Promoting rural electrification in Sub-Saharan Africa: Least-cost modeling of decentralized energy-water-food systems

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Abstract

Two major obstacles for economic development in Sub-Saharan Africa (SSA) are limited purchase power and insufficient access to affordable and reliable electricity, especially in rural areas. The outstanding solar potential in SSA enables significantly cheaper levelized costs of electricity for decentral solar systems compared to the commonly used diesel generators. Yet, the limited purchase power in SSA impedes rural electrification by solar systems due to their high investment costs.

Decentralized Energy-Water-Food systems have the potential to solve this problem. Using solar-powered water pumps, rural communities can supply water for drinking and irrigation. Thereby, agriculture does not depend on rainfall solely and can be done all over the year, which leads to increasing productivity. The increased crop production reduces the community´s expenses for nutrition and enables profit by sales, which in turn enables a payback of the initial investment costs of the solar system. The increased amount of biomass waste enables economically feasible small-scale biogas production. The biogas can be used for cooking and for electricity production by biogas motors. These motors can supply private, social or small commercial loads, which enhance the local productivity even more.

To identify the least-cost system design, the linear optimization model *urbs* was adapted. *urbs* was developed for energy system modeling, yet its sector coupling feature allows to add processes like water pumps and commodities such as biogas. The available amount of ground water is implemented based on GIS data and the possible types of crops are restricted based on soil data and agricultural habits in the respective region.

The modelling results shall support local governments and entrepreneurs in their decision making. A Zimbabwean community recently started to implement an energy-water-food system according

to the results of the model, which has already improved the living quality of the local population significantly.

Keywords: Decentralized renewable energy solutions; Energy-water-food systems; Biogas; Least-cost modeling; Economic development

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