutron albedo on the inner surface of the moderator have been theoretically established.

On the basis of this research an original method of determining thermal neutron albedo in spherical and cylindrical-symmetrical moderator systems has been formulated and applied with a high degree of accuracy (0.5%).

Measurement and regeneration of fast neutron spectra in heterogeneous shielding and moderating media

V. Khristov, J. Jordanova, M. Mikhajlov, O. Penchev, K. Ilieva, G. Vojkov

A fast neutron scintillation spectrometer was developed with a stilbene crystal and a circuit for discriminating neutrons from gamma-quanta on the basis of pulse shape. A high degree of gamma pulse discrimination was achieved, as was good resolution in particle recording.

The amplitude distributions of protons created by fast neutrons from a 14-MeV source were measured behind various shield and moderator materials (graphite, beryllium, iron, water). The D150 neutron generator was used as a 14-MeV source. The neutron distributions were found by differentiation from the fitted amplitude distributions. In order to compare the experimental and theoretical results, programs for numerical calculation of neutron distributions by the discrete ordinates method and the Monte-Carlo method were adapted as required. A program for obtaining average group microscopic cross-sections was also adapted and improved.

Automation of neutron physics experiments

V. Gadzhokov, N. Stancheva,
K. Konstantinov

The work aimed to use available mini-computers for applying modern methods of collecting and processing experimental data suitable for neutron albedo research in multi-layered spherical and cylindrical symmetrical media using the pulse method. During the last year the KAMAK system developed on the TRA-1001-I and M6000 base was improved and put into operation together with specialized mathematical software. The system operates in the following regimes: (a) data input directly into the memory of the TRA-1001-I computer; (b) on-line layout of the time spectrum using a display with a functional keyboard; and (c) retrival of data in standard exchange format with final processing for analysis of hidden exponents on the M6000 computer. Operation of the system in actual experimental conditions has shown that it works relatively stably and the results of express (same day) data processing concur with the processing results of more complex programs using automatic control and double precision on large computers.

Construction of a streamer spectrometer for studying rare reactions with neutrons producing electron-positron pairs

T.M. Troshev, A.I. Trifonov, M.N. Mikhajlov, V.P. Khristov,
I.V. Falomkin, U.A. Shcherbakov

At the end of 1980 a spectrometer was constructed on the basis of a streamer chamber. The spectrometer is designed to study rare neutron reactions on the horizontal beam of the IRT 2000 reactor in Sofia. The streamer chamber is 30 x 20 x 10 cm^3 and is filled with argon or hydrogen. It acts as a gas target placed in a magnetic field of 0.07 T. The construction of the equipment enables a wide programme of experiments to be carried out in which it is necessary simultaneously to observe the points of interaction of the neutrons, to detect reactions with emission of particles, to evaluate the ionization and to establish their spatial correlation. The streamer chamber can work with high-intensity neutron beams, which means that processes with small cross-sections can be recorded effectively. The apparatus is designed to detect and photograph the tracks of internal conversion electron-positron pairs resulting from the capture of thermal neutrons by the argon and hydrogen nuclei. In our case the gas filling the chamber served as a target, thus providing the opportunity of observing the points of pair emission and relatively good conditions for angular and energy measurements.

The development of program complexes for calculating the neutron physics characteristics of fast reactors and their optimization

I. Jordanov

A one-dimensional multi-group program was developed for neutron physics calculations on fast reactors in the multi-group diffusion approximation. The program calculates the critical dimensions, the effective multiplication factor, the real and/or conjugate neutron flux, the integrated neutron flux for each energy group and for each space zone, and the distribution of fission neutron sources.

The ANALIT program for criticality calculations in plane geometry was developed from the existing method for the analytical solution of multi-group diffusion equations. Calculations were made for the French MASURCA fast reactor. The advantages of this method in terms of accuracy and efficiency have been demonstrated. The PRVDAN program - for preparing macroscopic constants for actual reactor systems - was developed.

Measurement of mass and angular distributions of fission fragments from thermal neutrons and gamma-rays

N. Kalinkova, I. Ivanov, E. Antonova, A. Mateeva, N. Yaneva

During the year preparations were made for measurements on the accelerator of the fission physics group at the Kurchatov Institute. A new improved type of detector electronics linked to the small IZOT-310 computer has been installed. The improvement aims to increase the operational stability of the electronic equipment and to improve the performance of the data recording and processing system associated with a dual pulse ionization chamber.

A new method of obtaining thin layers of metallic uranium by evaporation in a vacuum has been developed.

Experimental data processing on the small computer has been improved, and the programs used have also been refined and optimized.

Measurements of absorption cross-sections and interlock coefficients for ^{235}U and ^{239}Pu

N. Yaneva, St. Toshkov, G. Ilchev, T. Bakalov, N. Koyumdzhieva, A. Mateeva, N. Kalinkova

The joint group of workers of the Institute of Physics and Power Engineering at Obninsk and the Bulgarian Institute of Nuclear Research and Nuclear Energy is continuing its work in this field on the neutron time-of-flight spectrometer using the IBR (pulsed fast reactor)-30 base at Dubna. The average characteristics of the resonance structure of neutron

cross-sections in the resolved and unresolved resonance regions for ^{235}U and ^{239}Pu were measured and processing has been completed. Average total cross-sections and resonance self-screening factors (total cross-section and fission cross-section) in the 2 eV-20 keV region were measured by the transmission and self-indication method. From the experimental data, subgroup parameters were obtained for the cross-section structure in specified energy intervals, and also for the resonance interlock factors. The experimental results were transmitted in the form of files and subgroup constants to the Nuclear Data Centre at Obninsk. They are available in data libraries and are intended for use in fast reactor design.

The production of targets of different thickness from fissionable material

E. Antonova

During the year a new method was developed for obtaining thin layers of ^{238}U by evaporation in a vacuum. New equipment was designed jointly with specialists at the Institute of Electronics of the Bulgarian Academy of Sciences. Several types of support were tested - aluminium and cadmium gilded and non-gilded films. The fact that uranium had to be applied to a thin backplate of gilded collodion meant that a suitable working method was required, and the task was particularly difficult with large targets (6 cm diameter). The required targets were made from thin layers (50 mg/cm^2) of ^{238}U and their spectrometric properties examined.

Measurements of the multiplicity of fission neutrons using the "Romashka" detector

Ts. Pataleev, N. Yaneva, G. Panajotov, A. Mateeva, N. Kalinkova

The "Romashka" multi-section scintillation detector for measuring the multiplicity of gamma-rays is installed in horizontal channel IV of the IRT-2000 reactor. A collimator system and shield made in Hungary have been finished and assembled. Our own Institute has produced and tested electronic circuits which can be used to measure the γ-ray multiplicity spectra of non-fissile nuclei.

With this equipment and shield the multiplicity spectra of gamma-quanta emitted in thermal neutron capture were measured. Provisional measurements have been made for 26 nuclei.

The measurements carried out jointly with Soviet specialists (from the Kurchatov Institute) have led to an important result. In the reactor, the "Romashka" detector produces a strong signal against a very small background. This means that unique cross-section measurements can be carried out with a very small quantity of material. This opens up possibilities for studying rare processes, obtaining cross-sections for a wide range of radioactive nuclei and carrying out multi-parametric correlation measurements.

Measurement of neutron spectra in fast reactor systems

K. Ilieva, L. Stoeva, M. Gelev, N. Yaneva

The latest revised version of the RFSP program and a microscopic cross-section data library covering 15 detector elements for fast and thermal neutrons have been received from the TsIFI in Budapest.

Using the NEDF-B/4 library (dosimetry file) we have compiled a similar file containing data for 15 detectors.

A range of activation detectors were irradiated in horizontal I and in vertical channel I of the IRT reactor at Sofia.

On the basis of the experimental data obtained, spectrum unfolding experiments are being conducted in vertical channel I using the RFSP program.

The BONNER program using the statistical adjustment method has been adapted and the neutron spectrum in the horizontal reactor channel was established by measurements with activation detectors.

Experiments on the ZR-6 and LR-0 critical assemblies

A. Stanolov, L. Stoeva

Statistical experiments aimed at investigating WWER core microparameters have been completed (for regular lattices) on the ZR-6 critical assembly. The experiments, carried out at atmospheric pressure and ambient temperature, involved no inhomogeneities and were performed on absorbing elements, assemblies, layers of uranium fuel with different enrichments, water "holes" and so on. The neutron flux micro-distribution and loss coefficients were determined for the WWER elementary cell (enrichment in ^{235}U 4.4%, lattice spacing 12.7 mm) for zero boric acid concentration in the moderator. A core with these characteristics was considered most suitable owing to the weak dependence on boric acid concentration. The activities of the dysprosium and copper activation detectors and the loss coefficients were determined, as were the neutron micro-distribution and a number of spectral indices in the elementary cell with europium absorbers present. Detectors with a macro-cross-section close to that of the absorber were used to reduce the perturbations of the neutron flux. The RFIT programme was used to process the results. The experimental data were compared with analogous computational data.

Preparation of computer programs for physical calculations of WWER reactors

T. Apostolov, M. Manolova, P. Petkov,
R. Prodanova

A family of close-mesh diffusion programs called KhEKSAB has been developed to determine the neutron physics characteristics of WWER-1000 cores. Model problems for the ZR-6 critical assembly have been solved with the two-dimensional diffusion program thus developed. A method has been developed and a program written which take account of the actual fuel assembly structure in WWER reactors. A KhEKSAB-II-ZOV program has been prepared to calculate energy release and burn-up microfields with allowance for power feedback, xenon and so on. Thorough methodical research on the establishment of macro-cross-section libraries has been carried out in connection with this work. A three-dimensional diffusion program, KhEKSAB-II-30, has been written for element-by-element calculations of the neutron flux and energy release distribution. The LEOPARD and UIMS programs have been adapted and used for calculating average small-group cross-sections. A complex of programs has been written to calculate fuel burn-up and the fuel conversion ratio in WWER-440 fuel assemblies.

Development of noise diagnostic methods for determining reactor core states

N. Antonov, L. Sybotinov

The DENSITY program has been developed for reactor system studies based on noise diagnosis. A complex of equipment has been devised for stochastic measurements of reactor parameter signal fluctuations, including a single-channel analog magnetic recorder, a stochastic analyser, a set of neutron emission detectors and so on.

Methods have been developed for determining the thermohydraulic parameters of the diagnostic assemblies by means of sub-channel annalysis which takes into account turbulent and convective displacements in the transverse direction.

Investigation of the hydrodynamics of two-phase flows. Distribution of vapour content in rod clusters

L. Sybotinov, A. Boyadzhiev, T. Totev, N.P. Kolev,
N.I. Kolev, S. Stefanova

An improved version of the sub-channel analysis program COBSOF has been developed for a wide range of operating parameters. A methodology and a program for analysing parameter behaviour in nuclear power station rooms containing bubblers has been evolved, and a model developed for critical

equilibrium two-phase flow with quasi-constant phase slippage. A series of models of two-phase flow based on algorithms and programs has been developed for WWER reactors, and comparisons with available experimental data have been made. Finally, an improved version of the dynamic program ELIN has been written.

An analysis of the course of serious accidents in nuclear power stations

L. Sybotinov, A. Boyadzhiev, N.I. Kolev,
S. Stefanova

Loss-of-coolant accidents were analysed at the outflow stage for real WWER-440 geometry with the help of the BRUKh and RELAN programs. The results were used as boundary conditions for a detailed analysis of fuel element behaviour based on channel programs and also for analysing processes at the Kozloduy nuclear power station. A survey has been prepared on the problems of analysing thermomechanical processes in fuel elements in steady and non-steady conditions.

Development of computer programs for heat physics calculations of reactor cores and circuits

L. Sybotinov, A. Boyadzhiev, T. Totev, N.P. Kolev,
N.I. Kolev, S. Stefanova

A program has been drawn up for steady-state, non-steady-state and accident calculations of temperature fields for fuel elements and surrounding coolant.

A method has been developed for analysing and optimizing the thermal reliability of fuel elements, cores and other nuclear power station systems using the PRENTO, TENAZ and KADO programs. A number of optimization calculations have been performed for reactors and other systems at the Kozloduy nuclear power station.

An absolute measurement method for the isotopic compositions and concentrations U, Pu and ^{241}Am in special nuclear materials

T.N. Dragnev, B.P. Damyanov, G.G. Grozev

There has been further development of a method of internal self-calibration in gamma and gamma-X-ray spectrometric measurements. Using and extending a method of internal self-calibration they developed earlier, the authors have drawn up special techniques and programs for determining the isotopic composition and concentration of uranium in different samples and also the isotopic composition of Pu and ^{241}Am on the basis of gamma-spectrometric measurements; the results are then processed on the TI-59 microprocessor, so that the method can be put to practical use by IAEA inspectors in the verification work required by the Treaty on the Non-Proliferation of Nuclear Weapons. This method has been improved by the use of a correlation between the experimental gamma and X-ray line widths and by the introduction of an iteration procedure when drawing the curve for full detection effectiveness of the beams being measured.

The "IMPAKT" model - an economic estimate of the evolution in Bulgaria's energy system

P. Tsvetanov, P. Jordanov, V. Badeva, M. Denisiev, P. Penkov, D. Asparukhov

The experimental version of a specialized dialectical balance model for evaluating the external links in Bulgaria's energy system is described. The model is used to prepare data and programs for evaluation and analysis of five different scenarios for the evolution in Bulgaria's energy system up to the year 2000. The prospects for further improvements in this useful model and for the continuation of its use in a long-term planning and forecasting system for the evolution of Bulgaria's fuel and energy system are examined.

Methodology and organization of research and development work on long-term programs for the evolution of Bulgaria's energy system

P. Tsvetanov, I. Tsvetanov, E. Kamenski

The task was to establish a research procedure encompassing a complex of formal and informal methods applicable to energy technology as well as model systems and a set of computer programs and decision-making techniques for making long-term forecasts leading to the preparation of basic development programmes for Bulgaria's national fuel and energy system.

Method and organizational approach for linking long-term energy development with the national economy as a whole and with the energy systems of CMEA member countries

P. Tsvetanov, I. Tsvetanov, V. Gadeva

Work has focused on the application of systems analysis techniques to the study of links between energy and the social and economic development of the country, including the anticipated long-term development of power production in member countries of the Council for Mutual Economic Assistance (CMEA) and throughout the world. It includes the preparation of a long-term scenario for Bulgaria's social and economic development, joint development work with the Moscow Scientific Research Institute for Planning and Administration and other organizations in CMEA member countries and also the evaluation and application of the results of studies carried out by the International Institute for Applied Systems Analysis (IIASA) in Vienna on global energy strategies with a view to forecasting the evolution of Bulgaria's fuel and energy system.

A macroeconomic model for long-term forecasting of the development of Bulgaria's national energy system

P. Tsvetanov, I. Tsvetanov, A. Dimitrov, Kh. Blagov,
G. Minasyan, Kh. Koprinkov

The paper provides a review of existing macroeconomic models prepared in Bulgaria, by the International Institute for Applied Systems Analysis (IIASA) in Vienna, by the Sverdlovsk Energy Institute of the USSR Academy of Sciences (Siberian Branch) and also at the Brookhaven Laboratory in the United States. The links between energy and the economic system as a whole and also the structural and functional principles underlying macroeconomic models are examined and analysed. The paper provides methodological recommendations for the design of a macroeconomic model for Bulgaria's energy system.

A long-term evolution model for Bulgaria's energy consumption

P. Tsvetanov, I. Tsvetanov, V. Badeva, P. Jordanov,
E. Kamenska, I. Rajkov, A. Tsvetanskij

The paper contains an analysis of an energy consumption model developed at the International Institute for Applied Systems Analysis (IIASA) in Vienna and describes the methodological premises underlying sound energy consumption evaluations. During the preparation of the study, methodological and organizational questions associated with the adaptation of this model to Bulgarian conditions were examined.

A long-term evolution model for Bulgaria's energy supply

P. Tsvetanov, P. Petkov, E. Kamenska, V. Badeva and other experts from the Bulgarian Academy of Sciences' Institute of Nuclear Research and Nuclear Energy and from "Ehnergoproekt"

The task was to develop a dynamic extrapolation of the long-term evolution model for the country's energy supply. The model compares alternative technological systems entailing primary and secondary conversions of distribution and final consumption to satisfy each of the components of useful energy consumption, constraints being imposed in respect of resources, the schedule and rate of introduction of new technologies, and environmental pollution.

For each combination of external conditions the model generates optimum energy resource utilization patterns (including the distribution between local and imported resources) and also the optimum evolution dynamics for energy technologies, including new ones. In this way an optimum structure for the energy supply system as a whole, governing the development of various subordinate systems such as electric power, coal, gas and oil drilling is found.

A model for estimating direct and indirect inputs and resources for the long-term development of Bulgaria's combined energy system

P. Tsvetanov and co-workers at the Bulgarian Academy of Sciences' Institute of Nuclear Research and Nuclear Energy, GIIU, Ministry of Energy, MNIPIES, "Ehnergoproekt", MNIPKI MINPROEKT (Mining Project of the Scientific Research and Design Institute for Construction) and the Scientific Centre of the State Committee on Scientific and Technological Progress (DKNTP)

The aim was to establish a national version of a specialized dialectical balance model for estimating production volumes, taking into account the rate of introduction of new capacity in energy-related branches of industry and also capital investment and expenditure on limited resources (water, land, manpower, materials and energy) within Bulgaria's fuel and energy system and related activities. The basis of the model is the approach developed at the Sverdlovsk Energy Institute of the USSR Academy of Sciences (Siberian Branch) as a result of improvements in the model developed at the International Institute for Applied Systems Analysis (IIASA) in Vienna together with the version of this model now being used to forecast the evolution of Bulgaria's fuel and energy system up to the year 2000, which was developed in Bulgaria in 1979 and 1980.

Methodology and decision-making techniques for the analysis of different versions of the development programme for Bulgaria's fuel and energy system

V. Badeva, P. Tsvetanov, B. Vasev

The paper outlines the procedure used for selecting different options in situations where uncertainty exists in long-term forecasts regarding Bulgaria's national fuel and energy system. It discusses the formulation of proposals for long-term development programmes in the production and scientific and technical spheres, and brings together the results of studies on the evolution of the system taking into account the interactions between this national programme and others elaborated in the context of the Council for Mutual Economic Assistance (CMEA).

A set of computer programs for forecasting the long-term development of Bulgaria's fuel and energy system

P.D. Jordanov, P. Tsvetanov, I. Pisanov, P. Belyashki

These programs are designed to solve problems of long-term planning and forecasting related to the development of Bulgaria's national fuel and energy system. One special purpose is to develop and introduce programs on which computer models of the system can be based. Making this set of programs functional presupposes a man-machine dialogue leading to an efficient and extensive exchange of information, the results of which can be transmitted for use by all member states of the Council for Mutual Economic Assistance (CMEA).

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