

# Biomass in the Energy System: Resource Requirements and Competition for Land

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## Abstract

Biomass has a major role in the global primary energy supply in almost all forward-looking global energy scenarios. Substitution of biomass for fossil fuels is a key strategy in reducing the carbon dioxide (CO<sub>2</sub>) emissions, which represents the largest anthropogenic contribution to the greenhouse effect. Modernized bioenergy systems are suggested to be important contributors to future sustainable energy systems and to sustainable development. In this thesis we analyze the prospects for a global large-scale production of biomass for energy.

Assessments have arrived at widely different conclusions about the potential contribution of biomass in the future global energy supply. The major reason is that the two most crucial parameters, land availability and yield levels in energy crop production, are very uncertain. The question how an expanding bioenergy sector would interact with other land uses, such as food production, biodiversity, soil and nature conservation, and carbon sequestration has been insufficiently analyzed in these assessments. It is therefore difficult to establish to what extent bioenergy is an attractive option for climate change mitigation in the energy sector.

We conclude from analyses of labor and water requirements in energy crops production that labor availability in society *per se* is not a constraint for a large-scale bioenergy future. Global water resources are large compared to those required to operate a large-scale bioenergy system but very unevenly distributed around the world. Restricted water availability will be an important limitation for bioenergy production in regions with scarce water resources. One major conclusion for future research is that assessments of bioenergy potentials need to consider restrictions from competing demand for water resources. Such analyses should be employed on a basin scale level.

Stringent CO<sub>2</sub>-control policies will increase the competitiveness of biomass over fossil fuels, which, in combination with a growing demand for food (and fibers), will increase the pressure on global bioproductive lands. We analyze the interplay between carbon taxes and food prices, and show that wheat prices can more than double under a high carbon tax. We analyze the consequences of this.

The energy balance of bioenergy systems has been analyzed extensively. Besides clarifying whether specific bioenergy systems are sinks or sources of energy, assessments of energy use in bioenergy feedstock production and processing are employed in order to evaluate the environmental performance of bioenergy systems. We analyze energy input for irrigation and show that the energy input for irrigation of bioenergy crops can be significant compared to the bioenergy yield response to water. The range of possible values for critical parameters is too wide to allow general conclusions regarding the net energy effect of irrigating energy crops.

**Keywords:** Biomass, bioenergy, biofuel, labor, water, land, scarcity, energy balance, net energy, food, competition, climate change, scenario