Bioenergy is often considered an important component, alongside other renewables, to mitigate global warming and to reduce fossil fuel dependency. Determining sustainable strategies for utilizing biomass resources, however, requires a holistic perspective to reflect a wider range of potential environmental consequences. To circumvent the limitations of scenario-based life cycle assessment (LCA), we develop a multiobjective optimization model to systematically identify the environmentally optimal use of biomass for energy under given system constraints. Besides satisfying annual final energy demand, the model constraints comprise availability of biomass and arable land, technology- and system-specific capacities, and relevant policy targets. Efficiencies and environmental performances of bioenergy conversions are derived using biochemical process models combined with LCA data. The application of the optimization model is exemplified by a case aimed at determining the environmentally optimal use of biomass in the Danish energy system in 2025. A multiobjective formulation based on fuzzy intervals for six environmental impact categories resulted in impact reductions of 13-43% compared to the baseline. The robustness of the optimal solution was analyzed with respect to parameter uncertainty and choice of environmental objectives.