

# Research Activities and Lectures

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## **Research**

The chair has two fields of activities mainly focusing on:

- **Life cycle analysis and market introduction of new energy systems:**
  - Energy analysis of industrial processes and cities in terms of saving energy and improving efficient energy supply.
  - Further development of tools for accumulated energy and life cycle assessments for the evaluation of environmental performance and for mass flux analysis. Essential parts of the data base can be accessed via the internet.
  - System analysis and optimization of efficient and innovative technologies like wind, hydrogen and solar energy.
  
- **Reactor simulation and safety:**
  - Development and improvement of physical models and computer modules for a strengthening of the capabilities of international severe accident analysis- and aerosol codes.
  - Severe accident analysis of cooling circuit and containment in order to improve prevention.
  - Progressive reactor concepts.

## **International cooperations**

LEE maintains a manifold of international cooperations – e.g. has the chair scientific cooperations with Tianjin University in China, Malavia National Institute of Technology in Indian and Shri Mata Vaishno Devi University in India – and good relationships to a great variety of organisations in- and outside Germany.

## **EU SOCRATES/ERASMUS programme**

The chair is responsible for the study exchange with the University of Sheffield (UK) within the EU SOCRATES/ERASMUS programme.

## **Current research projects on the field of energy precaution research, arranged by funding institutions:**

- **DEVELOPMENT OF A CONCEPT FOR THE USE OF THE HARD COAL MINE PROSPER-HANIEL AS AN UNDERGROUND PUMPED HYDROELECTRIC STORAGE PLANT**

In interdisciplinary collaboration with research teams from the University of Duisburg-Essen and the Ruhr-University Bochum as well as experts from the RAG, the DMT and the RISP, it will be investigated to what extent shafts and tunnels of decommissioned hard coal mines can be used to accommodate underground storage spaces. Geological and technical conditions of potential sites will be analyzed together with the required technical systems, their construction and operation. LEE carries out the economic evaluation under energy market dynamics' considerations.

Sponsored by: Federal Ministry of Economics and Energy (BMWi)

Duration: 2016 - 2017.

- **KRYOLENS - LIQUEFIED AIR ENERGY STORAGE (LAES)**

The objectives of the Chair of Energy Systems and Energy Economics are the economic evaluation of selected LAES-Application variants as well as the identification of improvement potentials. For this purpose, the conditions of relevant energy markets will be determined and also costs and revenues will be estimated. Furthermore, the ecological impacts of selected LAES-Application variants based on a Life Cycle Assessment (LCA) will be estimated. In addition, a comparison between selected LAES-Application variants and other energy storage and power plant technologies will be carried out based on LCA results in available literature. Sponsored by: Federal Ministry of Economics and Energy (BMWi) Supported by: Uniper Technologies GmbH, RWE Power AG and Vattenfall Europe

Duration: 2016 - 2019.

- **GW-RUHR - DEVELOPMENT OF INNOVATIVE AND EFFICIENT HEATING CONCEPTS, TAKING ACCOUNT OF MINING INFRASTRUCTURE IN THE RUHRGEBIET**

The Project "GW-Ruhr" has the proposal to examine, how the existing mining infrastructure can be used in terms of renewable energy generation. For this purpose, different scenarios have to be developed in the first phase of the project in consideration of the different, conventional energy systems, which should be substituted. In this context the estimated costs for the implementation and the reduced carbon dioxide emissions are determined. Finally there is an implementation concept, which should be ready for decision and be realized in the second phase of the project.

Sponsored by: Federal Ministry of Economics and Energy (BMWi)

Duration: 2016 - 2019.

- **INTEGRATION OF FLUCTUATING RENEWABLE ENERGIES BY CONVERGENT USAGE OF ELECTRICITY AND GAS GRIDS**

The objective is to calculate the intake capacity, storing and distribution of renewable energies through the linking of electricity and gas grids. The energy flows from supply and demand will be modelled.

Sponsored by: Federal Ministry of Economics and Energy (BMWi), Federal Ministry of Education and Research (BMBF), Federal Ministry for Environment, Nature protection, Construction and Nuclear Safety (BMUB)

Duration: 2016 - 2016.

- **CENTRAL INFORMATION SYSTEM ON ENERGY RESEARCH FUNDING (ENARGUS 2.0)**

Development of a central information system on energy research funding by federal states and federal government. We support the integration of field ontologies into the total system based upon our energy-economical expert knowledge of renewable energies.

Promoted by: Federal Ministry of Economics and Energy (BMWi)

Duration: 2013 - 2016.

- **ACCOMPANYING RESEARCH ON “COMPETITION ENERGY EFFICIENT CITY” (ENEFF STADT BF II)**

Sustainable and exemplary approaches for the increase of energy efficiency in the “system city” are the centre of this project. Together with the Karlsruhe Institute of Technology (KIT) and the Institut for future studies and evaluation of technology (IZT) LEE accompanies five communal projects focusing the increase of energy efficiency in cities. The research activities of LEE include surveys of energy consumption in private households under socio-demographic aspects, the development of indicators for transferability of energetic realization strategies to other communities and integral and systematic considerations of measures to increase energy efficiency, including services, energetic redevelopments and transport.

Promoted by: Ministry of Education and Research (BMBF)

Duration: 2011 - 2016.

## **Current research projects on the field of reactor simulation and safety, arranged by funding institutions:**

- **EXTERN VALIDATION AND ANALYSIS OF ACCIDENT CODES ASTEC, ATHLET AND ATHLET-CD (EVA3A)**

The severe accident analysis codes ASTEC (Accident Source Term Evaluation Code), ATHLET (Analysis of Thermal-hydraulics of Leaks and Transients) and ATHLET-CD (Analysis of Thermal-hydraulics of Leaks and Transients – Core Degradation) will be through experiments evaluated.

Promoted by: Federal Ministry of Economics and Energy (BMWi)

Duration period: 2016 – 2019

- **CODE FOR EUROPEAN SEVERE ACCIDENT MANAGEMENT (CESAM)**

CESAM (Code for European Severe Accident Management) is a R&D project aiming at the improvement of the European reference code ASTEC (Accident Source Term Evaluation Code) towards a usage in severe accident management analysis for nuclear power plants (NPP). Research activities in this project will jointly be carried out by the 18 project partners from 12 European countries and India. At first, current ASTEC modeling capabilities for the relevant phenomena during severe accidents are assessed providing recommendations for code development and model improvements to be performed in this project. The improved ASTEC models will then be validated against experiments and assessed for reactor applications. ASTEC reference datasets for the main generic types of NPPs (PWR, BWR, CANDU) will jointly be prepared by the partners. Plant calculations for various accident scenarios will be performed in order to analyze possible improvements of SAM measures and to provide appropriate guidance on how to apply ASTEC for plant analysis.

Promoted by: European Union in the 7th Framework Programme

Duration period: 2013 – 2017

- **VALIDATION, ANALYSIS AND COUPLING OF ATHLET-CD AND COCOSYS (VAMKOS)**

The severe accident code systems ATHLET-CD and COCOSYS are tools to simulate system processes of LWR during transients, incidents and accidents. The code developments on the one hand and the expectation of improved code quality on the other hand require the evaluation of the model basis and the continuative external validation of ATHLET-CD and COCOSYS by application of the codes on selected experiments. With respect to the assessment of the modelling of spray and wall boiling phenomena as well as the core degradation phase the project contributes to the code development, particularly with regard to involving external code users. Further, the coupling of ATHLET-CD and COCOSYS is utilized and investigated in the frame of plant applications.

Promoted by: Federal Ministry of Economics and Energy (BMWi)

Duration: 2013 - 2016.

- **SIMULATION OF THE ACCIDENT FUKUSHIMA-DAIICHI FOR THE EVALUATION OF THE CODE ATHLET-CD (SUBA)**

In this project, databases related to the accident Fukushima-Daiichi from different studies will be gathered, compared and harmonized. This information is the basis for the simulation of the accident with the accident analysis code ATHLET-CD. By analyzing the simulated system behavior, the ability of the code for mapping the late accident phase will be assessed.

Promoted by: Federal Ministry of Education and Research (BMBWF)

Duration: 2013 - 2016.

- **VALIDATION AND INTERPRETATION OF THE COCOSYS MODEL BASIS (COSMO)**

In the framework of the German reactor safety research, the integral code COCOSYS is analysed and assessed concerning selected phenomena, which can occur in a light water reactor (LWR). Furthermore, comparative simulations with ASTEC V2.1 should give the ability to evaluate the quality of COCOSYS' models in context with another code. Potential model- and program weaknesses of COCOSYS should be identified, analysed and communicated to the program developers. Moreover, the external validation of COCOSYS gives the ability for an exchange of experience between code users'

of different institutions. The research project is realised in accordance with program development and -validation and should also take part in the frame of extraction of knowledge concerning processes and physical phenomena in a light water reactor during potential severe accident.

Promoted by: Federal Ministry of Economics and Technology (BMWi)

Duration: 2016 - 2018.

## **Overview of topics of finished research projects**

Over the recent years several research projects were finished. Here are the main topics as following:

- CHANGE – Interventional instruments to promote an energy efficient user behavior
- MEM-BRAIN – Gas separation membranes for emission-free fossil plants
- Energy Efficient City I
- Integration of solar heating and cooling in residential buildings with low energy and passive house standards
- EUROTRANS – examination of technical feasibility of transmutation of in an accelerator driven system
- Innovative modeling an optimizing of regenerative energy supply systems
- ATHLET-CD MODELS
- Network of Excellence for a Sustainable Integration of European Research on Severe Accident Phenomenology - Sarnet 1
- Model experiment MEX V: Innovation and modern energy techniques.
- Wholistic analysis of conventional and innovative energy supply systems for low-energy-buildings and settlements.
- Compilation and application of indicators on sustainability by means of selected renewable energy sources.
- Energy demand analysis of low-energy-houses in consideration of innovative technologies (EduaR&D).



- Fundamentals of a biotechnological and biomimetical approach of hydrogen production – system analytical research, energy balancing and environmental research.
- Influence of resuspension processes on the source term and contribution to the modelling of water pools adapted to COCOSYS.
- Feasibility study of geothermal heat supply of Ruhr-Universität Bochum and surrounding area.
- Innovative modelling and optimising of the production of renewable energy converters: temporal decoupling of supply and consumption.

## **Offered software**

After request for the password at [www.lee.rub.de](http://www.lee.rub.de), the following software can be downloaded:

- EMIL – Database for the calculation of the cumulated energy.
- KEAPOLIS – Planning software for the capture of the integral energy complexity in low-energy-house settlements.

## **Lectures**

The chair of Energy Systems and Energy Economics (LEE) is integrated in the Institute of Energy Technology and belongs to the Faculty of Mechanical Engineering of the Ruhr-Universität Bochum.

The faculty gives students the possibility to choose between three courses of study: *Mechanical Engineering*, *Environmental Engineering and Management of Resources*, and *Sales Engineering and Product Management*. The chair is involved in all three fields of study. The courses are also visited by students of Physics, Electrical Engineering and Mining and Energy Law. A brief description of the contents of the courses follows.

### **Energy economics**

Here the main topics are formation of terms and characteristics of the energy economy, energy resources and consumption world-wide and in Germany, the ways of energy from the deposit to the end-user from a technical point of view, price mechanism for oil, coal, gas, price formations and tariff forming of grid-bounded energy sources shown at the electricity example, organizational structure of the energy economy, liberalization, energy stock market, environmental effects of the energy transformation.

### **Energy conversion systems**

This course mainly deals with physical and technical basics, design and functionality of selected energy plants and systems. In particular: “centralized” supply systems – like coal-, gas fired combined cycle and nuclear power plants – and “decentralized” supply plants – like block thermal power plants, combined heat and power plants, boiler plants, renewable energies (selection), and fuel cell systems.

### **Renewable energies**

The mayor items include electricity generation by solar thermal as well as photovoltaic plants and wind energy conversion systems. In particular: present structure of electricity generation and request from the view of the electrical energy supply, energy availability (solar, wind), functionality and design-options of solar thermal power plants, wind turbines and photovoltaic energy conversion and their design, connection to the electricity grid, costs, and entering of compensation for electricity fed into the grid.

## **Safety and reliability analysis for technical plants and systems**

This course's issues are methods for the assessment of safety, reliability, and the risk of technological systems and their use. The aim is to introduce basic skills for performing and assessing probabilistic safety analysis.

## **Hydro power plants**

Here the main topics are construction, functionality, and the role of hydro power in electricity supply, overview of the modern use of hydro power, energy economical and statutory guidelines, physical-technical basics of the hydro power use, technical construction and components of river- and storage power stations as well as use of the sea energies.

## **Investment and costing**

This course mainly deals with the contemplation of basic aspects of costs, selected methods of investment (e.g.: method of capital value and annuity), description of external costs and value benefit analysis.

## **Reactor theory**

The major items include basic characteristics of the reactor and the application in the nuclear power plant technology, structure of the matter. Nucleus structure, binding energy, nuclear transformation types of radioactivity. Nuclear fission, energy release, generation of neutrons, nuclear fission as chain reaction, multiplication factor (four-factor-formula). Neutron flow density distribution, neutron diffusion. Diffusion-, multiple group- and transport theory.

## **Nuclear power plant technology**

This course's emphasis is on classification of various reactor types and discussion as power plant reactors. Thermo-dynamical aspects, design of the reactor core and the primary system, and selected safety arrangements. Fuel cycle facilities for changing and storing the fuel elements. Reactor safety and radiation protection, possible accidents, accident courses and radiological consequences, function of different radiation barriers and safety demands.

## **Strategic management and business management**

This course gives an overview of management needs in industrial companies: Motivation, training and communication of staff leadership. Strategic planning instruments in companies. Benchmarking for cost optimization, instruments for leading people and instruments for change management.

## **Process technology and resource management**

The chair's contributions to this cycle of lectures are principles of Life Cycle Assessment: Material flow cumulated energy demand and cumulated emissions, proceedings of Life Cycle Assessment and definitions of impact categories.

## **Professors**

Univ.-Prof. Dr.-Ing. Hermann-Josef Wagner

apl. Prof. Dr.-Ing. Marco K. Koch (academic director)

Prof. Dr.-Ing. Hermann Unger (emeritus)

## **Honorary Professors**

Prof. Dr.-Ing. Thomas Hoffmann

## **Lecturers**

Dr.-Ing. Eberhard Hoffmann

Dr.-Ing. Andreas Richei

## **Secretary**

Manuela Kötter