Stochastic Techno-Economic Microgrid Model – A Microgrid Investment Risk Assessment Tool: Model Development and Case Study

Bobson Rugambwa, Lefu Maqelepo
Carnegie Mellon University Africa, Kigali, Rwanda

October 4, 2018

Overview

- Understanding the Problem
- Project Objective
- Solution overview
- Use cases & Results
- Further work
- Influences & Sources

Understanding the problem

Background

Electrification rates have experienced significant growth within the past two decades, and so has the population growth. About a billion people still left out, more than 85% of which are in developing countries

Constraint

Microgrids often hailed as potential solution to electrification in remote areas but there's low adoption of Microgrids due to investor perception that micro-grids in developing countries are risky business ventures

Problem

There are limited data to support the notion that microgrids are risky and at the same time there are limited data to support that they are not

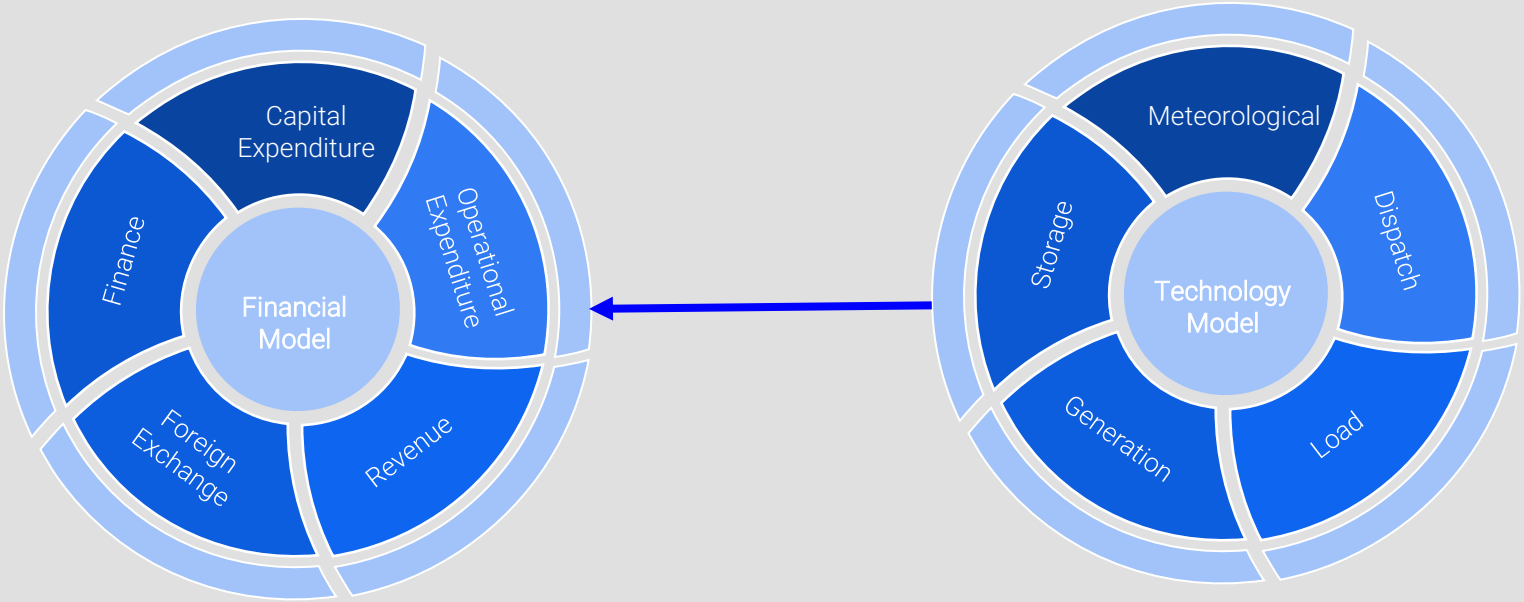
Project Objective

Build a software tool that permits modelling of microgrid utilities from an investor’s perspective, simulating the financial returns of a microgrid under uncertainty.

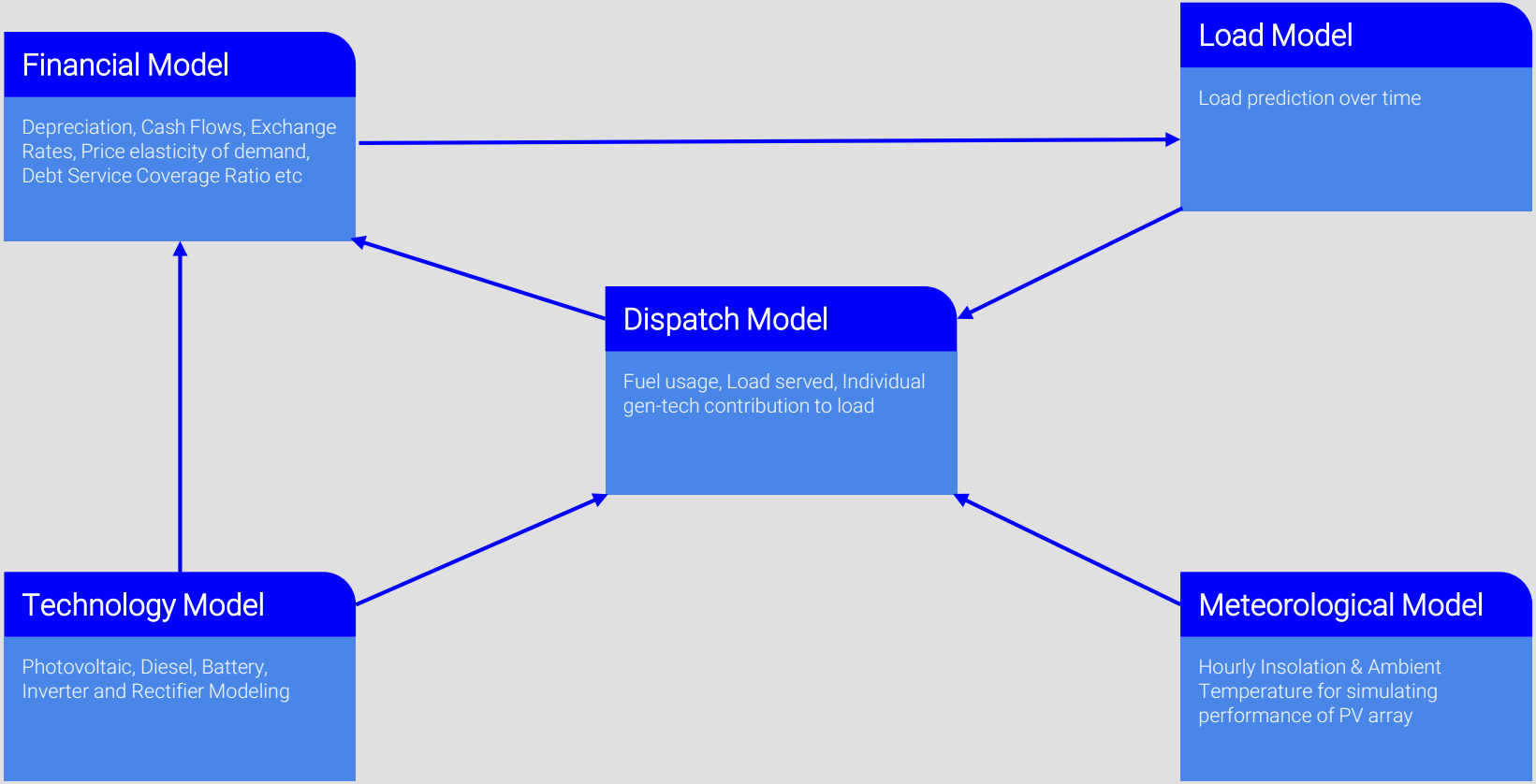
The STEMM Techno-Financial Model

- Model microgrid technical and financial performance
- Account explicitly for uncertain inputs
- End goal: enable scale up of microgrid deployment by facilitating easier techno-financial modeling for microgrid investors

The STEMM Techno-Financial Model

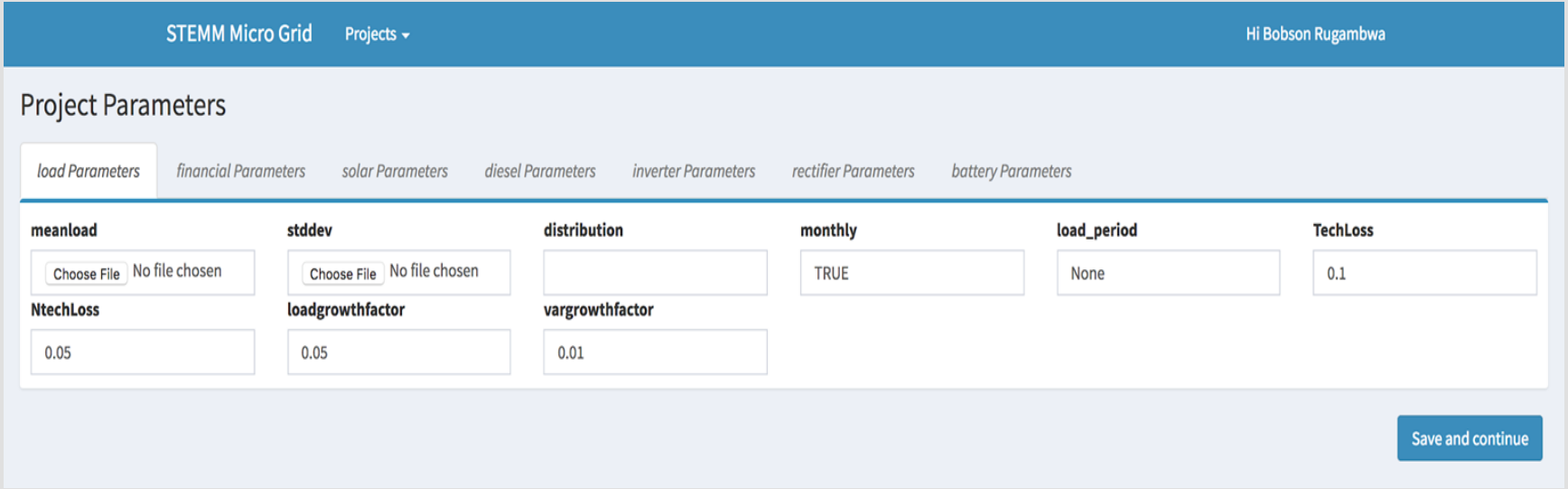


Interaction of the Component Models



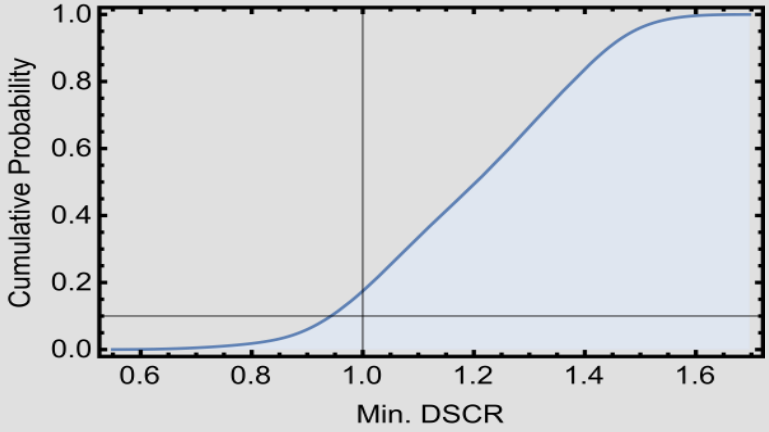
The Software Tool

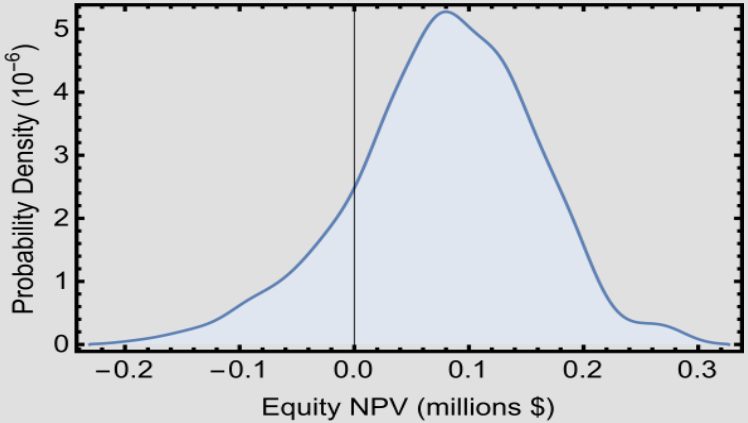
- Graphical User Interface collects all project parameters
- Linked to the NASA Meteorological API for Irradiance and Temperature data.
- Links with techno-financial model to produce and graph results



Model Outputs

- Indicators used
  - For bankability
    - Debt Service Coverage Ratio (DSCR)
  - For Equity
    - Net Present Value (NPV)





Possible Applications/Uses

- Technology based cost function optimization for project developers

- Financial viability analysis for financial institutions, lenders and Investors.

Future Work

Deliverable 1	Add more microgrid renewable energy technologies (Wind, Hydro Biogas, etc)
Deliverable 2	Understand how business models, technologies and policies improve financial performance and mitigate risk
Deliverable 3	Measure the probability of project success/failure to a higher confidence level for investors.
Deliverable 4	Create a downloadable PDF document report summarizing the results of model

Some of the papers that informed our project

- RICHARD PEREZ, PIERRE INEICHEN, ROBERT SEALS, JOSEPH MICHALSKY, RONALD STEWART, "MODELING DAYLIGHT AVAILABILITY AND IRRADIANCE COMPONENTS FROM DIRECT AND GLOBAL IRRADIANCE," *Solar Energy,* vol. 44, no. 5, pp. 271-289, 1990.
- Hossein Khorasanizadeh, Kasra Mohammadi, Navid Goudarzi, "Prediction of horizontal diffuse solar radiation using clearness index based empirical models; A case study," *International journal of hydrogen energy,* vol. 41, pp. 21888 - 21898, 2016.
- Nathaniel J.Williams, Paulina Jaramillo, Jay Taneja, "An investment risk assessment of microgrid utilities for rural electrification using the stochastic techno-economic microgrid model: A case study in Rwanda," *Energy for Sustainable Development,* vol. 42, pp. 87-96, 2018.
- R. J. AGUIAR, M. COLLARES-PEREIRA, J. P. CONDE LNETI, "SIMPLE PROCEDURE FOR GENERATING SEQUENCES OF DAILY RADIATION VALUES USING A LIBRARY OF MARKOV TRANSITION MATRICES," *Solar Energy,* vol. 40, no. 3, pp. 269-279, 1988.
- R. AGUIAR, M. COLLARES-PEREIRA LNETI, "TAG: A TIME-DEPENDENT, AUTOREGRESSIVE, GAUSSIAN MODEL FOR GENERATING SYNTHETIC HOURLY RADIATION," *Solar Energy,* vol. 49, no. 3, pp. 167-174, 1992.
- JAMES F. MANWELL, JON G. McGOWAN, "LEAD ACID BATTERY STORAGE MODEL FOR HYBRID ENERGY SYSTEMS," *Solar Energy,* vol. 50, no. 5, pp. 399-405, 1993.