# Study of Optimization in Economical Parameters for Hybrid Renewable Energy System

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***Abstract***

With the fast progression of renewable energy markets, the importance of combining different sources of power into a hybrid renewable energy system (HRES) has gained more attraction. These hybrid systems can overcome limitations of the individual generating technologies in terms of their fuel efficiency, economics, reliability and flexibility. One of the main concerns is the stochastic nature of photovoltaic (PV) and wind energy resources. Wind is often not correlated with load patterns and may be discarded some- times when abundantly available. Also, solar energy is only available during the day time. A hybrid energy system consisting of energy storage, renewable and non-renewable generation can alleviate the issues associated with renewable uncertainties and fluctuations. Large number of random variables and parameters in a hybrid energy system requires an optimization that most efficiently sizes the hybrid system components to real-ize the economic, technical and designing objectives. This chapter provides an overview of optimal sizing and optimization algorithms for hybrid renewable energy systems as well as different objective functions considered for designing such systems.

***Keywords:*** Hybrid Energy System, Objectives, Optimization, Renewable Energy, Sizing

## I. Introduction

Use of solar and wind power has become more and more significant, attractive and less expensive, since the oil crises in the early 1970s. Even though there is a need to use renewable energy sources, the main problem with it is the dependency on environmental conditions like solar irradiance and wind speed. The individual energy sources cannot provide continuous power supply to the load because of the uncertainty and on-and-off nature of the environmental conditions [1]. Combining intermittent renewable energy sources with other dispatch able sources of energy such as biogas and fuel cells as well as energy storage systems provides a solution to address this challenge. Hybrid renewable energy system (HRES) is a term to describe the combination of two or more renewable and non-renewable energy sources. Basic components of such systems are power sources (wind turbine, diesel engine generator and solar arrays), the battery and the power management center, which regulates power production from each of the sources [1]. As an example of such systems, micro grid is an integrated energy system that includes energy resources, loads and storages. Micro grids found popularity over the years due to the needs for distributed generation and with the integration of HRESs including photovoltaic (PV) and wind generators as well as the battery storage devices. The micro grids have many benefits for both utility grids and customers, such as higher power quality, reduction in carbon emission, energy efficiency and reduced costs. Another capability of micro grids is islanding which allows the micro grid to be disconnected from the utility grid in the case of upstream disturbances or voltage fluctuations [2].

Operating an HRES requires optimizing its performance while satisfying its physical and technical constraints. Therefore, optimization tools, techniques and applications have found popularity to achieve these goals [3].

## II. Optimal sizing for hybrid renewable energy systems

HRESs require an optimal design for their component sizing to economically, efficiently and reliably meet the objectives outlined in Section 4. Table 1 provides examples of studies related to HRES optimization parameters evaluated along with details regarding the hybrid system components, their load characteristics and sizing.

**Table-1 Survey Optimized parameters for Hybrid Energy system**

| References | Hybrid System | Load Specifications | Paramaters Optimized |
|---|---|---|---|
| [4] | Wind/PV/Battery | 225kW peak, 25 kW base | Size, NPC, LCOE. |
| [5] | Wind /PV/Micro | 1.5kW constant | Size, NPC, LCOE. |

| | | | |
|---|---|---|---|
| | Turbine/ Battery | | |
| [6] | Wind/ PV/diesel/ Battery | 26kW peak, 5kW base | Size, NPC, LCOE, Emission factor |
| [7] | Wind /PV/ Battery | 1500W | Size, NPC, LCOE. |
| [8] | Wind/ diesel/ Battery | 3.5kW peak, 0.25 kW base | NPC, LCOE,Emission factor |
| [9] | Wind/PV/Energy storage | 1MW peak, 0.4 MW base | Size, NPC, LCOE. |
| [10] | Wind/PV/Energy storage | 1MW constant | Size, NPC, LCOE. |

## III. Optimization objectives for HRESs

Various criteria are considered for optimal design and component sizing of HRESs. These criteria can be broadly categorized as economic and technical. Economic criteria are used to minimize costs of HRESs. Technical criteria include reliability, efficiency and environmental objectives to supply the load demand of HRESs at desired reliability levels with maximum efficiency and minimum greenhouse gas emissions. HRESs often times include higher capital costs and lower operation and maintenance (O&M) costs which require an optimization to determine the compromise solution between the costs and benefits. Cost optimization of hybrid renewable energy systems includes minimizing energy cost, net present cost (NPC) and any other costs associated with such systems.

a. Energy cost minimization

Several studies have investigated minimizing levelized cost of energy (LCE) for HRESs. LCE is the ratio of total cost of the hybrid system to the annual energy supplied by the system. Study of the related research works, with their objective functions and techniques used for optimization and their main findings is performed.

b. Net present cost minimization

Net present cost (NPC) of an HRES is defined as the total present value of the system that includes the initial cost of the system components as well as the replacement and maintenance cost within the project lifetime. The objective here is to minimize the NPC of HRESs. Study of the related research works, with their objective functions and techniques used for optimization and their main findings is performed.

c. Other cost-related optimization

Other cost-related optimizations include minimizing life cycle cost (LCC), levelized unit electricity cost (LUEC), annualized cost of the system (ACS), capital cost (CC) of the hybrid system, total cost of the system (TCS) and average generation cost (AGC).

## IV. Conclusion

The study of various hybrid renewable energy systems is performed and the optimization parameters evaluated are presented and discussed. The main parameters are sizing, net present cost, levelized cost of energy and emission factors. Based on the site survey report the hybrid system is proposed and then the optimization is performed in HOMER pro software to check the feasibility of the proposed system to meet the electricity demand.

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