AIM SEA
Associazione Italiana delle Macchine a fluido e dei Sistemi per l'Energia e l'Ambiente

Mini Grid Day Sapienza University Rome
21st of June 2018

Sapienza University of Rome – DIMA

FS4MGO International Research Group

Resp.: Andrea Micangeli

A. Corsini, F. Rispoli, V. Naso, R. Del Citto, C. Tacconelli

SPEAKERS:

Andrea Micangeli, Riccardo Del Citto, Carlo Tacconelli

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DIMA Group: who’s who

Professors and researchers (5)
Franco Rispoli
Alessandro Corsini
Domenico Borello
Luca Cedola
Andrea Micangeli

Research Assistant & PostDoc (9)
Giovanni Delibra
Paolo Venturini
Katiuscia Cipri, Eileen Tortora, Andrea Marchegiani, Alessandro Tallini, Alessio Castorrini, David Volponi, Silvia Sangiorgio

Ph.D. Candidates (3)
Tommaso Bonanni, Fabrizio Bonacina, Riccardo Del Citto

Ph.D. students (7)
Francesca Lucchetta, Giuliano Agati, Lorenzo Tieghi, Gino Angelini,
Arash Aghaalikhani, Carlo Tacconelli, Gabriele Gagliardi.

Rationale: the Research on Multi Source Grid optimization for Sustainable Development requires an in-depth data campaign on the operational micro-grids that started in East Africa (Rwanda, Congo, Uganda, Kenya), and Latin America with data collection, remote monitoring, satellite analysis of sites, surveys, desktop analysis, comparisons between suppliers, ex ante impact measurement and ex post.

Field Study Abroad (FSA): We realized with more then 300 students in 10 editions a training course on renewable energy on field, in East Africa and North/Central America, visiting Enel's activities, such as the 50 MW Hydro of Chucas in Costa Rica, and the Nairobi Conference with the Micro Grid Academy of RES4Africa.

Hybrid systems for rural area management, still require a comparative analysis between different strategies (such as battery master, diesel master, load following, flywheel stabilizer) that’s why new technologies and new data anlisys are performed on field by renewable energy and multisources minigrids (Sun, Wind, Biomass, Tides, batteries and Gen Set)

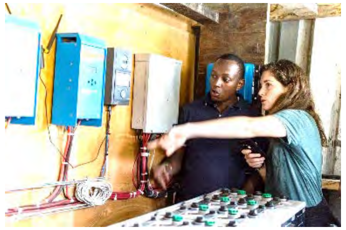
Name Microgrid	Project Description	Plant Size
Remote Village, Kenya	Feasibility study and design of Hydroelectric Minigrid	300 kW Hydroelectric
Marsabit Wind Farm, Kenya	Analysis of flywheel application	
Remote village in Gatsibo District, Rwanda	Feasibility study and design of Minigrid	50 kWp Photovoltaic, 34 kW Genset 100 kWh BESS (Lithium)
Remote village in Nyagatare District, Rwanda	Feasibility study of 2 Minigrids	Each Minigrid: 25 kWp Photovoltaic , 17.6 kW Genset 30 kWh BESS (Lithium)

<u>The Research Group, focused on Mini Grids,</u> is carrying out a work of data analysis both in Africa and Central America with MIT, Columbia and State Uni of NY, on more then 20 case studies. The real development, of innovative plants, is an «accelerator» of rural electrification and local development sustained by the research on:

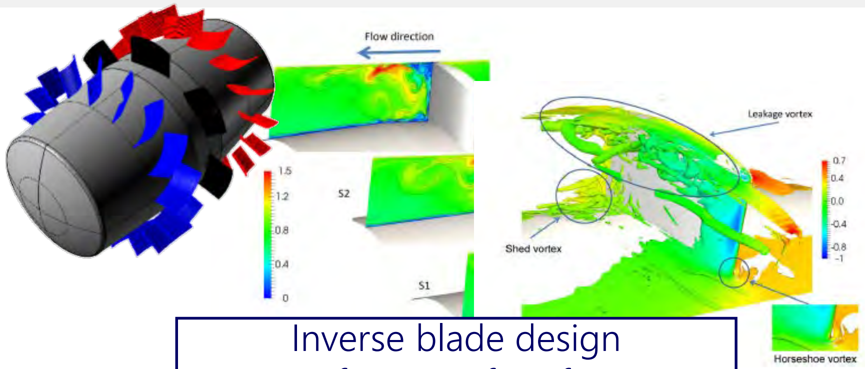
Energy generation and use analysis with specific sizing and multi source optimization, as well as stochastic sizing of isolated rural mini-grids, with fuel and operational strategies costs evaluation,

Sustainability and bankability of real projects, are strictly related to energy optimization, and technology innovation to preserve the battery life and the whole energy system long period efficiency.

Microgrid	Project Description	Plant Size
Quiha' Hospital, Ethiopia **Volisso Hospital, Etiopia** **Other hospitals in Kenya and Uganda**	Feasibility study, support on both the project design and the supervision of project execution in Partnership with: Enel Green Power, BIP Sapienza Chirurgia Solidale and other donors	50 kWp Photovoltaic 150 kWh BESS (Lithium) 70 kVA Diesel Generator
Kalangala Island, Uganda	Feasibility study, Design, Commissioning and Training to local technicians	228 kWp Photovoltaic 70 kW Genset, 520 kWh BESS (Vanadium)
Bugala Island, Uganda	Operation Analysis and Optimization of existing minigrid	1 MW Diesel Generators 0.6 MWp Photovoltaic 658 kWh BESS (Lead-Acid)
Talek, Kenya	Operation Analysis and Optimization of existing minigrid	40 kWp Photovoltaic 3210 Ah BESS (lead-acid) 10 kW Genset
Habaswein, Kenya	Operation Analysis and Optimization of existing minigrid	410 kW genset, 30 kW Photovoltaic 60 kW Wind Farm



POSEIDONE PROJECT



Inverse blade design
CFD verification of performance

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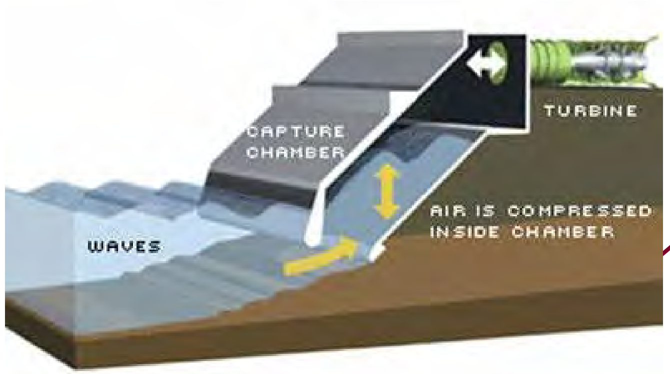
Mecha design, proto assembly and experimental validation in lab

FAGGIOLATI PUMPS S.p.A. ISO 9001 - ISO 14001 ISO 80079 (ATEX)
Macerata - Italy
Divisione Energia

MINISTERO DELL'AMBIENTE
E DELLA TUTELA DEL TERRITORIO E DEL MARE



OWC caisson design

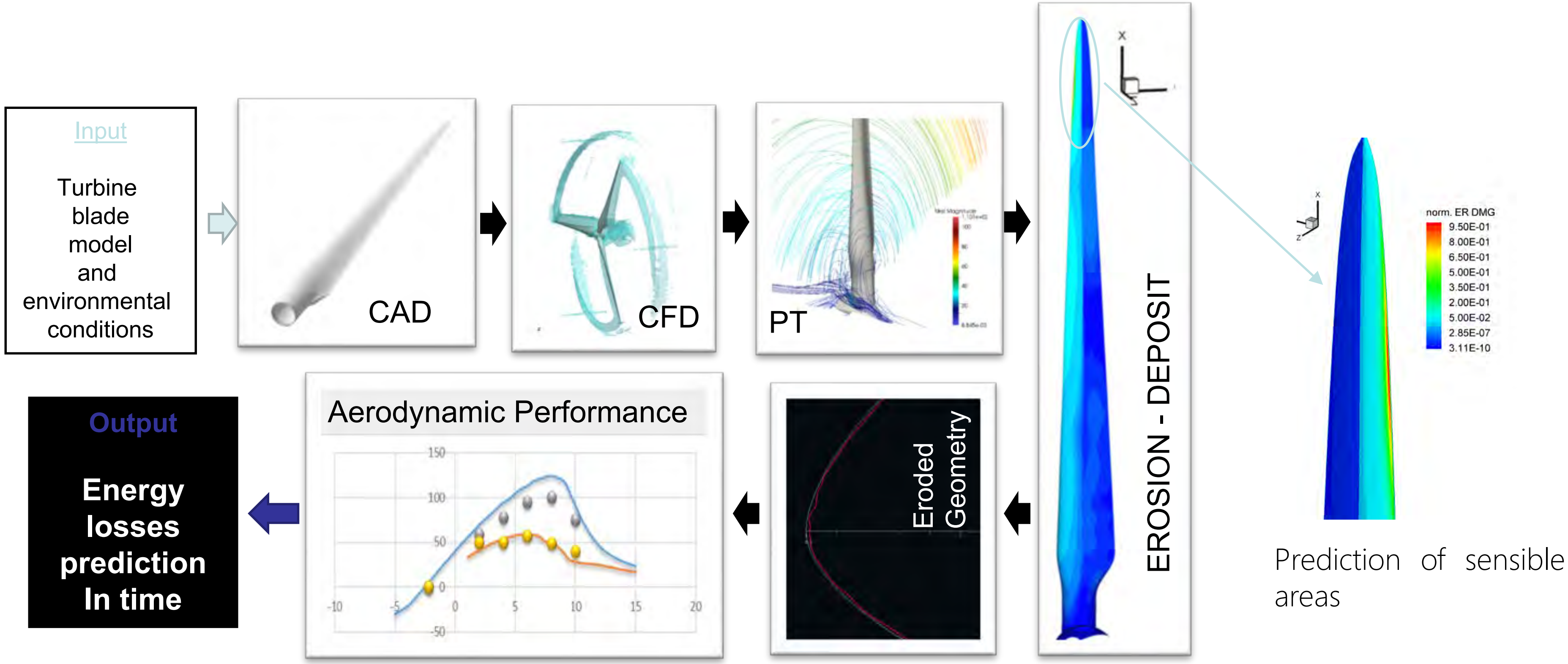
wavenergy.it

On-shore installation and test

Università degli Studi Mediterranea di Reggio Calabria

DICEAM

MaSAI (Multiphase Solver and Adaptive-mesh Interface):
In-house code for simulation of blade aging due to erosion/deposit in particle laden flows.

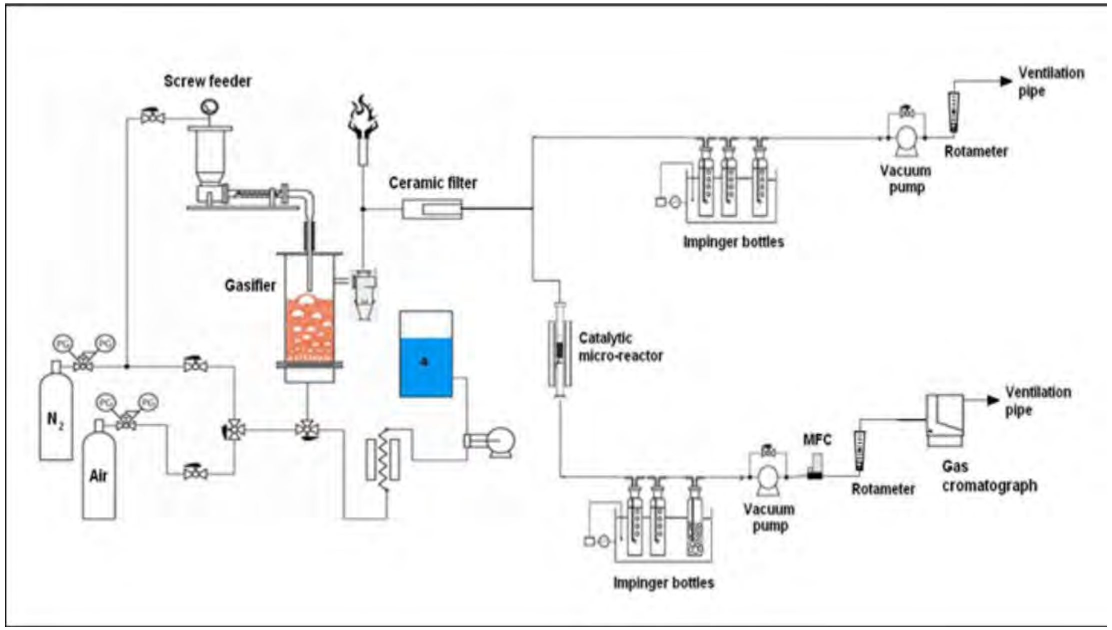


Prediction of sensible areas

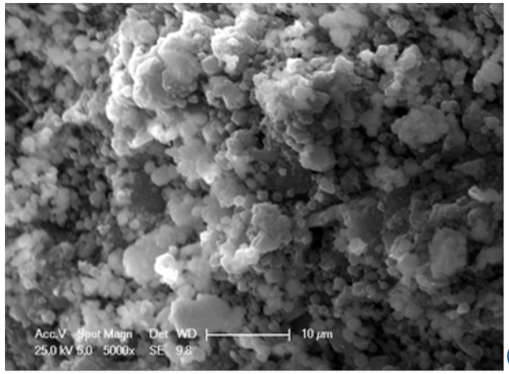
Catalyzers for tar reforming

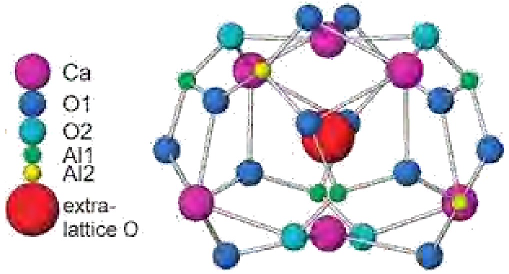
Plant-assisted Fitoremediation

✓ Experimental test-rig, cooperation with RESET s.r.l., CNR and ISPRA



Ni-Mayenite catalyzer





Mayenite structure

Our background – field experience

Capacity Building

Surveys for baseline assessments and impact evaluation, data collection

Feasibility studies, design and optimization of microgrids

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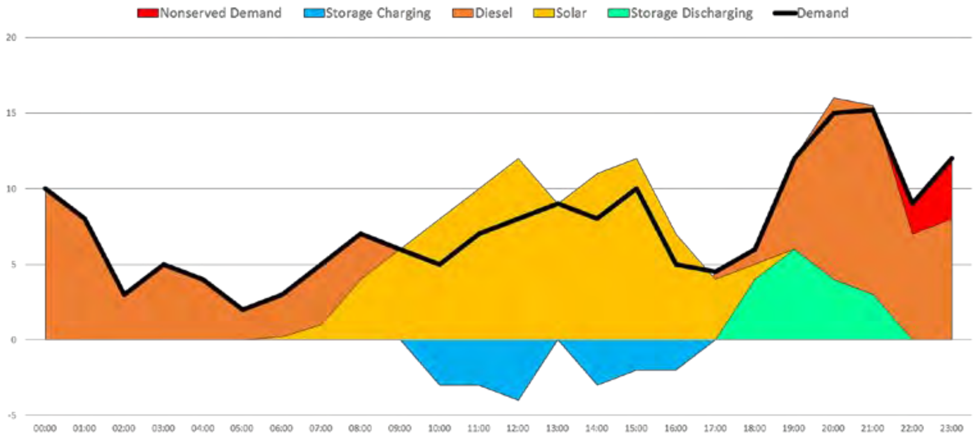
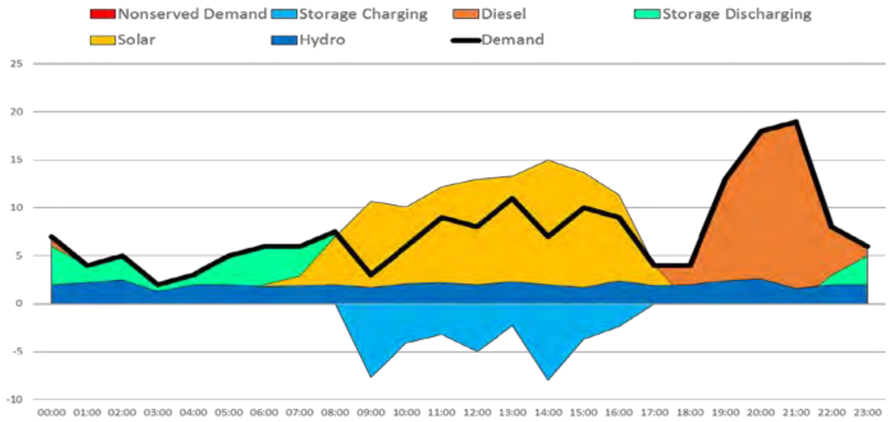
Evaluation of available sources

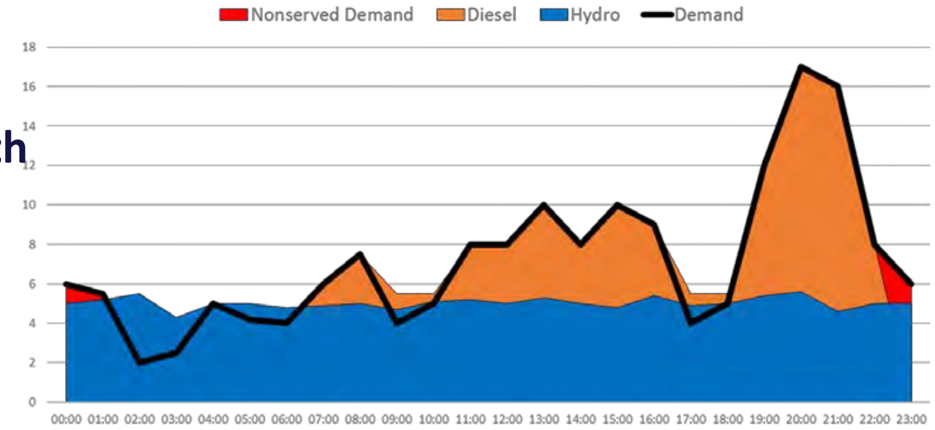


Hybrid microgrid with diesel genset, PV and storage

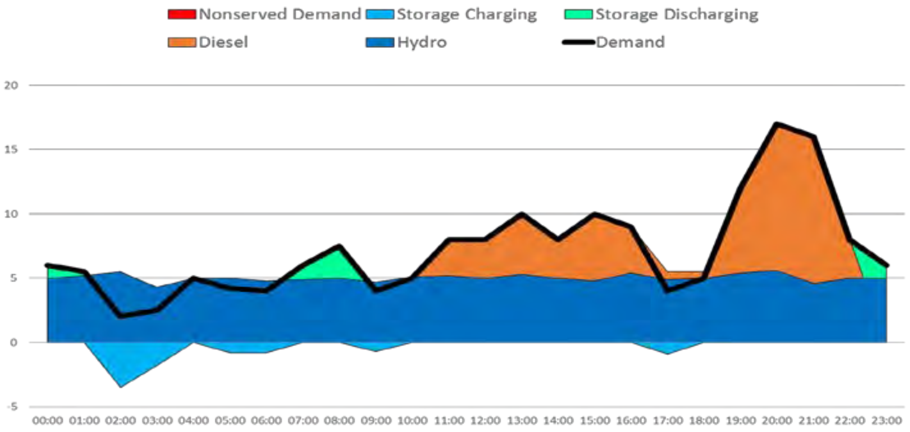


Hybrid microgrid with diesel genset, PV, hydro and storage (dry season)

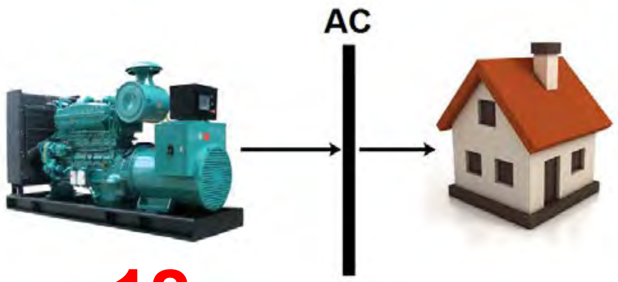
Hybrid microgrid with diesel genset and hydro (without storage)



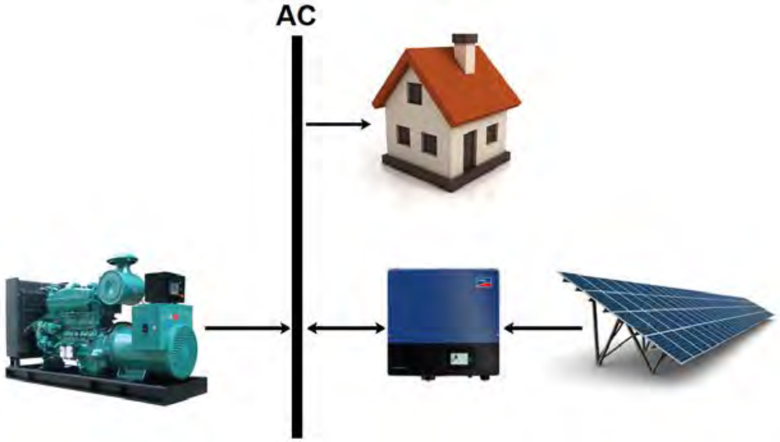
Hybrid microgrid with diesel genset and hydro (with storage)



Case study: Kenya KPLC mini-grids

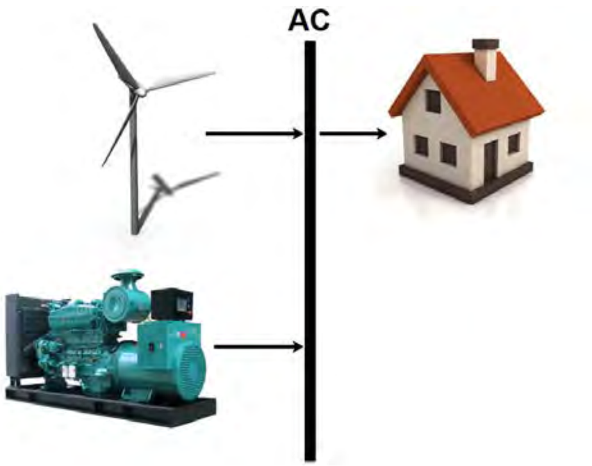


12 Diesel-based

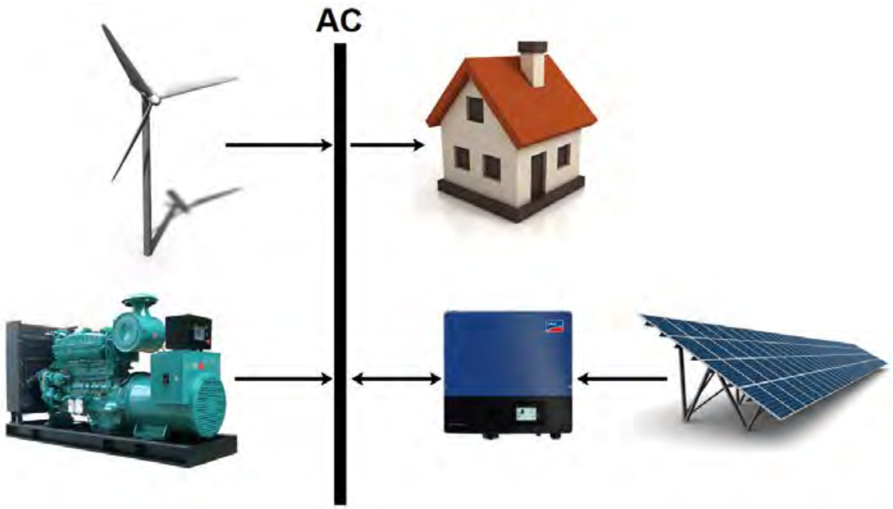


7 Genset + PV

Huge potential for hybridization

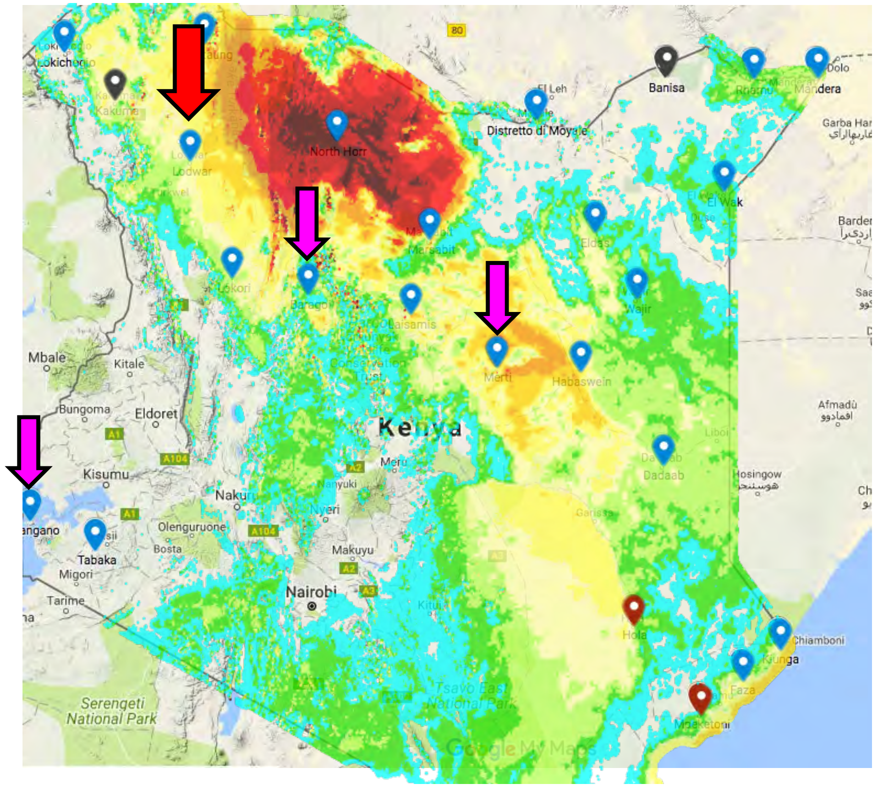


1 Genset + Wind Turbines



1 Genset + PV + Wind Turbines

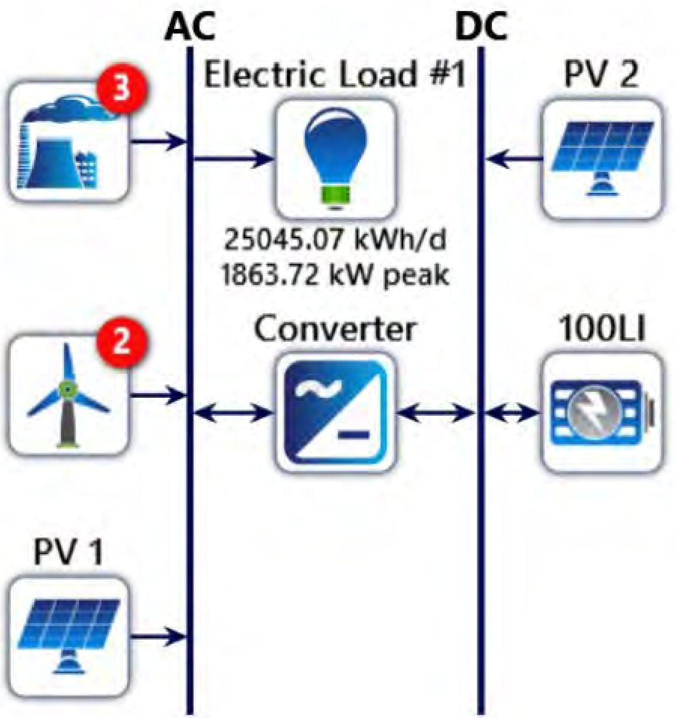
Evaluation of available resources – wind potential in Kenya



- In operation
- Commissioning
- Connected to the national grid

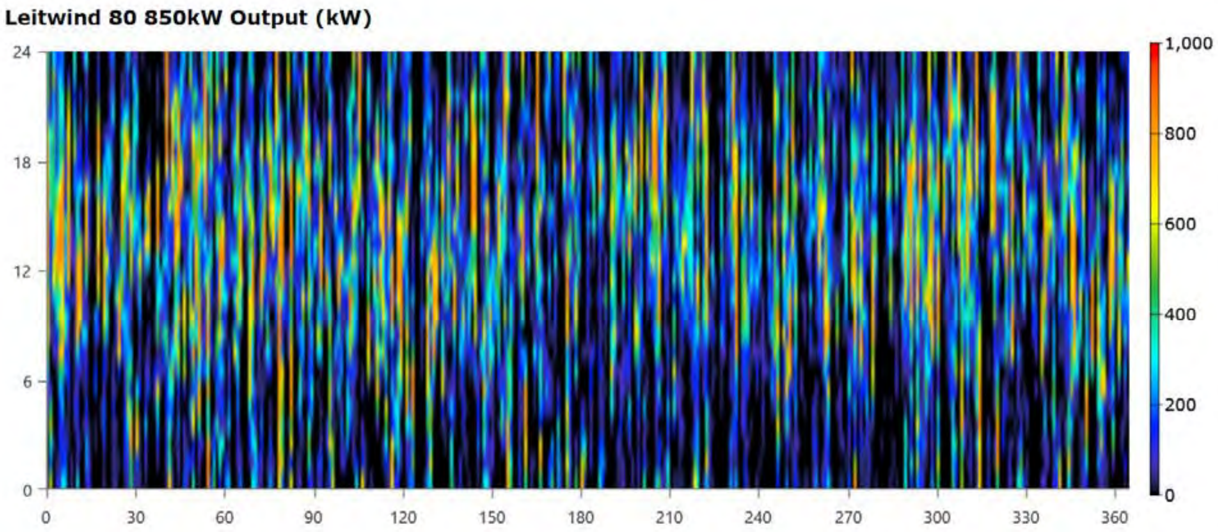
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

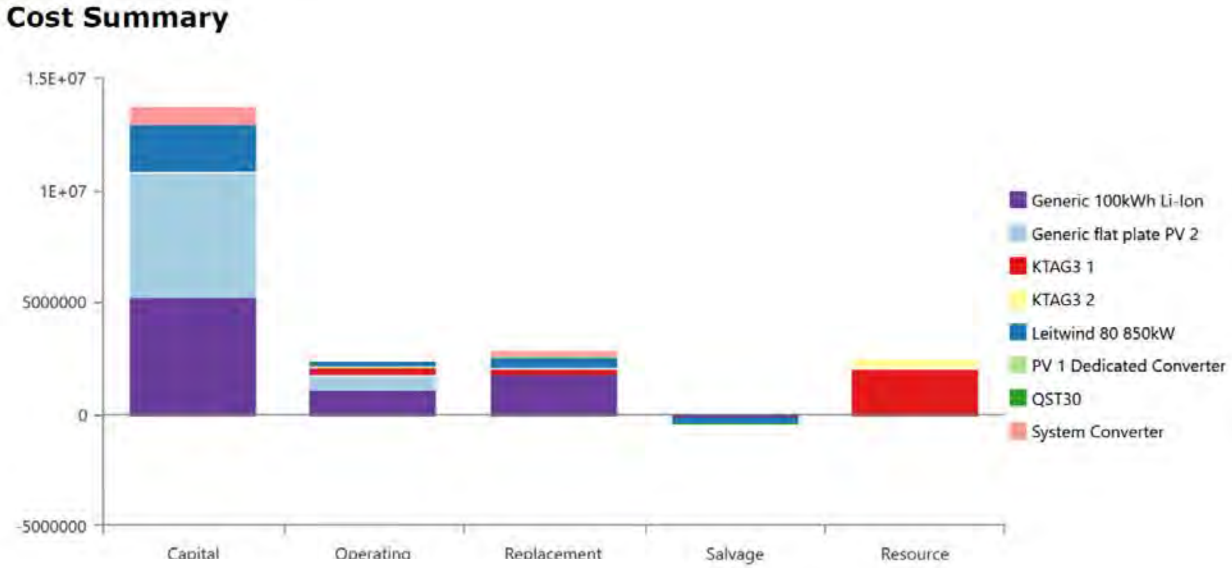
Source: https://maps.nrel.gov/gst-kenya/

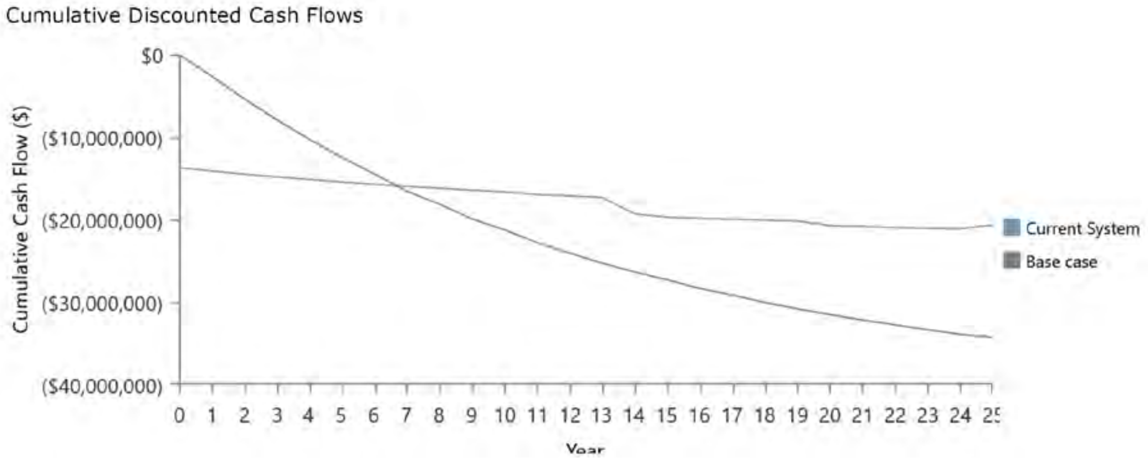


Simulation with HOMER PRO

Case Study - Lodwar







This is just a single scenario that can be improved by using more detailed meteorological data and serve as a basis for more sophisticated simulations

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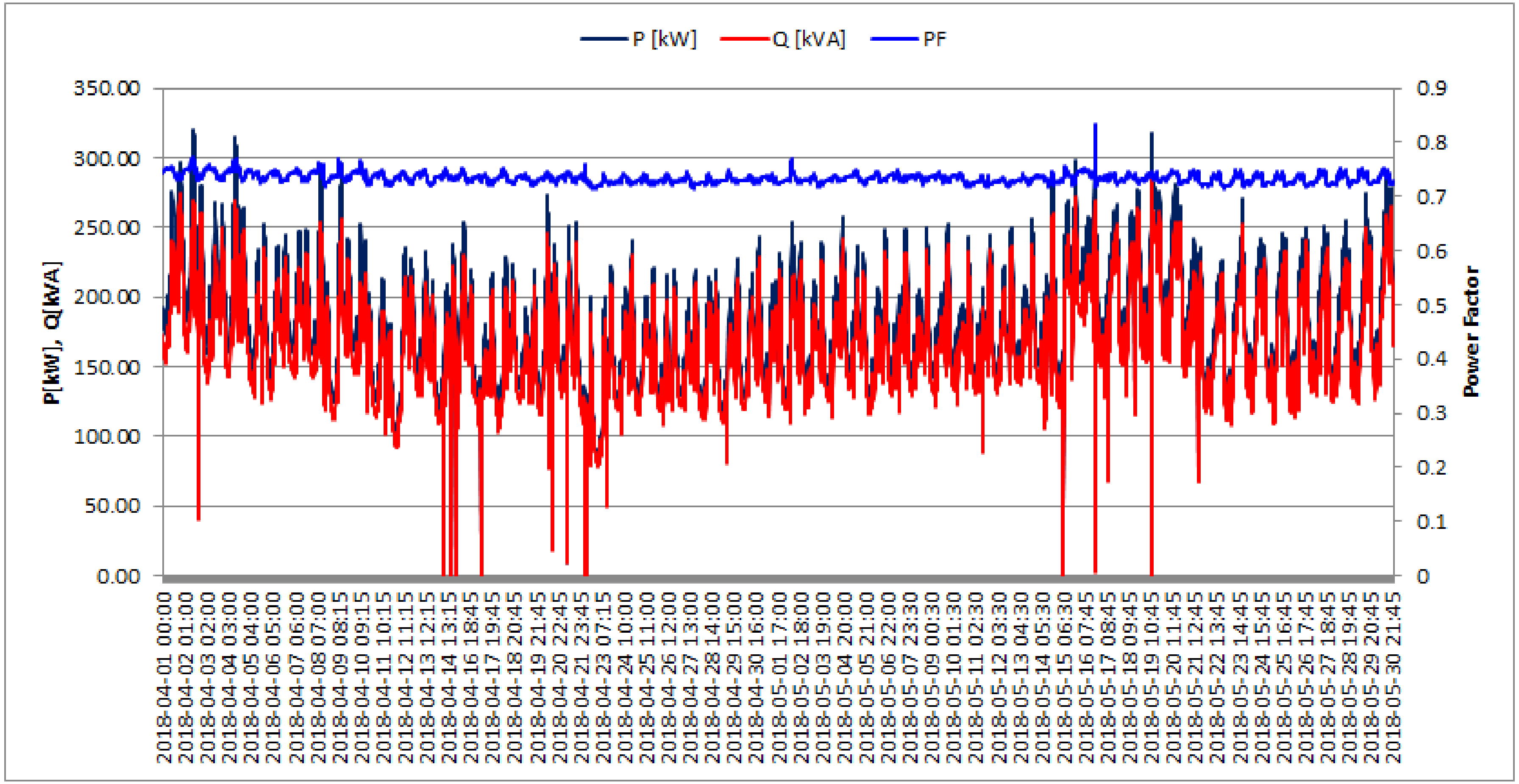
Case Study - Elwak

- Losses in distribution system of micro-grids are relevant, and KPLC is installing meters in the feeders of some of their plants to study the power flows and power factor



Selected References

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- Gambino V., Micangeli A., Naso V., Michelangeli E:, Di Mario L., A Sustainable and Resilient Housing Model for Indigenous Populations of the Mosquitia Region (Honduras), Sustainability 6 (8), 4931-4948, **2014**
- Micangeli A., Michelangeli E., Ricci M., Sciubba E., Exergy-Based Analysis of an Isolated Honduras Community, ASME 2014 International Mechanical Engineering Congress and Exposition, **2014**

Design and Optimization of Minigrid Models for Rural Development

- Objective of the study is to define and validate an effective methodology for the optimization of Hybrid Minigrids
- The development of an electrification project faces two main problems:
  - **Load assessment** and its evolution during the years
  - **High development costs**
- The aim of the study is to define a methodology which can help developers in **defining the energy needs and optimize the size and the components** of a Minigrid
- The research is taken by developing projects from the green field to the operation in collaboration with actors involved in rural electrification (Universities, Private Companies, NGOs and Governments)

Design and Optimization of Minigrid Models for Rural Development

Energy need assessment Methodology

A methodology developed to define the energy needs of not electrified communities.

Objective of the research:

- Definition of energy needs in not electrified villages
- Load curve forecast evolution
- Evaluation and monitoring of ongoing projects
- Definition of best practices

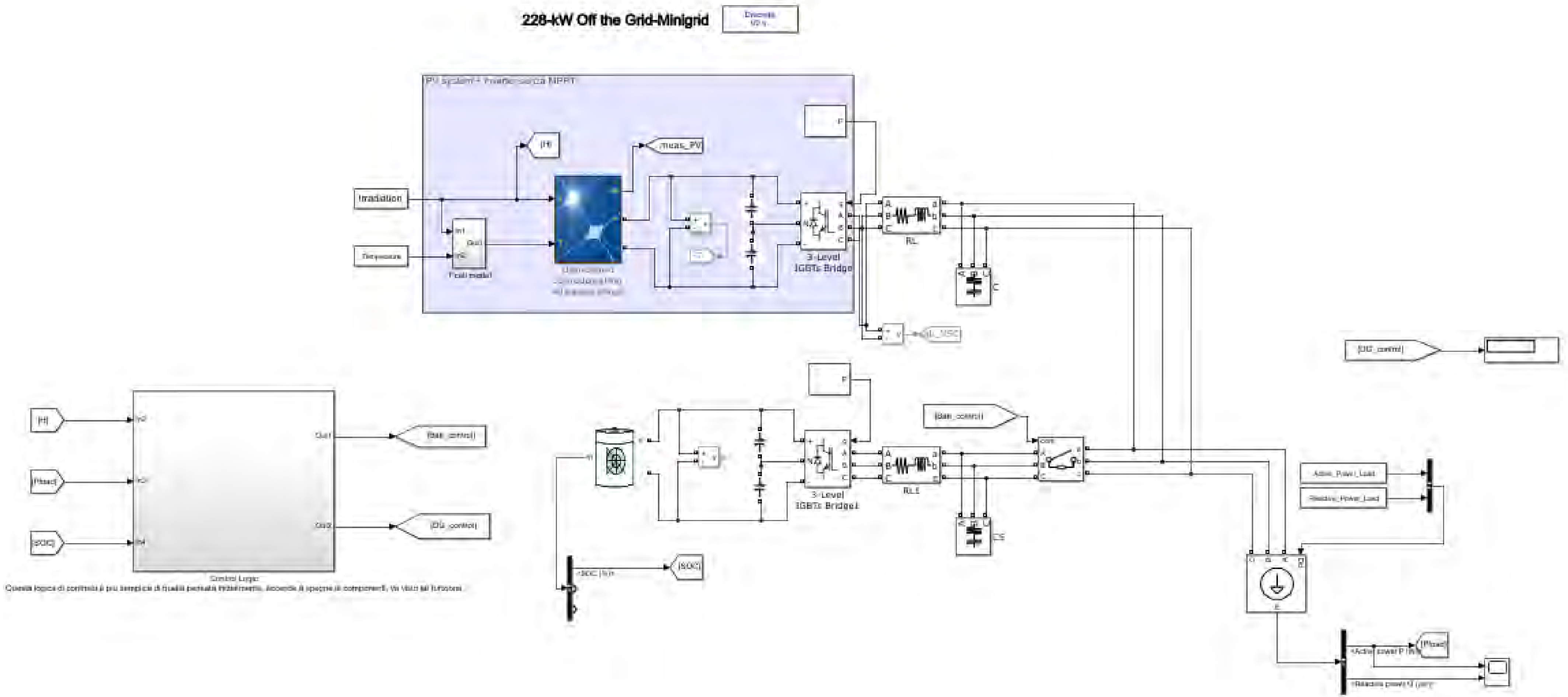
Simulink validation model

A **flexible model validated** on existing and monitored hybrid minigrids.

Objective of the research:

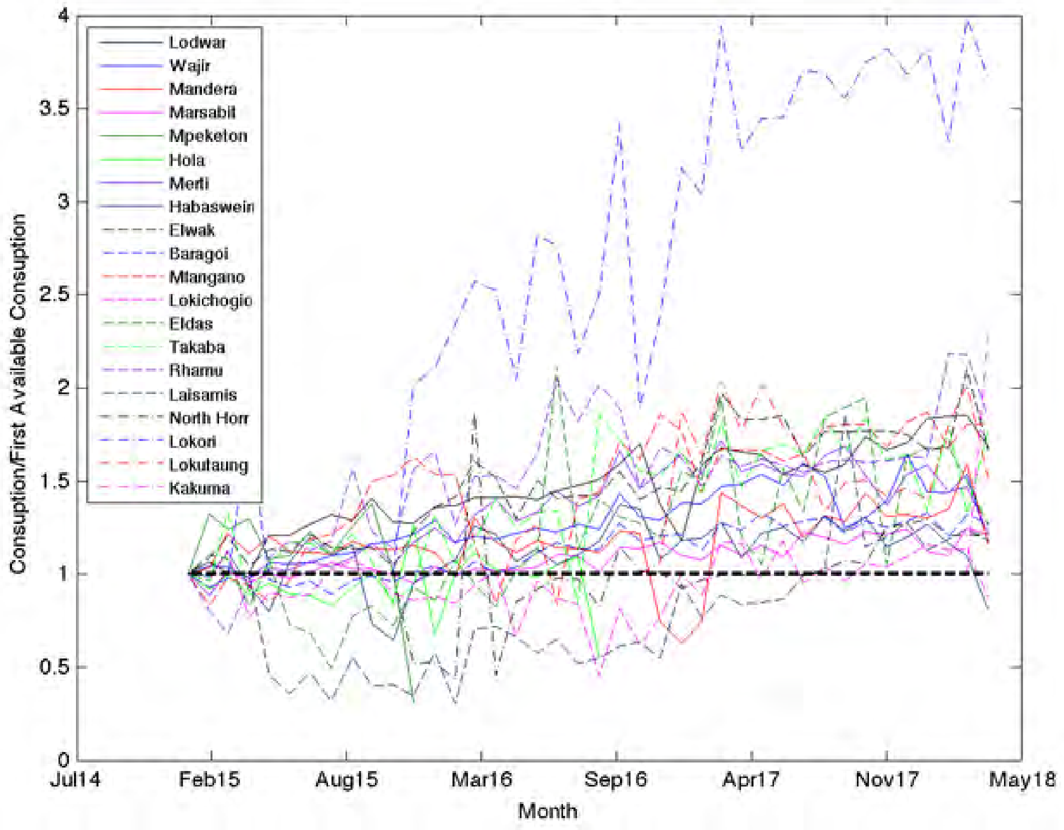
- Evaluation of component performances
- Evaluation of System performances
- Validation of optimization models
- Comparison and evaluation of different control logics (CC, LF, MISTI Control Logic,…)

Simulink validation model - overview



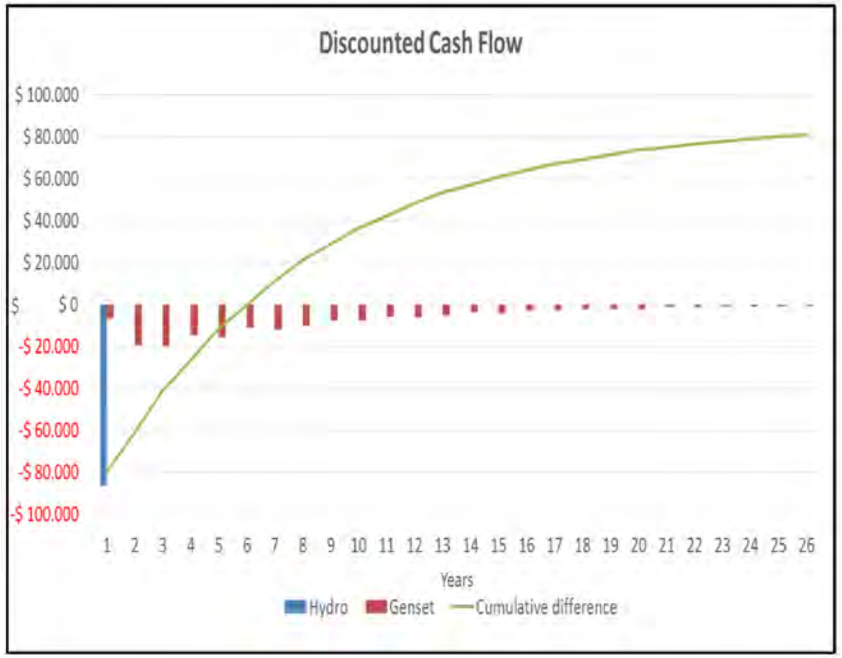
Off-grid Energy Demand Evolution Analysis

- **Object:** Load forecasting is a crucial aspects in generation and distribution system sizing.
- **Methodology:** Data collection campaigns and analysis are carried out to identify energy consumption trends on operating mini-grids in East Africa and Central America, to characterize load growth factors and off-grid demand ramp-up.
- **Expected outputs:** Off-takers behaviour profile will be correlated to several factors such as grid availability, local economic context, weather and climate conditions, externalities.



«Normalized» consumption profiles for several Kenyan microgrids

Social Return On Investment



Traditionally, financial analysis for microgrids projects doesn't consider explicitly social and environmental values

Object: the SROI is a systematic approach to include extra financial factors impacts by mini-grids that can be monetized to improve the accuracy of the project performance evaluation

Methodology: Key indicators will be measured through data collected about social, health care, education, economic growth of selected target groups benefiting from energy from renewable mini-grids. Those outcome will be assigned to a monetary value and implemented in an enhanced financial model, to achieve a better understanding of the techno-economic features of a mini-grid project.

Expected outputs: An outcome based tool will be issued to assess and value extra-financial impacts deriving from mini-grids on a target community.