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Innovating Energy Access for Remote Areas: Discovering Untapped Resources

System Analysis of Electricity Infrastructure Evolution of Developing Countries Using Hybrid Simulation Tool

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In this research, the hybrid simulation model is developed using a combination of an Agent Based Modeling (ABM) approach and System Dynamics (SD). This hybrid modeling method depicts the concept of the electricity infrastructure evolution that final electricity infrastructure is considered as an aggregated behavior of all agents.

Introduction

To meet the growing demand, billions of people around the globe should be connected through effective electricity infrastructure options either centralised or decentralised considering the resource availability (Sanoh, Kocaman, Kocal, Sherpa, & Modi, 2014). However, decisions for electricity infrastructure are often being made based solely on political motivations and often disregard a comprehensive comparison between centralized and decentralized electricity infrastructure options for a region. Most of the decisions commonly rely on econometric methods, but often require many unrealistic assumptions and neglect non-linear interactions. This misunderstanding on energy use and other aspects of a society results the underestimation or overestimation of the future demand growth resulting enormous economic losses and receding new investments (Levin & Thomas, 2012). It is stated from majority of case studies that the appropriate sizing of system to meet growing demand is a key leverage for a successful implementation of electricity infrastructure.

Research objectives

As energy access is seen as a critical primer for human development, the reciprocal dynamics between the impacts of electricity infrastructure and demand growth should not be disregarded in order to 1) make more accurate and realistic demand projections; as well as 2) to understand the impacts of the energy system on a society.

Methodology

In my model, I address the electricity infrastructure as a part of society having socio-economic dynamics. Each agent represents a village and chooses the optimal type of electricity infrastructure based on the independent decision rules. Once the type of infrastructure is determined, the system dynamics of the local environment drives the embedded agent behaviors in order to forecast the future demand and update the system capacity accordingly. The combination of different methodologies can effectively describe the final electricity infrastructure that "emerges" from the integration of individual behaviors of all agents.

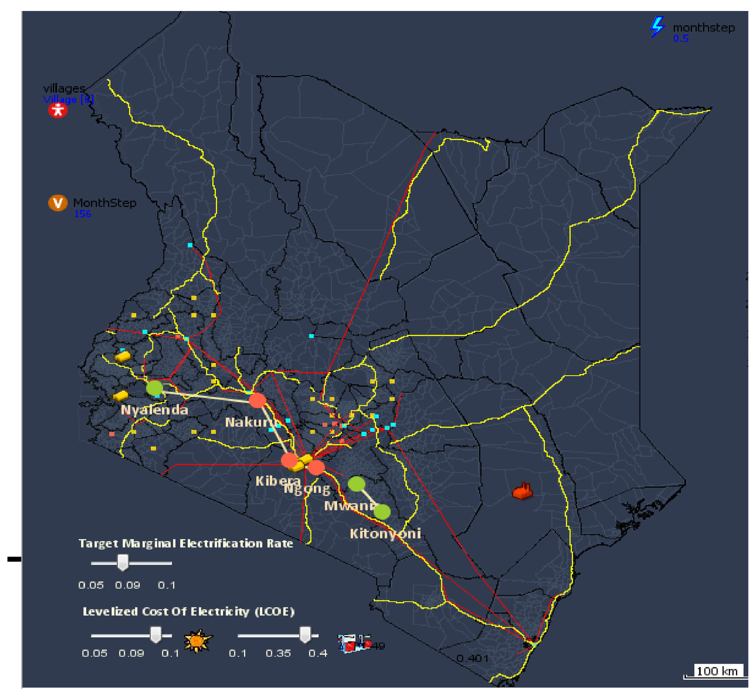


Figure1. The screen shots of simulation

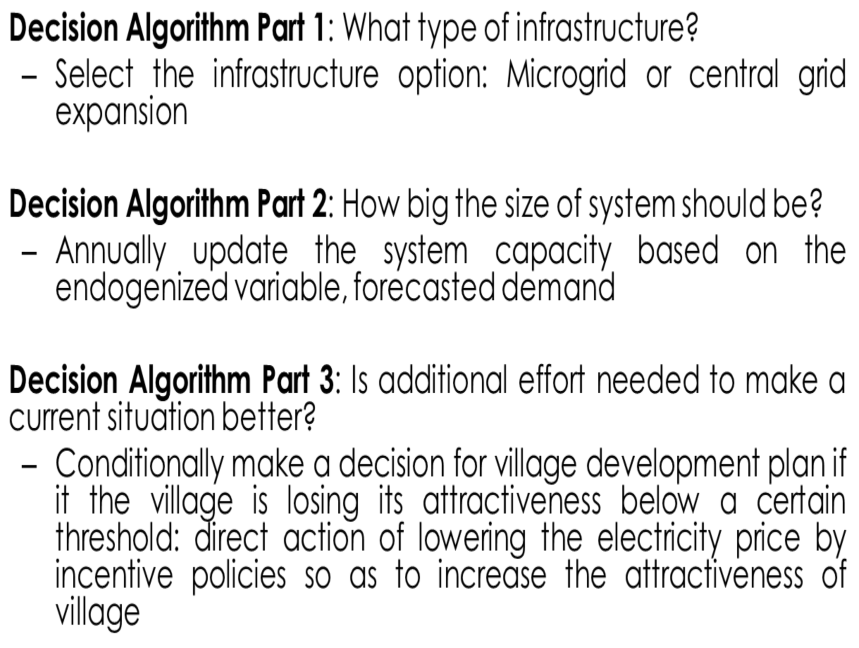
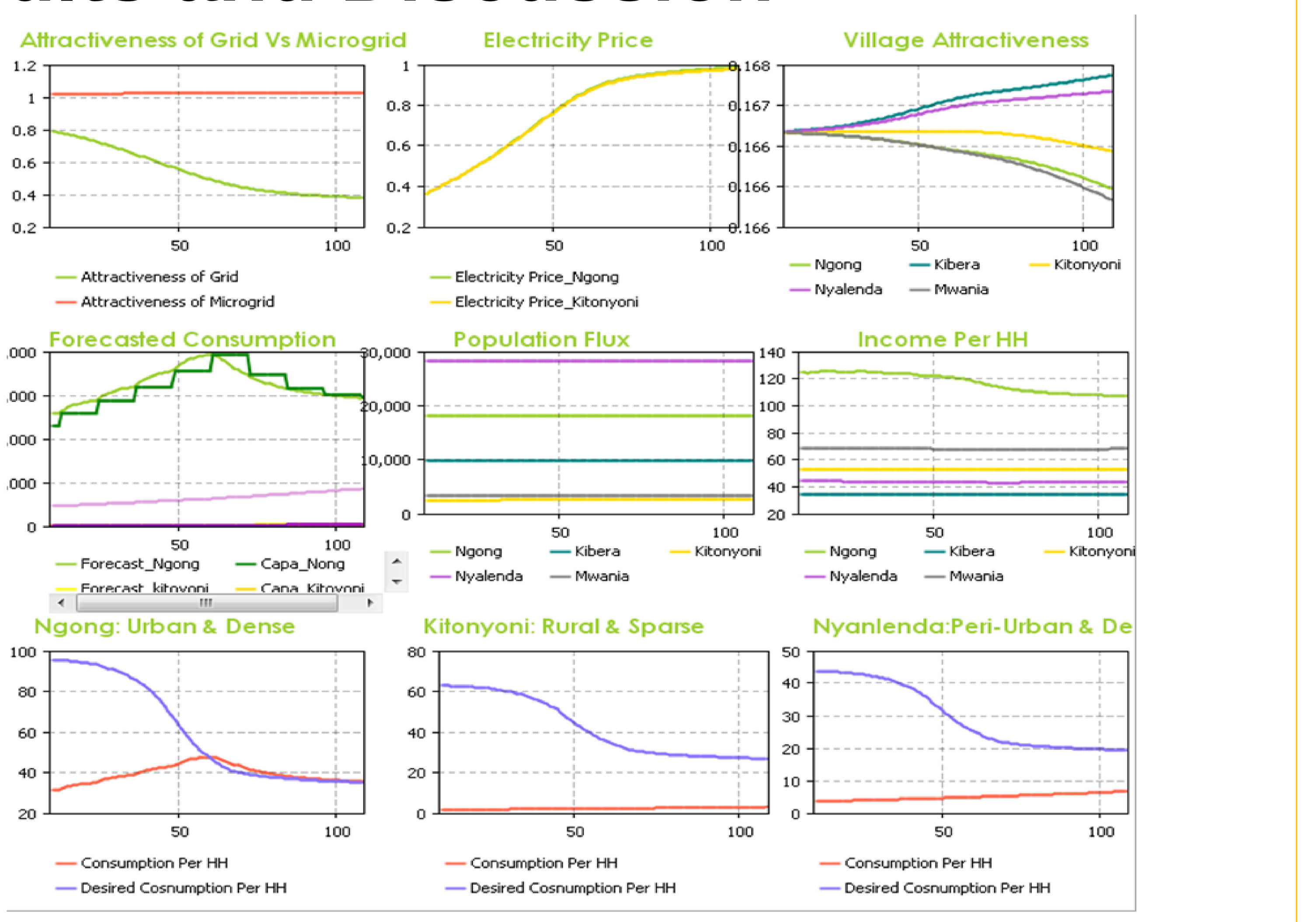


Figure2. The decision algorithms of agents

Results and Discussion



As a part of Decision Algorithm Part 1, the five villages of non-electrified in Kenya were identified for a suitable electricity infrastructure type. The result of calculation is shown in the simulation screen in Figure 1. Ngong, Kibera and Nyalenda are selected as centralized grid extension and Kitonyoni and Mwania are better suited for Microgrid option. The threshold determined as a breakeven is 700kWh/year. In reality, Nyalenda has strong wind resources and VESTAS with a support from the government of Kenya installed a 850kW wind power plant. This can also be seen from the calculation that if the cost difference component reduces due to the support from government policies or technological advancement, then the Microgrid potential can become dominant in a resource rich region. The above figure shows the endogenous dynamic variables of villages which is the results of Decision Algorithm Part 2 and 3. The function of attractiveness on each option is set exogenously by referring to the research conducted by Steel [2].

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