Developing speed-up methods from Applied Mathematics and Computer Science for the optimization of energy systems models

BEAM-ME

Aim of the project:

BEAM-Me is a research proposal for a three year project within the German 6th Energy research program funded by the German Federal Ministry for Economic Affairs and Energy. The research project aims at improving computational performance of energy system models.

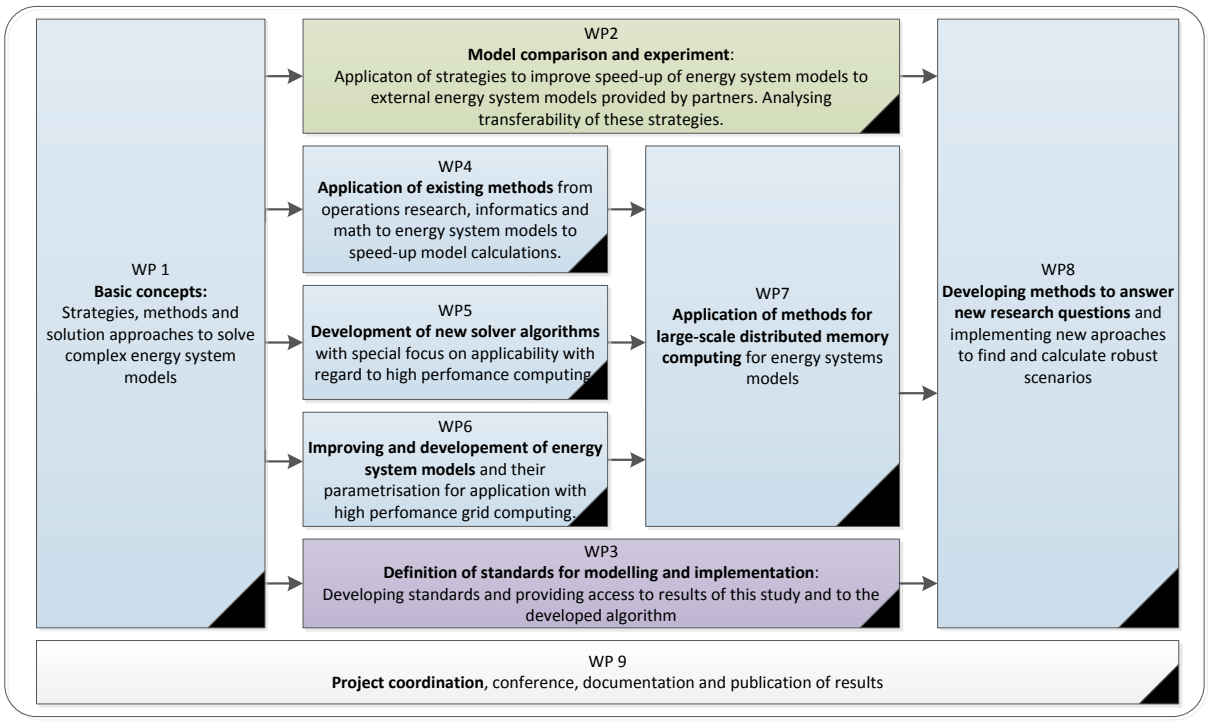
Energy system models (ESM) are widely used in research and industry to analyze today's and future energy systems and potential pathways for the European energy transition. Current studies address future policy design, analysis of technology pathways and the analysis of future energy systems. To analyze these questions and support the transformation of today's energy systems, ESM are required to become increasingly complex in order to provide valuable quantitative insights for policy makers and industry. Especially when analyzing uncertainty and integration of large shares of renewable energies, ESM requires a detailed implementation of the underlying electricity system. Due to the increasing complexity of the models, for research institutions and industries all over Europe applying ESM becomes more and more difficult, as boundaries with regard to computational power of today's decentralized workstations impose significant constraints to energy market modelling. Severe simplifications of the models regarding complexity are required to allow them to solve in a reasonable amount of time – with significant influence on the validity of results and reliability of the models in general.

Within this project the consortium of researchers from different research fields (system analysis, mathematics, operations research and informatics) develop new strategies to increase computational performance of energy system models and to apply energy system models to high performance computing. Within the project, ESM will be applied to two of Germans fastest supercomputers. The project further implements a "modelling experiment" for up to seven energy system models in order to jointly develop, implement and benchmark speed-up methods. The project aims at identifying efficient strategies and developing general standards for increasing computational performance and for applying ESM to high performance computing. The project consists of the following objectives:

- Identification, implementation and comparison of strategies for optimizing computing time for high resolution energy system models.
- Standardization of acceleration strategies (e.g. parallelization) for different types of large scale energy system models.
- Implementation of energy system models on High Performance Computing.
- Development and adaptation of mathematical algorithms for parallel solving of energy market models on High performance Cluster
- Development of new complex energy system models that cannot be solved today. These models address new research questions especially with regard to robust scenario development and decisions under uncertainty.

Structure of the project:

The project consists of nine work packages:



Consortium:

The interdisciplinary consortium is led by the German Aerospace Agency in cooperation with five German research partners:

1. **German Aerospace Agency (DLR),** Department for System Analysis and Technology Assessment at the Institute for Technical Thermodynamics (TT)
2. **Forschungszentrum Juelich (FZJ),** Juelich Supercomputing Centre (JSC)
3. **University of Stuttgart,** High Performance Computing Center Stuttgart (HLRS)
4. **Zuse Institute Berlin (ZIB),** Department for Mathematical Optimization and Scientific Information
5. **TU Berlin,** Institute for Mathematics
6. **GAMS Software GmbH**

Model experiment

Six additional ESM will be incorporated into the project in order to ensure transferability of speed-up methods and to jointly develop common standards for energy system modelling and its application to high performance computing. The members of the model experiment are funded through the project and will contribute their own ESM to the project. The project partners will help to further develop these models, apply all models to HPC and provide a thorough analysis of different speed-up methods for each model (model implementation, algorithm development, HPC) and benchmark analysis between the models. The members of the model experiment will be determined based on a public tender at the beginning of the project.

Steering group and access of international partners

The consortium seeks an additional steering group based on ten leading international experts from different disciplines. The steering group will participate in annual meetings and contribute to a conference at the end of the project. Aim of the steering group is to:

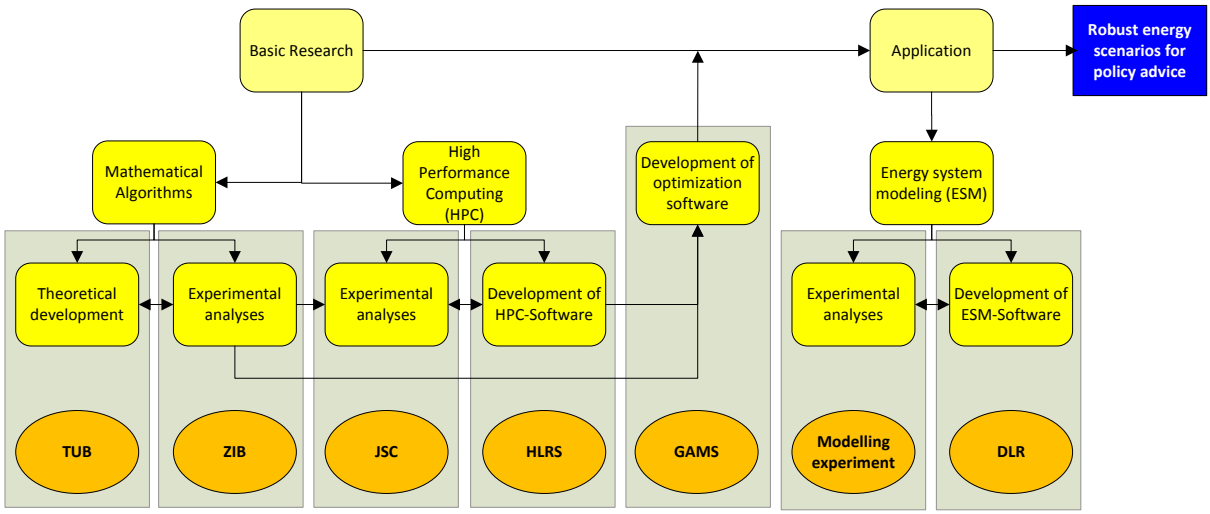
- provide guidelines to the project
- discuss and review the results of the different work packages
- ensure transparency of the overall results and transferability of the developed methods
- support the definition of standards
- develop new research questions and approaches to energy system models together with the project partners.

The steering group will have early access to all the results with regard to speed-up methods, benchmark analysis and future approaches to ESM. The steering committee will help to ensure that insight from this project will be distributed and provide benefits for the international energy modelling community on the one hand, and insights for leading experts in supercomputing, on the other hand.

The steering committee will meet once a year over a period of three years. These meetings will be accompanied by three to four annual telephone conference calls.

The consortium is further open to integrate international partner organizations/ consortia with own ESM and access to high performance computing into the project.

Flow chart of the project:



Contacts

Frieder Borggrefe frieder.borggrefe@dlr.de T: +49 (0) 711-6862-431 **Dr. rer. nat. Benjamin Fuchs** benjamin.fuchs@dlr.de T: +49 (0) 711-6862-261	***German Aerospace Center (DLR)*** Institute for Technical Thermodynamics System Analysis and Technology Assessment Wankelstraße 5 70563 Stuttgart, Germany
Dr. Ambros Gleixner gleixner@zib.de T: +49 (0) 30-84185-213	***The Zuse Institute Berlin (ZIB)*** Mathematical Optimization and Scientific Information Takustraße 7 14195 Berlin, Germany
Prof. Dr. Thorsten Koch koch@zib.de T: +49 (0) 30 314 - 78790	***Technische Universität Berlin (TUB)*** Software and Algorithms for Discrete Optimization Straße des 17. Juni 136, 10623 Berlin Germany
Dr. Bastian Koller koller@hlrs.de T: +49 (0) 711- 6856-5891	***High Performance Computing Center Stuttgart (HLRS)*** at the University of Stuttgart Numerical Methods & Libraries Nobelstr. 19, 70569 Stuttgart Germany
Dr. Daniel Rohe d.rohe@fz-juelich.de T: +49 (0) 2461-61-8846	***Forschungszentrum Jülich GmbH*** Institute for Advanced Simulation (IAS) Jülich Supercomputing Centre (JSC) Wilhelm-Johnen-Straße 52425 Juelich Germany
Dr. Michael R. Bussieck MBussieck@gams.com T: +49 (0) 221-949-9170	***GAMS Software GmbH*** P.O. Box 4059 50216 Frechen Germany