EUDP IEA Task 41
Deliverable 3.2 Review of mini-grid modelling tools and approaches

Department of Wind Energy
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Summary:
This report presents a brief review of some software packages available for the simulation of mini-grids, particularly for the inclusion of small wind turbines. It is neither exhaustive nor to be taken as indicative of any modelling preferences by DTU researchers.

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Content

1. Introduction

This report has been produced with the intention of giving an overview of some of the software tools available for simulating the performance of mini-grid designs. In this instance, we refer to a mini-grid as an infrastructure that is intended to supply electricity to a relatively small number of consumers using either exclusively renewable energy or a high percentage of electricity produced from renewable resources. A typical mini-grid constellation would be a combination of solar PV, wind turbines, batteries and a distribution system to deliver the power to consumers. There is also the possibility that a diesel generator could be a component.

Our focus is on simulation tools that are able to combine components in an optimal way, given a set of conditions or to investigate the interaction between components of the mini-grid. An economic optimisation is a desired attribute but not an essential prerequisite.

The reader should be warned that this current work does not present an exhaustive survey of the market for simulation tools, neither does it intend to recommend any particular product, particularly as not all of them have been used 'hands-on' by the author. Limited verification of a product's capabilities has, though, been attempted by using multiple references.

1.1 EUDP IEA Task 41: Distributed Wind

This work constitutes part of a work package deliverable 3.2 of the EDUP IEA Task 41 Distributed Wind project. A summary of this project is given here:

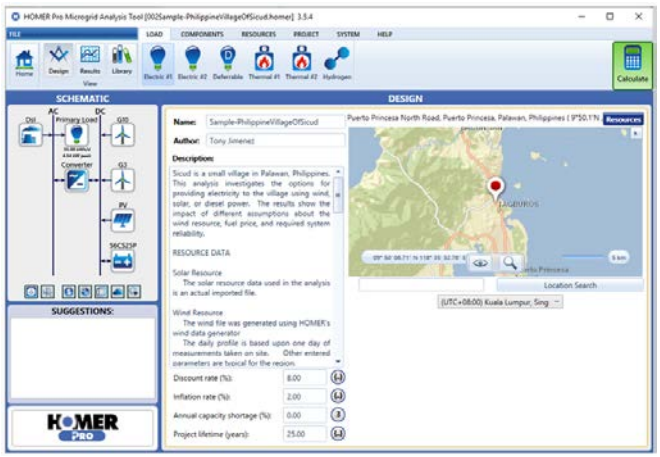
The overall objective of this project is to identify and explore studies of particular Danish interest of Distributed Wind (DW) for cost effective technology development and integration into a continuously evolving energy system. This is done by collaborating and contributing to the IEA Wind TPC Task 41 international activities on DW turbine technology development and assessment in a series of dedicated work packages (WPs). IEA Wind TPC Task 41 is an international network centred on international collaboration and coordination in the field of DW. The purpose is to accelerate the development and deployment of DW technology as one of the leading generation source in global renewable markets, the facilitation of easier and faster DW integration into electrical grids, increasing thus the competitiveness of wind and accelerating the replacement of fossils fuels. The IEA collaboration is enforced partly by exchange of information, sharing of results, and conducting analyses and explorative studies in the form of reports and publications and partly by implementing a strong cross IEA Wind TPC Tasks collaboration effort.

2. Review of mini-grid simulation software

This chapter reviews seven software tools readily available and briefly details their attributes and their approaches to mini-grid modelling.

2.1 Homer

HOMER has become the benchmark commercial software for the optimisation of mini-grid systems from both a component-sizing perspective and financial investment and economics point of view. It is able to cover small systems for a village, larger isolated systems and – with the grid package – grid connected systems. Databases are available for resource data, as well as a component library for various generation devices and system components.

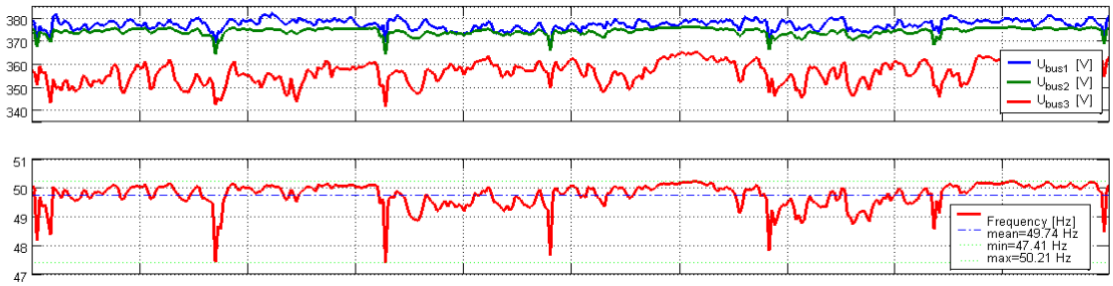


Screenshot from HOMER website: https://www.homerenergy.com/products/pro/index.html

Reference: www.homerenergy.com

2.2 Ipsys

ISPYS is an open source software tool developed by DTU, Technical University of Denmark for analysing the technical performance of isolated and interconnected energy systems, based on renewable energy. Central to the software is the ability to implement very different control strategies, programmed by the user. Time steps of the simulations can be varied in a quasi-static model with explicit interaction between different balancing domains (electrical, mechanical, thermal, hydraulic and gas flow). From the mini-grid perspective, the software can model the electrical network (load flow, active and reactive power sharing) and include electrical storage.



Screenshot of typical IPSYS graphical output of system variables

Reference: https://sourceforge.net/projects/ipsys/

2.3 Mini-grid Builder (GIZ)

Developed by OneShore Energy, with support from GIZ, this is a web-based simulation tool that is publically available and is aimed at providing results that indicate the required and optimum generation capacity based on an energy demand. The user enters data relevant to the system to be modelled and includes economic aspects, whereby a capital spend can be calculated and used for decision-making. Data can be stored for later use and adjustments.

Reference: http://www.minigridbuilder.com/

2.4 Open Energy Modelling Framework (OEMF)

This provides a toolbox that is generic and open source to assess the operation of an energy system. There are various modules that can be selected depending on the purpose and system to be modelled. Energy sectors can be linked and time steps can be varied to suit the system being studied. Of particular interest to the mini-grid environment, is the “Offgridders” package that looks at an isolated “local” electricity system, although mostly from the point of view of a connection to a weak national grid, as would be the case when an electrification scheme is implemented.

Reference: https://oemof.org/

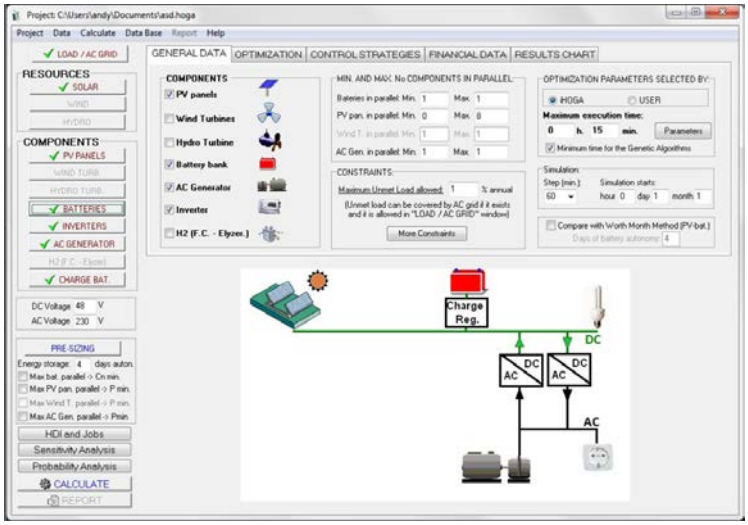
2.5 Distributed Energy Resources - Customer Adoption Model (DER-CAM)

Developed by the Berkeley Lab, this model is designed to be used to optimise the investments in distributed energy resources when looking at either buildings or micro-grids with various energy resource inputs. It will also find optimal component sizing and dispatch.

Reference: https://building-microgrid.lbl.gov/projects/der-cam

2.6 Ihoga

iHOGA (improved Hybrid Optimization by Genetic Algorithms) has been developed by scientists at the University of Zaragoza (Spain). Used for simulating isolated electrical systems based on renewable energy sources, and can handle other domains, such as hydrogen and water. Most generation technologies can be added, along with various storage options, which also include a lifetime estimation of storage technologies. Systems can be connected to a national grid and time steps of up to a minute can be used.



Reference: https://ihoga.software.informer.com/

2.7 MiGrids

This is an open source software designed for simulating isolated micro-grids with various components, load consumption profiles and renewable energy resources. Fundamentally, the programme is based on energy balancing at each time step, down to the order of seconds.

Reference: https://github.com/acep-uaf/MiGRIDS

3. Further References

The following references were also used in the preparation of this report:

https://cleanenergysolutions.org/sites/default/files/documents/mini-grid-tools.pdf
https://building-microgrid.lbl.gov/projects/der-cam
https://hybridpowersystems.org/wp-content/uploads/sites/9/2018/05/2B_1_062_presentation_Berendes_Sarah_Update.pdf

DTU Wind Energy is a department of the Technical University of Denmark with a unique integration of research, education, innovation and public/private sector consulting in the field of wind energy. Our activities develop new opportunities and technology for the global and Danish exploitation of wind energy. Research focuses on key technical-scientific fields, which are central for the development, innovation and use of wind energy and provides the basis for advanced education at the education.

We have more than 240 staff members of which approximately 60 are PhD students. Research is conducted within nine research programmes organized into three main topics: Wind energy systems, Wind turbine technology and Basics for wind energy.

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