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The HOMER® Micropower Optimization Model

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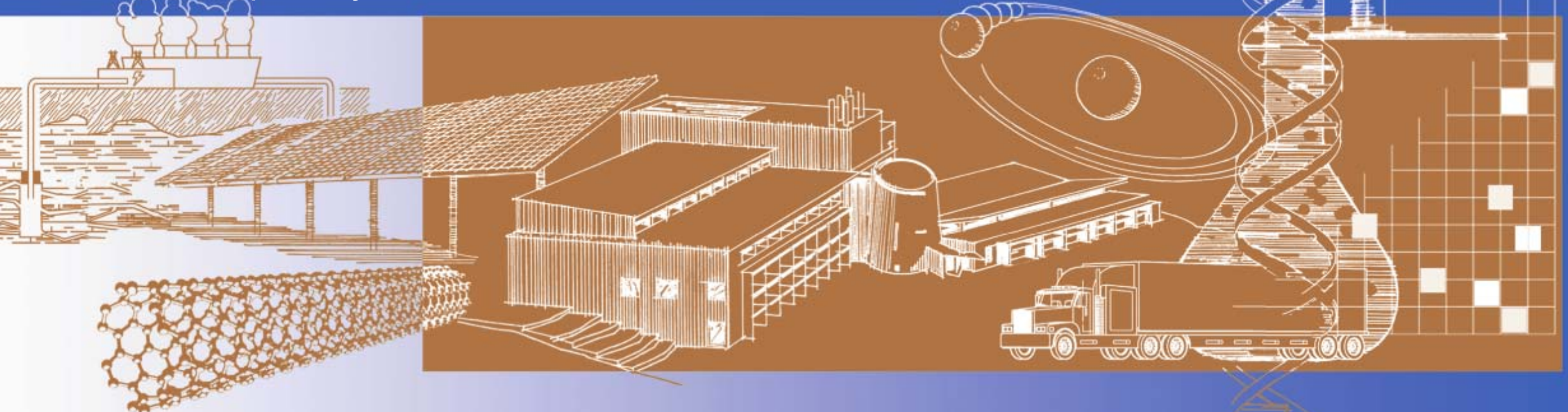

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The HOMER® Micropower Optimization Model

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ABSTRACT

NREL has developed the HOMER micropower optimization model. The model can analyze all of the available small power technologies individually and in hybrid configurations to identify least-cost solutions to energy requirements. This capability is valuable to a diverse set of energy professionals and applications. NREL has actively supported its growing user base and developed training programs around the model. These activities are helping to grow the global market for solar technologies.

1. Objectives

The international activities of the Solar Program are designed to overcome barriers to the global adoption of solar technologies. One of the greatest obstacles is the unfamiliarity of energy planners throughout the world with small-scale renewable technologies. This task has developed and is maintaining the HOMER model, an easy-to-use tool that designs small-scale power systems using any combination of renewable and conventional power technologies. System integrators can use the model to optimize the design of their systems. Electrification program developers can use it to focus their programs on the most cost-effective types of systems. Policy makers can use it to analyze the impacts of changes in subsidies and tariffs and to forecast the impacts of future changes in prices and technologies. Technology developers can use it to analyze the market impacts of potential improvements to the technology

2. Technical Approach

The HOMER model is an optimization tool that minimizes total discounted cost. The user inputs the cost and performance characteristics of his components of interest, the daily and monthly load profile, and renewable resource. This information can be provided at varying levels of detail, depending on the purpose of the analysis. For example, the model can generate a realistic load and resource profile for all 8760 hours of the year from a typical daily load profile or monthly average solar radiation. The user must also define the search space, which is the set of configurations over which the model will optimize. For most analyses, the user will want to also perform sensitivity analyses, whereby the model will perform repeated optimizations as it varies one or several input variables. This is useful when the input data is uncertain, an analysis is meant to cover a range of scenarios, or when the user wishes to find a threshold where a particular technology becomes cost effective.

Figure 1 shows an example of one of the outputs from a sensitivity analysis. This analysis varied the wind speed and diesel fuel price for a Philippine village with a peak load of 4.5 kW. It shows that in low wind speeds and at diesel fuel prices below $.60 per liter, the least-cost solution is a diesel generator with a battery and inverter for off-peak hours. It also shows the minimum wind speed at which wind turbines are cost effective and the extent to which that is dependent on the fuel price. In some cases, the optimal solution is a combination of PV and wind. There are also situations where it is more cost effective to increase the size of the renewable components and the battery bank than to include a diesel backup generator.

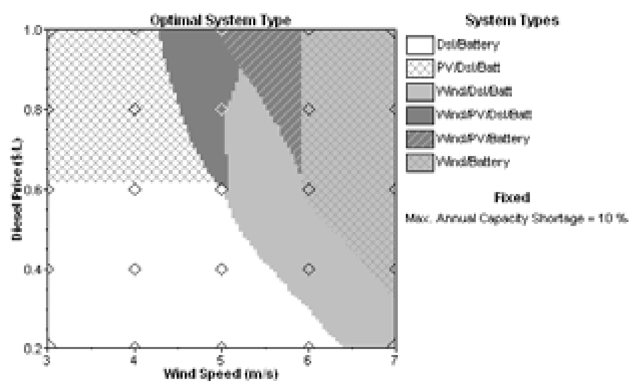

Fig. 1. Fuel price and wind speed sensitivity analysis

The HOMER model simulated the performance of 7560 different systems over 75 different scenarios to develop this sensitivity analysis. For each of those systems and in each scenario, a separate simulation was performed over all 8760 hours in the year. The model reports annual and hourly output details for each of these simulations.

The model was originally developed in 1993 as part of NREL Village Power Program. In 1997, it was rewritten in C++ to run on Windows PCs instead of Unix workstations running specialized optimization software. In 2000, a major upgrade was initiated to give the HOMER model the capability to model grid-connected systems. In 2004. that capability was expanded to include time-of-day and seasonal rates, avoided emissions, improved handling of multiple generators. The user interface continues to improve with automated retrieval of resource data from the Web, simplified inputs, and HTML and XML export reports.

In the interest of making the model as broadly useful as possible, NREL has been distributing it free of charge over the Web. The user simply registers in a database to reach the download page. After 6 months, the user must fill out a short questionnaire to receive additional license renewals.

NREL's International Team has developed a set of rural energy training curricula. The first one was a training course in using the HOMER model. Additional, complementary training modules are under development. The first two involve data collection, so that energy analysts learn how to collect data for the analyses, and rural energy technologies.

In collaboration with the DOE/Hydrogen Program, the HOMER model has been enhanced to include electrolyzers, reformers, hydrogen storage and fuel cells. The model is being used to look at alternative energy storage scenarios utilizing hydrogen, as well as renewable hydrogen production scenarios. Although these applications are currently far from cost effective, the model is an ideal tool for identifying the technical and economic conditions that would be necessary to justify the use of these technologies.

The HOMER model is being integrated into external software. ESKOM, the national utility of South Africa, contracted with NREL to integrate the model into its in-house GIS, which contains comprehensive renewable resource assessments, in addition to demographic and geographic data of all of South Africa's unelectrified households. NREL has also developed a prototype Web interface for the HOMER model. A local energy developer is further developing a Web interface that incorporates its own project development model with the HOMER model. Finally, NREL is working with the U.S. Agency for International Development and the United Nations Environment Program to jointly develop software that integrates the model with GIS-based resource mapping software. This concept is being considered for a more ambitious model of the U.S. electric sector.

Although the global community of users performs the vast majority of HOMER analyses, NREL is creating a library of case studies, sample files and analytical reports.

3. Results and Accomplishments

NREL has developed a user database of more than 5000 energy professionals in 162 countries. We have also developed valuable information about the needs of these energy professionals. As of October 20, 2004, 1744 of the users were from the United States, 2024 were from other OECD countries, and 1535 were from the rest of the world. The top five other OECD countries were Canada, Australia, Spain, Germany, and the UK. The top five developing countries were India, Brazil, Philippines, Thailand, and Chile.

Over the last year and a half, NREL has conducted HOMER model trainings to support country activities in Brazil, Philippines, China, Senegal, Chile, Mexico, and the Maldive Islands. Domestically, NREL has trained students at the University of Colorado, the United States Military Academy at West Point, the University of California at Berkeley, and the Coast Guard. Additional trainings are scheduled for October and November 2004 for GE Global Research and in Sri Lanka. There is also a large backlog of requests for additional training.

The most recent analysis, "Using the HOMER Software, NREL's Micropower Optimization Model, to Explore the Role of Gensets in Small Solar Power Systems, Case Study: Sri Lanka" is undergoing peer review. This study looked at small village systems to identify the factors that affected the maximum size for which a simple PV battery system was more cost effective than a hybrid system consisting of PV, diesel, and battery system. The study performed sensitivities on fuel price, reliability requirements, and the solar resource.

4. Conclusions

The rapid pace at which the HOMER model is being adopted throughout the world demonstrates the value of this relatively easy-to-use tool that can help develop cost-effective applications for PV and other small power technologies. The model has frequently been instrumental in creating new relationships between NREL and renewable energy professionals throughout the world. By continuing to further develop and support the HOMER model, NREL is enhancing its reputation and supporting the global development of markets for solar technologies.

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