

## Analyzing Bio-energy and Land-use Competition in a Coupled Modeling System: The Role of Bio-energy under Climate Policy

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In the context of energy security and climate protection, biomass is ascribed high importance. At the same time, however, there is abundant discussion on the potential negative repercussions of increased bio-energy production, such as land use conflicts and subsequently increased agricultural commodity prices. Up to now, such economy-wide effects remain largely unexplored.

To shed light on this issue we adopt the approach of coupling three distinct models: the multi-country computable general equilibrium model (CGE) DART, a regionalized agricultural land use model for Germany (RAUMIS) and a location choice model. First, we extend DART by technologies that produce bio-gas, bio-diesel and bio-ethanol, using diverse energy crops. These products are perfect substitutes for conventional gas, diesel and gasoline, respectively. The CGE framework allows capturing international and national feedback effects of an increased use of bio-energy such as e.g. increased food prices.

Second, we couple DART to RAUMIS to focus on the land use effects for Germany. RAUMIS is able to produce specific supply functions for various agricultural products that explicitly take into account geographic and agro-technical constraints. Given the much more precise representation of the agricultural sector in RAUMIS, a first step in linking the models is to feed price and quantity vectors for energy crops derived from RAUMIS into DART and to recalibrate the latter model accordingly (readjusting supply elasticities). The coupling then enables DART to represent the substitution possibilities between different agricultural activities in a more differentiated way and to determine the supply of biogenic energy resources available for the conversion to bio fuels, electricity or heat in Germany. In turn, DART delivers parameters such as intermediate, domestic end-use and world market prices that enter RAUMIS exogenously.

As a last step, we link this system to the location choice model. This newly developed model evaluates optimal locations for large scale bio-energy plants in Germany that use energy maize to produce biogas by taking into account various influencing factors such as legislation on renewable energies, infrastructure and transport costs. Specifically, given the RAUMIS supply function the location choice model derives a corresponding demand function for energy maize. The resulting modeling system as displayed in Figure 1 below thus links the interdependencies on global (energy) markets to the detailed specification of land use in Germany.

To show the potential of the modeling system we run different policy scenarios for the EU in which the current EU climate targets are reached either without fostering bio-energy or with a variety of policy measures that lead to an increased use of bio-energy. We then analyze the national and international economic feedback effects of bio-energy use and the resulting consequences for the potential role of bio-energy in a sustainable future energy mix as well as the impact of a policy fostering bio-energy on land use, sectoral production, factor input, and income. By comparing a model run with DART only and a model run of the integrated modeling system we can show the relevance of accounting explicitly for land-use competition.

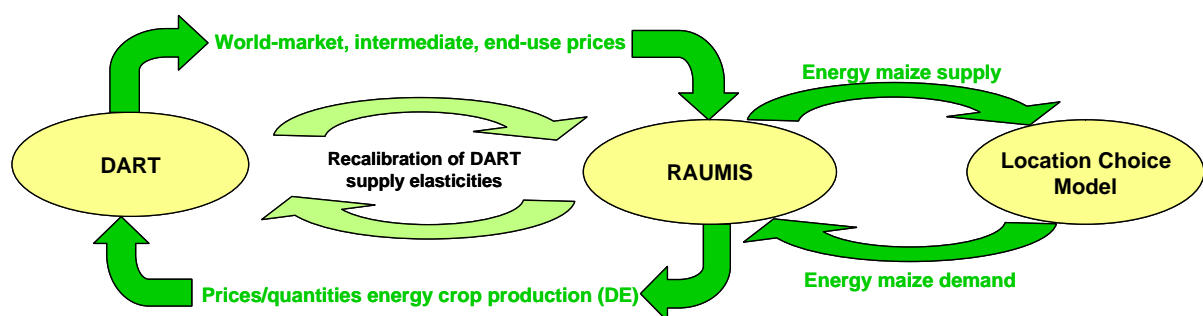


Figure 1. The NaRoLa Integrated Modeling System