Standalone Hybrid Power System Using HOMER Pro Software on Safricom Ethiopia Data Center

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1,Abstract: The renew interest for power generation using renewable due to global trends provides an opportunity to rethink the approach to address the old yet existing load shedding problem. In the literature, limited studies are available that address the load shedding problem using a hybrid energy system. This paper aims to fill this gap by proposing a techno-economic optimization of a hybrid renewable energy system to mitigate the effect of load shedding at the distribution level. The propose system in this work is will configure using a photovoltaic array, Generator power, Grid power an energy storage unit (of batteries), and a diesel generator system. The proposed system is equipped with a rule based energy management scheme to ensure efficient utilization and scheduling of the sources. The sizes of the photovoltaic array, Generator, Grid power, and the batteries are optimized via the grasshopper optimization algorithm based on the multi-criterion decision that includes loss of power supply probability cost of electricity, and payback period. The results for the actual case study in Addis Ababa show that the optimum sizes of the photovoltaic array, Generator, and the batteries are 10 kW, 20 kW, and 24.7 kWh, respectively.

Rural areas suffer from high costs of grid extensions obliging institutions to provide for other remedies for consumers, like using generators (GE) diesel often considered as economic and reliable solutions, but at the detriment of some order environment pollution and users convenience. Furthermore, the continuous decline in GEs prices based on a renewable energy (RE) and the increasing reliability of these systems have lead to a greater use of renewable energy sources for power generation in remote areas. A property which limits the use of renewable energy is related to the variability of resources. Fluctuations in load according to annual or daily periods are not necessarily correlated to the resources. In remote areas, the preferred option is the coupling between multiple sources, such as wind turbines and solar panels; this coupling is called hybrid power system

HOMER model is used here to size a propose system and determine an optimum configuration.

2, Introduction

This paper is an introduction to the concept of using on-site energy hybrid systems to provide enough power to meet the current and future power needs at an isolated site Addis Ababa, Ethiopia Safaricom Ethiopia Data center. Research will show that hybrid systems are intrinsically better as they allow for the *synergistic combination of two techniques with more strengths and less weaknesses than either technique alone*.

The environmental research center is in need of improving sustainable power to operate and improve its facilities, research activities and continued growth on a whole. Over the years, research activities have grown but the foreseeable future is impeded by the high cost of fuel and diesel and increased electricity demand at the site.

Simulation by Homer software

Model optimizing micro powers help to evaluate design of off grid and grid connected power system for several applications, when a power system is designed many discussions taken in to account about the system configuration
Which component including in the design system
The large number technology option and variation on technology cost
We will use hybrid optimization Multi electric renewable (HOMER) Software, homer due to its flexibility
Homer Pro is used to design and find optimize configuration of hybrid power system in terms of stability, low cost, size and number of components

The aim of this paper is to design hybrid power system model with metrological data inputs also describe feasibility technology components cost based on availability of resource.

The simulated result using Homer gives economic analysis with each configuration and evaluates the best configuration.

3, Background

In Ethiopia specially Addis Ababa cites more power fluctuation on the main grid and the fuel consumption every month’s increment and we are facing power issue.

The main goals of the MRC are to:

- Establish a financially self-sustaining field facility which will complement UB's programs
- develop UB's technical capacity to independently provide training, research and education on coastal issues

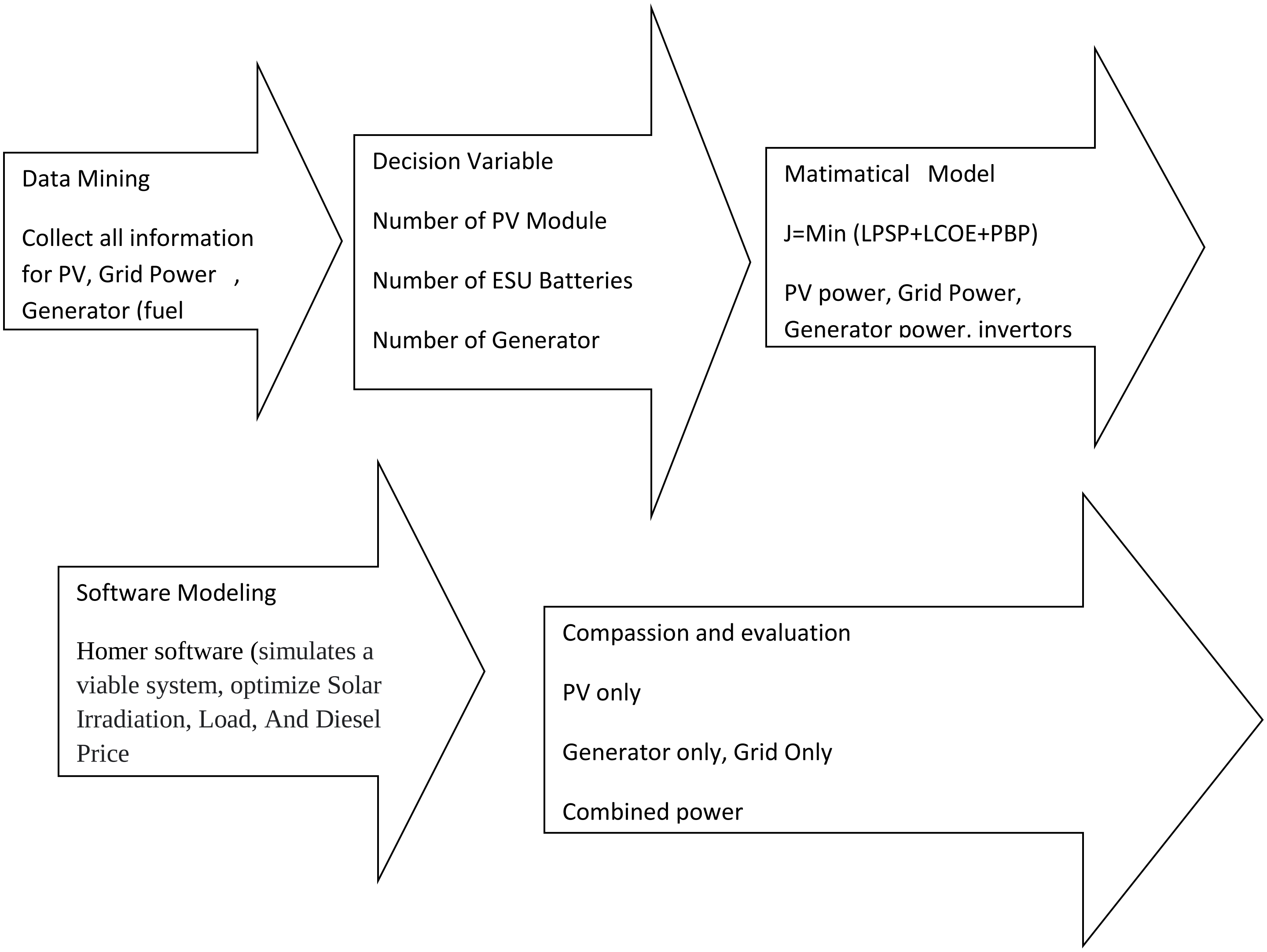
The Site information

The latest data obtained from the Meteorological Department includes information on solar power frequency period 2015 data is taken in frequency using PV, As is noted from the table below, the highest mean solar power are reported for March-April, with least mean solar power data reported for half of December, followed by January.

Month	Solar energy Wh/m2/d
September	10.34
October	9.98
November	9.38
December	49.04
January	9.25
February	9.85
march	10.36
April	10.47
may	10.22
June	9.98
July	10.04

4, Materials and Methodology

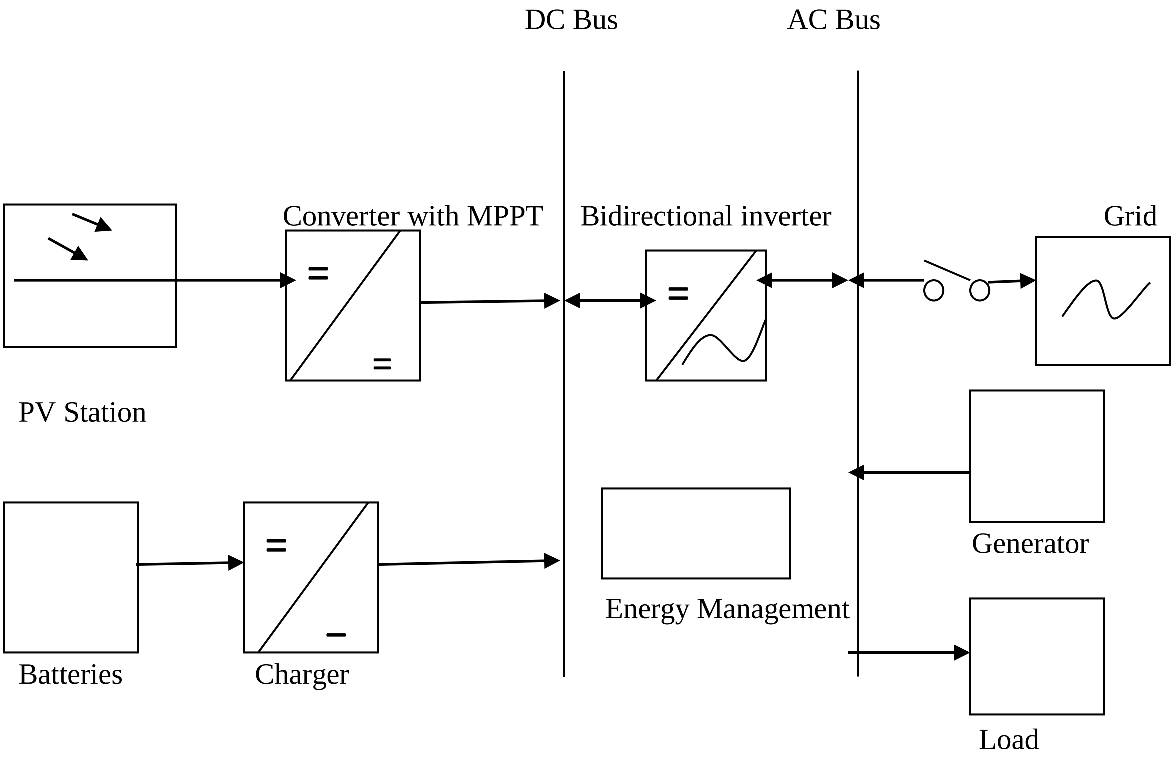
The HRES of the PV-WT-ESU-diesel generator system is consider to ensure uninterrupted power supply to a household community suffering schedule load shedding from the grid. Assumed given is the load shedding schedules, the availability of the endogenous renewable resources, the load demand profile, as well as the relevant technical and economic characteristics of commercially available equipment (rated power, efficiency, and capital cost). The objective is the optimal design of the system that minimizes, simultaneously, both the technical and economic objectives. The technical objective considered is the loss of power supply probability (LPSP), which reflects the reliability of the system. The economic objectives are describe by two parameters: the levelised cost of electricity (LCOE) and the payback period (PBP), both calculate using life-cycle assessment. The optimization will perform using a multi-objective GOA using the weighted sum method. Through the use of a weighting factor, which a priori expresses a trade-off between three objectives (LPSP, LCOE, and PBP), a multi-objective optimization problem is reduce to a single objective and solve in a simplify way The technical objective consider is the loss of power supply probability (LPSP), which reflects the reliability of the system. The economic objectives are describe by two parameters: the levelised cost of electricity (LCOE) and the payback period (PBP), both calculated using life-cycle assessment. The optimization will perform using a multi-objective GOA using the weighted sum method. Through the use of a weighting factor, which a priori expresses a trade-off between three objectives (LPSP, LCOE, and PBP), a multi-objective optimization problem is reduce to a single objective and solve in a simplify way.



HRES Architecture and Modeling the propose HRES of a multi-bus system is present. The PV, WT, and ESU are connecting to the DC bus, while the generator, grid, and load are directly connect to the AC bus. The PV array is connected by means of a unidirectional DC-DC converter with the maximum power point tracking control. The ESU, construct from a lead-acid battery bank, will connect via a bidirectional DC-

DC converter ,Here, P_Load (t) is the load demand at time step (t) and P_PV (t), P_WT (t), P_ESU (t), P_Gen (t) and P_Grid (t) are the power supplied by the PV, WT, ESU, generator, and grid at each t, respectively. The positive/negative sign associated with the ESU and the grid indicates the ability of the sources to generate and absorb the power, respectively. ηinv is the efficiency of the bidirectional inverter. For simplicity, the efficiency of other converters is assumed to be unity.

The energy supply of the system (i.e., the sum of all energy production components) should be equal to the load demand over the entire scheduling time range (P_PV(t) +) ± P_ESU(t) × ηinv) + P_Gen(t) ± P_Grid(t) = P_Load(t)



Photovoltaic Model The power output of PV (P_PV) for any irradiance (G) and temperature (T) can be calculated using a single diode model. The output current of PV is given as: IPV = [(ISC−STC + ki(T − TSTC)) G GSTC]−I0[(e) (VPV+IPV RS VT) − 1] − (VPV + IPV RS RP) (2) where ISC-STC is the short circuit current at standard test conditions (STC) (i.e., G = 1000 W/m2 and T = 298 K), ki represents the short circuit current coefficient, Io is the leakage current of the diode, VT = akT/q refers to thermal voltage, and a is the ideality factor that ranges between (1 ≤ a ≤ 2) . K represents the Boltzmann constant considered as 1.381 × 10−23 J/K and q is the electron charge considered as 1.602 × 10−19 C. RS and RP are the series and shunt resistances,]. For this research, the Kyocera KD325GX-LFB (325 W) solar panel is consider.. The total output power of the entire array (P_PV) is calculate by multiplying the total number of modules (NPV) with Pmax (t): $PPV(t) = NPV \times Pmax(t)$

Energy Storage Model the ESU is used to complement the energy excess or deficit via the charging or discharging process, respectively. It stores surplus power that is not absorb by the load and delivers the stored energy when there is a shortfall in the generation. The charging and discharging process of the ESU is controlled by estimating the state-of-charge (SOC) of batteries. The model present in is used to calculate the SOC of the ESU: $SOC(t) = SOC(t - 1) \times (1 - \sigma) + (PBat(t)) \times \eta Bat$ (7) PBat represents the charging and discharging power of battery according to its required and available power, respectively. For longevity, the SOC is bounded by the upper and lower limits (i.e., SOCU, SOCL). The power required by the ESU (P_ESU_Req) is the minimum amount of power that if applied continuously increases the SOC of the ESU from the initial to the upper limit (i.e., SOCU) in the time step Δt. The P_ESU_Req is given as: $P\_ESU\_Req(t) = (SOCU - SOC(t)) \times Cbat \times Nbat\ \Delta t$ (8) Likewise, the power available for the ESU (P_ESU) is the maximum amount of power that the ESU can deliver continuously before reaching the lower limit (i.e., SOCL) in one time step. The P_ESU is given as: $P\_ESU(t) = (SOC(t) - SOCL) \times Cbat \times Nbat\ \Delta t$.

5, Budget

Cost analysis of this project

Components	Capital cost
PV	18130$
Grid	14540$
Generator	12727$
Total	45397$

6, Reference

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2. Samy, M.; Mosaad, M.I.; Barakat, S. Optimal economic study of hybrid PV-wind-fuel cell system integrated to unreliable electric utility using hybrid search optimization technique. Int. J. Hydrog. Energy 2020, 46, 11217–11231. [CrossRef]