# ENERGY SYSTEM ANALYSIS MODELS FOR CLIMATE CHANGE MITIGATION AND CLEAN AIR STRATEGIES


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## Abstract

Energy models have been used for energy system analysis purposes for many years, be it as decision support tools for policy makers or as strategic planning tools for industry players. While the different models have become steadily more sophisticated, the competitive environment of the energy supply industry has experienced significant changes. Market structures and therewith competition rules have been altered by the intense re-regulation and restructuring efforts taken by the different European governments in order to put into place the plan of competitively structured, liberalised energy markets. At the same time, the present discussion on climate change and clean air strategies implies new challenges for this sector, given that a significant share of the total emission loads of greenhouse gases, especially $CO_2$, as well as other harmful gaseous emissions like $SO_2$ and $NO_X$ is related to power generation and fuel supplies.

These new framework conditions require new tools to address the arising research questions: How can existing energy supply systems best be adapted to the new market structures as well as to the existing or expected environment protection targets? What is the impact of policy measures on existing supply systems regarding costs, technology choice, prices and market shares of different players? What interdependencies between GHG emissions, other harmful emissions, electricity and heat prices have to be considered within a system design process towards a more sustainable energy supply industry?

At the IIP, several energy models have been developed to address these or similar research questions. This paper will present two examples of energy models designed to provide decision support in the fields of emission trading and combined emission reduction strategies, i.e. an integrated planning approach on reducing $CO_2$ as well as $SO_2$ and $NO_X$ at the same time. The models follow linear and mixed integer programming approaches. Their target functions consist of a minimisation of all decision-relevant expenditure within the entire system. Technical, economic and ecological restrictions are integrated into the models in a suitable way to consider relevant system characteristics of the real energy supply system. For both models, typical applications on planning issues and scientific problems are illustrated and discussed.

The paper will also address computation issues and the requirements that have to be fulfilled in order to apply the presented and/or similar tools at industrial customer sites. Beside the need of user-friendly interfaces, a general basic challenge is the transference of a detailed understanding on the methodology used in such models. Different to some other software products that may not require a deeper understanding of the internal processes and procedures, a pretty detailed understanding on the way how different input data influence on model results or on which implicit assumptions form part of the methodology applied is essential for any user in order to use these tools in an adequate way.