

# **Institute for Reactor Safety and Reactor Technology**

RWTH Aachen University

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September 2014

# Overview

- 1 Introduction
- 2 Energy Economic Systems Analysis
- 3 Research Topics

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# Institute for Reactor Safety and Reactor Technology



## Research Topics:

- Reactor Theory
- Containment Phenomena and Processes
- Energy Economic Systems Analysis

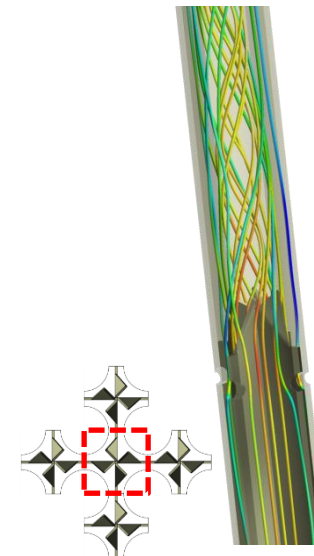
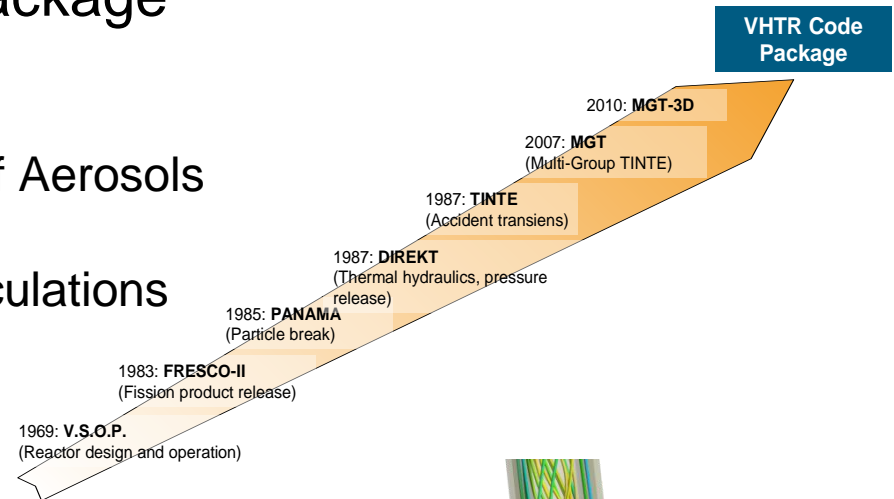
## Main Lectures:

- Reactor Technology I-III, Reactor Safety
- Energy Economy, Alternative Energy Technologies



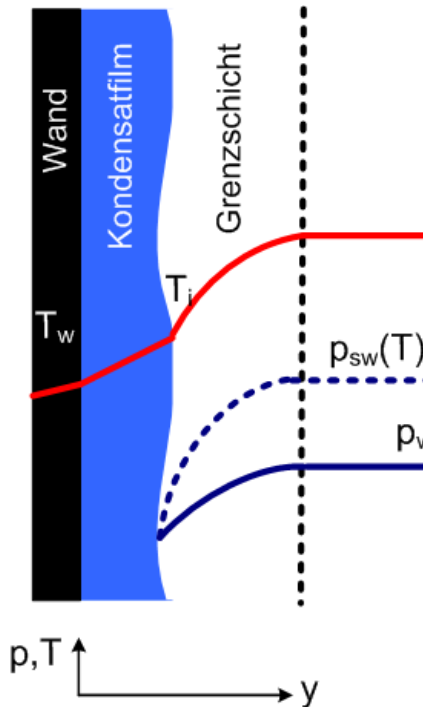
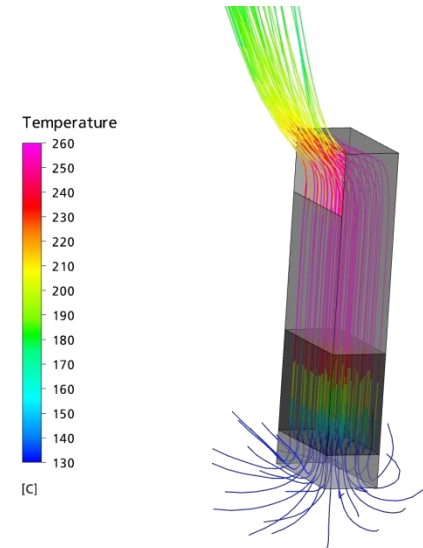
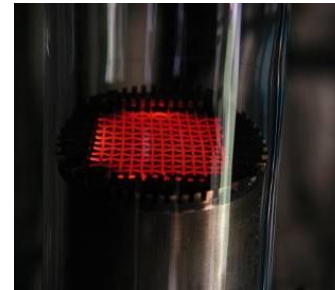
# Reactor Theory

- integrated HTR programme package
  - Movement of Pebble Bed
  - Source Term Analysis
  - Emission and Resuspension of Aerosols
  - Burn-Up
  - stationary and transient calculations
- Multi-physics-coupling
  - Thermal hydraulics and Neutronics in the Reactor core
  - CFD methods and lumped parameter codes in primary circuit and containment



# Containment Phenomena and Processes

- H2 Recombination
- Wall condensation
- Aerosol Behaviour
- Thermal hydraulics (COCOSYS, ANSYS-CFX)



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## Research Group: Energy Economic Systems Analysis

- Content of Teaching
  - Lectures
    - „Alternative Energy Technologies“
    - „Energy Economy“
  - Simulation Game „Energy Supply System“
    - Dimensioning and evaluation of an energy supply system
    - Application of methods for power plant operation planning
- Organisation: Colloquium of Regenerative Energies
- Currently 5 internal doctoral candidates  
+ 1 external doctoral candidate  
(University of Luxembourg)  
+ 2 external doctoral candidates  
(Jülich Research Centre)
- Numerous student assistants and bachelor/master theses

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# Energy Economic Systems Analysis

- Evaluation of different energy supply systems
- Mathematical optimisation methods in the field of the Operations Research:  
→ Development of computer-based models
- Statements about the interactions of individual system components within a selected system and time range

## Research Focus:

- **Stationary energy storage technologies in electricity and heating supply systems**

# Energy Economic Systems Analysis

## Energy storage technologies in electricity and heating supply systems

- Analysis and evaluation of technical, economical and regulatory system parameters of the applied technologies
  - Technical parameters:
    - Technology and performance classes
    - Efficiency
    - Flexibility parameter
  - Economical restrictions: exogenous requirements of the markets with their pricing structures
  - Consideration of interactions and dependencies of various markets
  - Impact of different operational strategies and methods to the system area
- ➔ Reproduction of acting decisions of the power plant and storage operators

# Tools and Software at the Institute

## Research Licences

- PLEXOS® Integrated Energy Model
  - Energy market modelling and simulation software
  - Mathematical programming and stochastic optimisation techniques
  - provides unsurpassed functionality across the application areas: Market Analysis, Operational Modelling, Transmission Studies, Resource Planning, Renewable Generation Integration, Distribution and Smart Grid
- MATLAB by The MathWorks, Inc.
  - Multi-paradigm numerical computing environment and fourth-generation programming language
  - allows matrix manipulations, plotting of functions and data, implementation of algorithms and creation of user interfaces
- IBM SPSS Statistics
  - Software package used for advanced statistical analysis
  - Descriptive statistics, bivariate statistics, Prediction for numerical outcomes and identifying groups

# Tools and Software at the Institute

## Self-developed Tools

- Storage optimisation model
  - Optimal storage operation schedule on wholesale and reserve markets
- Integrated market-based portfolio optimisation model
  - Optimal short term operation mode of combined portfolios including conventional and renewable power plants on relevant markets
- Control reserve market tool
  - Evaluation of optimal capacity/utilisation price combinations on control reserve markets (deterministic, stochastic)
- Photovoltaic battery storage model
  - Dimensioning and optimal operation mode of combined PV-Battery-Systems in decentralized energy supply systems
- Wind farm power dimensioning model
  - Generation of power output time series for wind farms by given wind speed input data

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# Market-based scheduling optimisation for RES

## Motivation

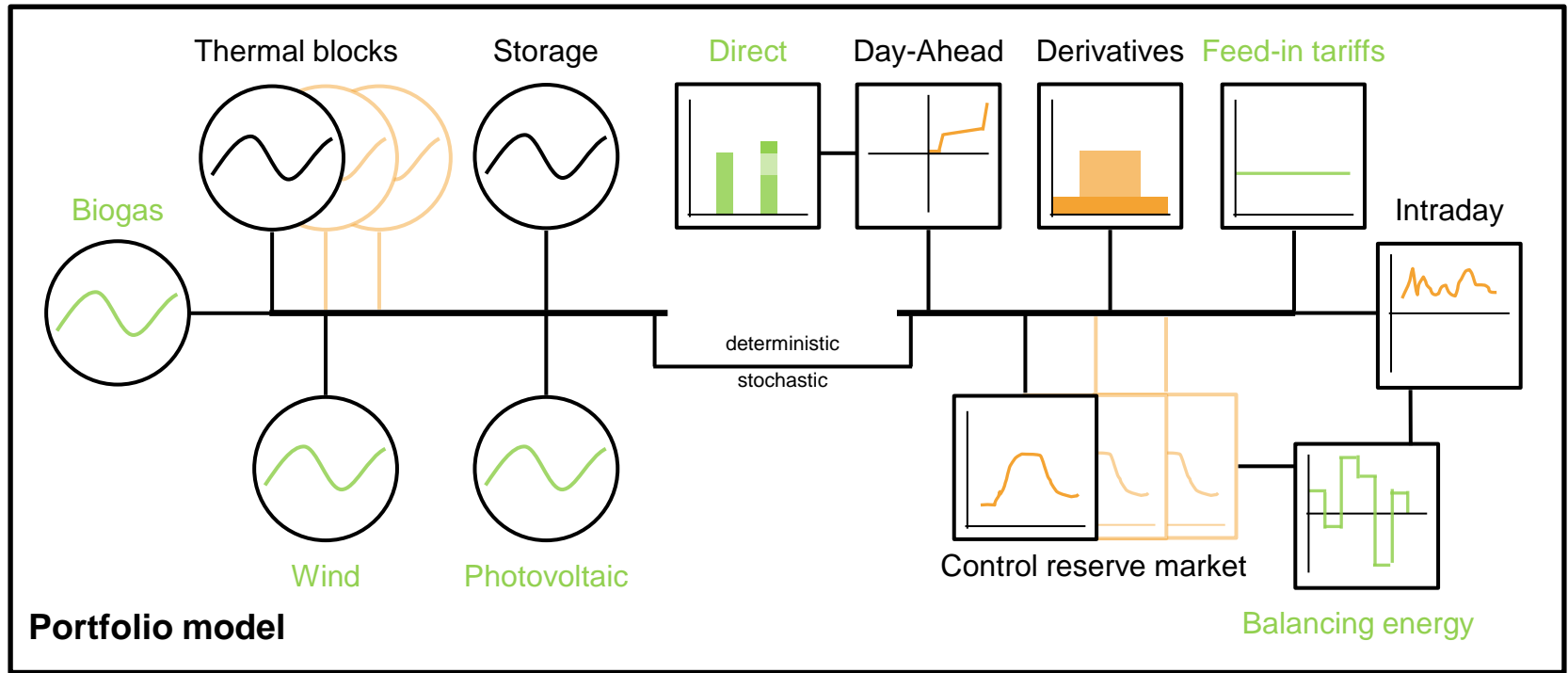
- Structural change in the electricity sector by expanding of volatile and supply-dependent power generation, especially wind and photovoltaic
- Transformation of energy supply companies: increased distributed generation
- ➔ Use of production units in the reality according to market-based (contribution margin maximizing) criteria
- ➔ Inadequate reproduction of market-specific reserve mechanisms in existing modeling approaches

## Key objectives of the works

- Determination of the optimal operation and trading decisions under market-based conditions in relevant markets
- Diversity in production and trading portfolio
- Adequate handling of planning uncertainties and new information quality
- Consideration of selected technical and economical restrictions as well as the intertemporal and regulatory constraints of all relevant markets

# Market-based scheduling optimisation for RES

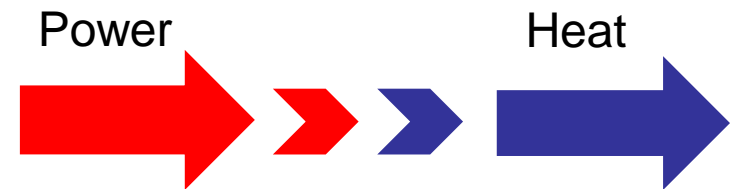
- ➔ Development of a dynamic market-based optimisation model for storage operation planning on wholesale and control reserve markets
- ➔ Further development to an integrated market-based portfolio optimisation model with combined power plants and storage facilities



# Models including the heat sector

## Motivation

- Technical and economical interactions of self-generation and marketing of power producers are not sufficiently researched
  - Consideration of personal requirements, CHP (cogeneration) and industrial processes lead to many degrees of freedom and therefore a high potential of optimisation
- Subproblems: Location decision  
Choice of technology  
Facility dimensioning  
Operational optimisation



## Key objectives of the works

- Development of models to determine the economic optimal performance and operation mode of combined power generation plants
- Investment and operation optimisation of small and medium size power and heat generation plants with own use
- Coupling of the power and heat markets against the background of a rising share of renewable energies
- Technical and economical evaluation of process heat generation by solar energy sources and high temperature reactors



# Cooperation Topic

## Integration of distributed controllable renewable generators in the Luxembourgish electricity system including innovative micro-hydrokinetic turbines

A cooperation with the *Université du Luxembourg*,  
financed by a scholarship of the Luxembourgian  
*Fonds National de la Recherche*



### Motivation

- Luxembourg imports more than 80 percent of the used electrical energy from Germany
- The urban structure with one bigger city and rural settlements as well as the electrical supply infrastructure is comparable to those of many European countries
- Only the combination of small renewable power generation sites with large-scale power plants are able to cover the national electricity demand

### Key objectives of the work

- Determination of the possible degree of independency for the Luxembourgish energy supply system achieved by a rising share of renewable energies
- Definition and evaluation of the influence of decentralised micro power generation plants on the energy system, especially with a focus on hydrokinetic water turbines
- Experimental development of a hydrokinetic water turbine

**Many thanks for your  
attention!**