

# Long-term electricity demand for rural contexts: modelling endogenous determinants via a system-dynamics approach

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## Abstract

More than half a billion people will still lack reliable and affordable electricity in 2040. Long-term energy planning based on reliable electricity demand models could help to achieve the energy access targets in developing countries, especially in remote rural areas. Indeed, wrong predictions of electricity demand could negatively impact the local socio-economic development and cause an inappropriate sizing of local energy solutions, leading to supply shortages or cost recovery failure.

In this context, system dynamics (SD) can be a valuable methodological approach to capture the long-term dynamics behind the evolution of energy demand in developing contexts, since the latter are affected by high uncertainty, strong non-linear phenomena, complex diffusion mechanisms, time-adjustments of technology perceptions.

A SD-based model to investigate the local socio-economic complexities of the electricity-development nexus and to generate long-term projections of electricity demand for rural contexts is here presented. The model is explained by analysing its building process. In the *conceptualisation*, the main feedback loops of the system are captured from the literature, in order to understand the causal and time-dependent relations between electricity demand and the multiple dimensions of socio-economic development. The structure of the model is then *formulated* iteratively by consulting the literature and the experts of CEFA, an Italian NGO which has been dealing with rural electrification in Tanzania since the 80s. The estimation of the parameters is carried out through local interviews and a computer-based calibration procedure with historical data of electricity demand gathered from a local hydroelectric plant managed by CEFA. The result of this process is a model of 100 levels, 333 auxiliary variables and 153 constants, which provides long-term projections of electricity demand for a typical rural community as the main output. The *testing* and *validation* phase has been conducted by performing *direct structure* tests, *structure-oriented behaviour* tests, and *behaviour pattern* tests through the Theil analysis. The results show that the model is able to replicate historical data with the same trend and very low bias in the mean.

Future works will be devoted to carry out an appropriate sensitivity analysis and test of the model's response to different policies, as well as an application to a future CEFA's hydroelectric project.