RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

The Hybrid Optimization Model for Electric Renewables (HOMER)

by Peter Lilienthal 7/98

Background

Hybrid power systems can consist of any combination of wind, photovoltaics, diesel, and batteries. Such flexibility has obvious advantages for customizing a system to a particular site's energy resources, costs, and load requirements. Flexibility also makes the design process more difficult, however. Previous models were either simple spreadsheets or detailed simulations. The simple spreadsheet models do not consider the time-dependent variability in the loads and resources. The detailed simulations, such as *Hybrid2*, give performance projections for specific systems, but are unwieldy to use for comparisons among many different configurations.

Scope

The National Renewable Energy Laboratory (NREL) has developed HOMER, an optimization model that takes into consideration hourly and seasonal variations in loads and resources, simple performance characterizations for each component, equipment costs, reliability requirements, and other site specific information. HOMER ranks the configurations by life-cycle cost and can automatically perform sensitivity analyses on any subset of its inputs. It is intended for prefeasibility analysis when the interest spans a broad range of inputs, either because the input data is uncertain or because the analysis covers a large area with differing conditions. Besides optimized configurations, HOMER provides hourly energy flows through each component, the impact of several simple load management strategies, and economic information such as the cost of energy and net cost of the system.

Results

NREL researchers have used HOMER in several analyses for Indonesia, China, Russia, Argentina, Chile, Brazil, Mexico, South Africa, and for market analyses for domestic renewable suppliers and technology developers. It also has been used for market assessment and screening to initialize detailed site-specific Hybrid2 analyses.

In 1997, HOMER was converted from specialized optimization software to Visual C++. This conversion improved the model's user-friendliness and facilitated wider distribution. There are now two versions of HOMER; a simple version intended for planners unfamiliar with hybrid renewables and an advanced version for experienced engineers.

The specifications of diesel fuel efficiency and maintenance requirements were improved. The dispatch algorithm was improved to reflect antic-ipated operator control. Loads and resources can now be specified either as typical days for each season, with a user-specified level of additional variability, or with a time-series data file for an entire year. It reports both optimal and near-optimal solutions. HOMER has been integrated with a mini-grid optimization model, ViPOR, to help planners compare mini-grids with individual systems for a particular village.

Planned Activities

HOMER will continue to be used for system screening and market assessment. Further enhancements to the dispatch capability are planned. A complete package of documentation is being produced.

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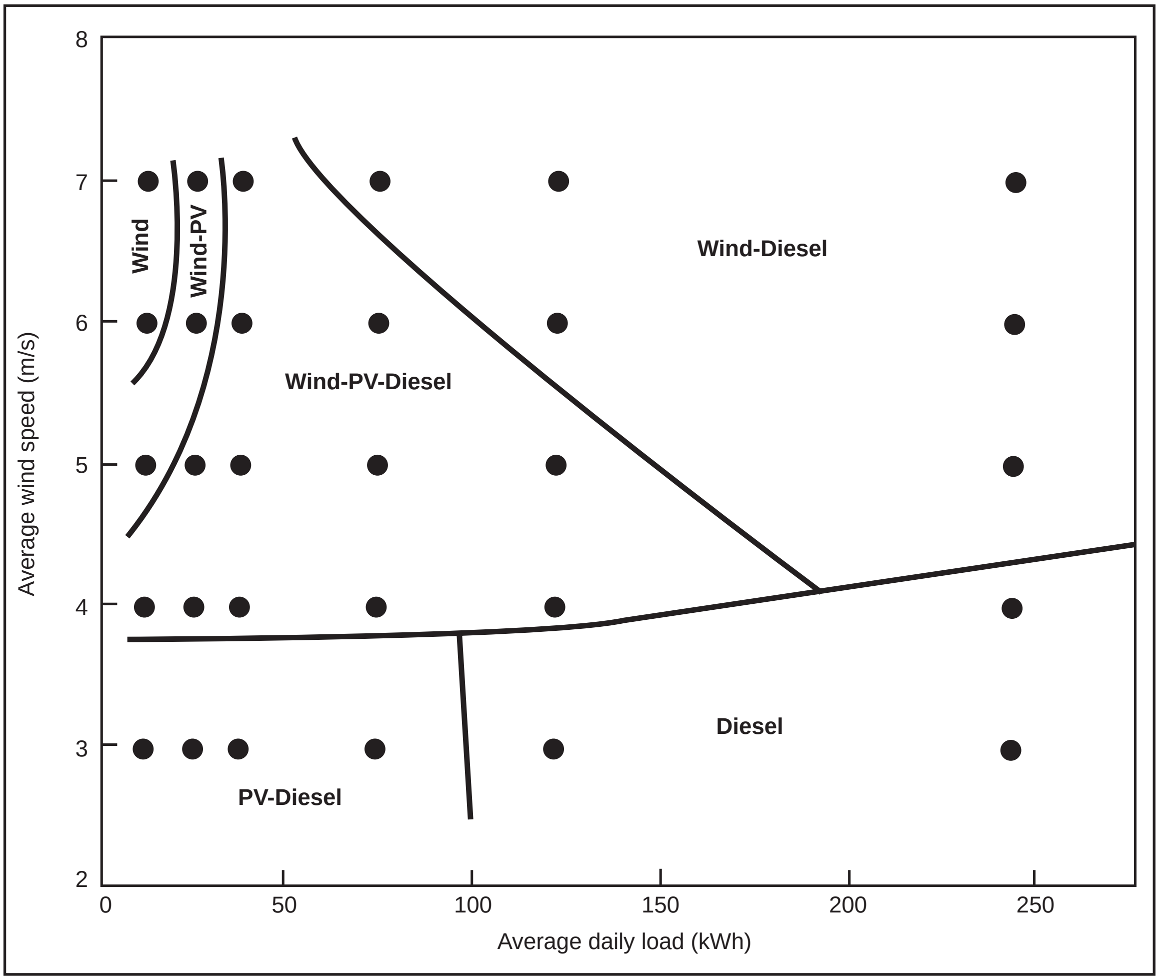

HOMER. *Assessing the "least" cost mix of supply technologies is a difficult analytical problem that depends on the quality of the various resources, the local costs of equipment, labor and fuel, and the site-specific descriptions of the daily and seasonal variations in the loads, as well as the options for simple load management. The Hybrid Optimization Model for Electric Renewables (HOMER) is a screening model that is useful for prefeasibility and sensitivity analysis. This graph is an example of a set of HOMER outputs for specific sets of assumptions. The results can change dramatically with different assumptions.*

Sensitivity analyses were performed on the size of the load and the average annual windspeed. For very low loads in a good wind resource, one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases, a combination of wind and PV is preferred. Although in this example PV-diesel is the optimal choice in poor wind resources for the smallest loads that were modeled (12 kWh/day), a pure PV system would be preferred for smaller loads or higher fuel prices or if more than 5% unserved energy would be acceptable. In the larger sizes, both wind turbines and diesel gen-sets have economies of scale that make PV less competitive. The vertical line representing 125 kWh/day demonstrates a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low windspeeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.