DATA ARTICLE

Dataset after Seven Years Simulating Hybrid Energy Systems with Homer Legacy

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Homer Legacy software is a well-known software for simulation of small hybrid systems that can be used for both design and research. This dataset is a set of files generated by Homer Legacy bringing the simulation results of hybrid energy systems over the last seven years, as a consequence of the research work led by Dr. Alexandre Beluco, Federal University of Rio Grande do Sul, in southern Brazil. The data correspond to twelve papers published in the last seven years. Two of them describe hydro PV hybrid systems with photovoltaic panels operating on the water surface of reservoirs. One of these twelve papers suggests the modeling of hydro-power plants with reservoirs and the other the modeling of pumped hydro storage, and a third still uses these models in a place that could receive both the two types of hydroelectric power plant. The other simulated hybrid systems include wind turbines, diesel generators, batteries, among other components. This data article describes the files that integrate this dataset and the papers that have been published presenting the hybrid systems under study and discussing the results. The files that make up this dataset are available on Mendeley Data repository at https://doi.org/10.17632/ybxsttf2by.2.

Introduction

Hybrid energy systems can take on very complex behavior, considering the characteristics presented by the energy availability of renewable resources, by the energy demand profiles of the consumers, by the energy storage devices and by the possible combinations between exploited renewable energy resources and between devices for energy storage.

The simulation of different hybrid systems with different components, operating in different locations and conditions, complemented by the observations (whenever possible) of the receptivity of these systems by their users, contributes to a better understanding of their characteristics and to better conceptions of the systems to be designed in the future.

In this context, Homer Legacy (HomerEnergy, 2007) is a well-known software (Connolly et al., 2010; Sinha & Chandel, 2014) and is a powerful tool for simulating hybrid energy systems. Homer Legacy (Lambert, Gilman & Lilienthal, 2005; Lilienthal, Lambert & Gilman, 2004) simulates all combinations of optimization variables to identify which combination leads to the lowest total net present cost over the period considered for project analysis, usually 20–25 years, and repeats these simulations for all sensitivity variables to perform a sensitivity analysis. Systems based on run-of-the-river hydropower, PV solar energy and wind power,

battery storage, AC and DC bus, supported by diesel and other fuel systems, among other alternatives, supplying various consumer loads, can be simulated with Homer.

Homer software was developed in the early years of this century by members of the National Renewable Energy Laboratory (NREL), until version 2.68. The team directly responsible for Homer then formed HomerEnergy to better support users and to develop new versions of the software, meeting a growing demand for services beyond what could be handled by a government lab. The latest version even distributed by NREL has become the Legacy version, still distributed free for educational and academic purposes.

This paper presents files obtained with the Homer Legacy software for nine different case studies and for three methods for simulation of specific hybrid systems. One such method (Canales & Beluco, 2014) describes how to simulate hydro power plants with reservoir and the other (Canales, Beluco & Mendes, 2017) describes how to simulate pumped storage plants, since Homer simulates only run-of-the-river hydropower.

The third (Silva & Beluco, 2018) of these methods for the use of Homer Legacy presents a viability space for new technologies for generating energy from renewable resources. This viability space, as a 'viability window', is a target to be pursued in order to make technical and economically viable new technologies. This paper shows the application to the ocean wave energy case on the southern coast of Brazil.

The two methods described above were applied in a location where it would be possible to build both a conventional hydroelectric power plant with water reservation and a pumped storage hydropower plant. The comparison (Canales, Beluco & Mendes, 2015) indicated, for similar capacities and performances, lower environmental impacts associated with the reversible hydropower plant.

Among the other case studies, the first three of them (Silva, Cardoso & Beluco, 2012; Beluco & Ponticelli, 2014; Beluco et al., 2013) deal with the insertion of PV modules and-or other components or new fuels into previously existing diesel hybrid systems and the fourth (Benevit et al., 2016) of them studies the subtle influence of different wind energy availability profiles on the performance of a wind diesel hybrid system.

The article by During Fo et al. (2018) study the influence of temporal complementarity in time [according to the concept of energetic complementarity introduced by Beluco et al. (2008) and discussed by Jurasz et al. (2019)] on the energy storage in batteries in PV hydro hybrid systems, applying a specific method (proposed by Beluco, Souza & Krenzinger, 2012 and revised by During Fº & Beluco, 2019) appropriate for the analysis of hybrid systems based on complementary energy resources.

The paper by Teixeira et al. (2015) evaluates the feasibility of a PV hydro hybrid system operating in a dam for water supply in southern Brazil. The hydropower plant is feasible only with the use of pumps as turbines and the PV modules must be installed on floating structures on the surface of the reservoir. This feasibility evaluation is similar to the one that was undertaken for the pumped storage plant proposed by Risso et al. (2017) in their study.

Finally, two papers consider an alternative to a hydropower plant whose construction was started in the 1970s and then interrupted after the completion of the dam. The first (Vasco et al. 2019a) proposes an engine room at the base of the dam, unlike the original proposal, with PV modules on floating structures on the surface of the reservoir. The other paper (Vasco et al., 2019b) evaluates the use of the reservoir's small power storage capacity to obtain a hybrid system with better performance.

This article consists of four sections. This introduction briefly presents the topics covered in the papers that were published from the Homer files composing this dataset. The next section describes the thirty Homer files contained in this dataset. The subsequent section briefly presents the method used to build the Homer files composing this data set and the fourth and final section outlines some basic information on how to get the Homer software, Legacy version, and how to use it and how to access the files in this dataset.

Data description

The files composing this dataset are available online in the Mendeley Data repository under a specific DOI (Beluco et al., 2019), with each file also identified with a specific DOI. **Table 1**, below, presents some specifications of this dataset, and subsequently each of the files is briefly described. The next section describes how the data in these files was obtained.

Table 2 describes the thirty *hmr* files that make up this dataset, corresponding to twelve articles, arranged in chronological order. In this table, the first column names the file and the second column indicates the associated article. Some articles were based on results from just one simulation file, while others required more than one file.

In **Table 2**, the third column describes the data of the file and the next two columns indicate the number of values of the optimization and sensitivity variables considered in the simulations. Eventually, these numbers do not exactly match all the variables presented in the associated articles, because some variables did not result in meaningful results and were not considered here so that the files could be reasonably sized.

Table 1: Specifications of the dataset.

Feature	Description
Subject	Engineering
Specific subject area	Renewable Energy
Type of data	Results of simulations performed by the software Homer Legacy, in the format of *hmr* files (compatible with this specific software)
Description of data set	30 *hmr* files corresponding to 12 publications, including proposed methods and case studies
Data format	Raw data, automatically analyzed by Homer Legacy when opened
Input data	Energy availability data of the resources used in each case, consumer demand profiles, technical specifications of the components of the hybrid systems
Output data	One-year operation simulations of hybrid systems for all combinations of optimization and sensitivity variables, and accounting for all costs for the period of analysis
Data source location	Simulation data were obtained for operational or design hybrid energy systems at some locations along the territory of the State of Rio Grande do Sul, the southernmost State of Brazil.
Data accessibility	Data available in Mendeley Data repository: 10.17632/ybxsttf2by.2.
Related research article	Silva et al. 2012. Int J Photoenergy, v.2012, #384153. Beluco et al. 2013. Comp W Energy Envrn Eng, v.2, n.2, p.43–53. Canales and Beluco. 2014. J Ren Sust Energy, v.6, #043131 Beluco and Ponticelli. 2014. Int J Ren En Tech, v.5, n.3, p.229–250. Canales et al. 2015. J En Stor, v.4, p.96–105. Teixeira et al. 2015. J Pow En Eng, v.3, n.9, p.70–83. Benevit et al. 2016. J Pow En Eng, v.4, n.8, p.38–48. Canales et al. 2017. Int J Sust En, v.36, n.7, p.654–667. Silva and Beluco. 2018. Curr Alt En, v.2, n.2, p.112–122. During Fo et al. 2018. Comp W En Envrn Eng, v.7, n.3, p.142–159. Vasco et al. 2019a. Comp W En Envrn Eng, v.8, n.2, p.41–56. Vasco et al. 2019b. Sm Grid Ren En, v.10, n.4, p.83–97.

In **Table 2**, also, the last column indicates the figures and tables in the associated publications bringing results of simulations with Homer Legacy. Some of these results correspond to direct results provided by Homer Legacy, while others were obtained from the manipulation of results provided by the simulations and the resulting construction of new graphs or tables. Figures and tables obtained from results provided by Homer Legacy appear in bold.

Methods

The Homer Legacy was used to generate the data available in this dataset and this software is available for free at the link provided by HomerEnergy (2007), as described in the next section. For each of the hybrid energy systems that were simulated and whose results appear in the files described above, the software received energy availability data for each of the energy resources employed, the software also received the demand profile of the consumer loads and also received technical information on each of the components of the hybrid systems that were simulated. The Homer software then performs simulations of these hybrid systems for all values of the optimization variables and the sensitivity variables, as explained by Lambert, Gilman & Lilienthal (2005) and Lilienthal, Lambert & Gilman (2004). The files indicated above then present the results of all these simulations.

Software Homer, version Legacy – how to get it and how to use it

Homer allows the selection of components that form the hybrid energy system to be studied, simulates this hybrid system for a full year, at 8760 hours of a year, simulates this system for all combinations of optimization variables choosing as optimal solution that solution presenting the lowest total net present cost, and repeats these simulations for all combinations of sensitivity variables, leading to an optimization space. The simulations are carried out for one year, but the economic feasibility takes into account the time established for the evaluation, usually 20–25 years. Homer can be well understood by consulting Lambert, Gilman & Lilienthal (2005) and Lilienthal, Lambert & Gilman (2004).

Table 2: Specifications of the *hmr* files composing the dataset.

hmr file	Associated publication	Short description	Optimization values	Sensitivity variables	Results in associated publication *
#01-silva-et-al-2012	Silva, Cardoso & Beluco (2012)	a PV wind diesel hybrid system with energy storage in batteries and water and environment heating	288	5880	Figs. 6, 7, 8 and 9
#02-beluco-et-al-2013-A	Beluco et al. (2013)	a PV hydro diesel hybrid system connected to the grid, with an existing hydro power plant	48	1536	Figs. 7, 8 and 11
#02-beluco-et-al-2013-B		a PV hydro diesel hybrid system connected to the grid, with a hydropower plant to be implemented	48	1536	Figs. 9 and 10
#03-canales-beluco-2014-1	Canales & Beluco (2014)	a wind hydro diesel hybrid system with pumped storage capacity	15	3	Fig. 7
#03-canales-beluco-2014-2		a wind hydro diesel hybrid system with pumped storage capacity	24	3	Fig. 9
#04-beluco-ponticelli-2014-fig1	Beluco & Ponticelli (2014)	a wind diesel hybrid system already in operation and whose improvement was analyzed	15	1872	Figs. 7, **10** and **11**
#04-beluco-ponticelli-2014-fig6a-b100		a PV wind biodiesel hybrid system with energy storage in batteries	1750	1000	Figs. 9, **10**, **11**, 20, 21, 22 and 23
#04-beluco-ponticelli-2014-fig6a-dsl		a PV wind diesel hybrid system with energy storage in batteries	1750	1000	Figs. 8, **10**, **11**, 16, 17, 18 and 19
#04-beluco-ponticelli-2014-fig6b		a PV wind diesel biodiesel hybrid system with energy storage in batteries	3500	50	Figs. 12, 13, 14 and 15
#05-canales-et-al-2015-Sys3PH	Canales, Beluco & Mendes (2015)	a wind hydro hybrid system with pumped storage capacity	12474	96	Figs. **5**, **7** and **Table I**
#05-canales-et-al-2015-Sys3Res		a wind hydro hybrid system with energy storage capacity in a water reservoir	1496	48	Fig. **7**

(Contd.)

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hmr file	Associated publication	Short description	Optimization values	Sensitivity variables	Results in associated publication *
#06-teixeira-et-al-2015–2000	Teixeira et al. (2015)	a PV hydro hybrid system designed for operation at a dam for water supply, with the capital cost of the PV modules at US$ 2000 per kW	300	1440	Figs. 10, 11, 12, 13, 14 and **15**
#06-teixeira-et-al-2015–2500		a PV hydro hybrid system designed for operation at a dam for water supply, with the capital cost of the PV modules at US$ 2500 per kW	300	1440	Figs. 9, 14 and **15**
#06-teixeira-et-al-2015–2000		a PV hydro hybrid system designed for operation at a dam for water supply, with the capital cost of the PV modules at US$ 3000 per kW	300	1440	Figs. 14 and **15**
#06-teixeira-et-al-2015-3500		a PV hydro hybrid system designed for operation at a dam for water supply, with the capital cost of the PV modules at US$ 3500 per kW	300	1440	Figs. 14 and **15**
#06-teixeira-et-al-2015-4000		a PV hydro hybrid system designed for operation at a dam for water supply, with the capital cost of the PV modules at US$ 4000 per kW	300	1440	Figs. 14 and **15**
#07-benevit-et-al-2016-180	Benevit et al. (2016)	a wind diesel hybrid system with energy storage in batteries, simulated with Weibull shape parameter equal to 1.80	360	108	Figs. 4, **5**, 6 and 7
#07-benevit-et-al-2016-210		a wind diesel hybrid system with energy storage in batteries, simulated with Weibull shape parameter equal to 2.10	360	108	
#07-benevit-et-al-2016-240		a wind diesel hybrid system with energy storage in batteries, simulated with Weibull shape parameter equal to 2.40	360	108	
#07-benevit-et-al-2016-270		a wind diesel hybrid system with energy storage in batteries, simulated with Weibull shape parameter equal to 2.70	360	108	
#07-benevit-et-al-2016-300		a wind diesel hybrid system with energy storage in batteries, simulated with Weibull shape parameter equal to 3.00	360	108	

hmr file	Associated publication	Short description	Optimization values	Sensitivity variables	Results in associated publication *
#08-canales-et-al-2017	Canales, Beluco & Mendes (2017)	a wind hydro hybrid system with energy storage in the reservoir of the hydropower plant	224	72	Figs. 7, 8, 9 and **Table 2**
#09-silva-beluco-2018	Silva & Beluco (2018)	a PV wind diesel hybrid system connected to the grid, including an ocean wave power plant	512	450	Figs. 8, 9, 10, **11** and Table **1**
#10-during-et-al-2018-d000	During Fo et al. (2018)	a PV hydro hybrid system with energy storage capacity in batteries, with time-complementarity index equal to 0.00	1476	87	Figs. 5, 6, **7**, **8**, 9, 10, **11**
#10-during-et-al-2018-d090		a PV hydro hybrid system with energy storage capacity in batteries, with time-complementarity index equal to 0.50	1476	87	Figs. 5, 6, **7**, **8**, 9, 10, **11**
#10-during-et-al-2018-d120		a PV hydro hybrid system with energy storage capacity in batteries, with time-complementarity index equal to 0.67	1476	87	Figs. 5, 6, **7**, **8**, 9, 10, **11**
#10-during-et-al-2018-d150		a PV hydro hybrid system with energy storage capacity in batteries, with time-complementarity index equal to 0.83	1476	87	Figs. 5, 6, **7**, **8**, 9, 10, **11**
#10-during-et-al-2018-d180		a PV hydro hybrid system with energy storage capacity in batteries, with time-complementarity index equal to 1.00	1476	87	Figs. 3, 4, **7**, **8** and **11**
#11-vasco-et-al-2019	Vasco et al. (2019a)	a PV hydro hybrid system connected to the grid, designed for an unfinished hydro power plant	486	567	Figs. 7, 8, 9, 10, 11, 12
#12-vasco-et-al-2019	Vasco et al. (2019b)	a PV hydro hybrid system connected to the grid, with energy storage in the water reservoir	18	72	Figs. 7, 8, 9, 10 and 11

* Figures and tables constructed from manipulation of Homer Legacy simulation results appear in bold.

The version Legacy of software Homer corresponds to the latest version provided by NREL [National Renewable Energy Laboratory (U.S. Department of Energy, 2019)]. The team responsible for Homer's development formed HomerEnergy and went on to develop more advanced versions in a commercial scheme. Legacy version is still available free for educational and academic activities after registration on the HomerEnergy website (HomerEnergy, 2019) and the completion of a specific form. Homer was part of the software package made available by NREL until 2007 and later distributed by HomerEnergy (still free of charge).

The files in this data set can be accessed directly with Homer and the results can be explored by searching for details that are not discussed in the papers cited above. The Getting Started Guide (Lilienthal, Lambert & Gilman, 2011) provides complete instructions for general operation of Homer and for detailed exploration of results, including fine-tuning a project. As commented in the text of the first section of the Getting Started Guide, "it should take about an hour to complete this exercise". The Getting Started Guide can also be accessed in the third line of the Help item in the main menu of the Homer software.

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Competing Interests

The authors have no competing interests to declare.

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