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Resource assessment of the renewable energy potential for a remote area: A review

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A B S T R A C T

Hybrid Renewable Energy Systems are the appropriate off-grid electricity generation technology for the remote area. These systems are proper solutions to overcome defects of each renewable resource, these system also have a simple structure and do not require to costly structure and complicated grid infrastructure. The HRESs are typically constructed by combining multiple most available Renewable Energy Sources in one particular area. Hence, the potential of various RES should be estimated to obtain the most available RES in the first step. The current study reviews previous outstanding studies in the context of various RES potential parameters (theoretical, geographical and technical) determination and various methodologies for estimating these parameters. This resource assessment is usually required to obtain the configuration of the HRES in the first step of the HRESs design. The main attempt is to provide a comprehensive study which can be employed as guidance for estimating resource assessment of the RES in different circumstances.

Contents

Abbreviations: AGL, Above Ground Level; MCP, Measure Correlate Predict; CNT, Centralized; MDM, Metrological Department Malaysia; CSP, Concentrating Solar Power; MMD, Malaysian Meteorological Department; DCNT, Decentralized; MHP, Micro Hydropower; DEM, Digital Elevation Model; MSG, Meteosat Second Generation; DG, Diesel Generator; NCAR, National Center for Atmospheric Research; DNI, Direct Normal Irradiance; NCEP, National Center for Environmental Prediction; ECMWF, European Centre for Medium-Range Weather Forecasts; NPC, Net Present cost; GIS, Geographical Information System; PDS, Parabolic Dish System; GSIS, Geo-Spatial Information System; PTC, Parabolic Trough Collector; GsT, GIS-based GeoSpatial Toolkit; PVC, Present Value Cost; HES, Hybrid Energy System; PVGIS, Photovoltaic Geographic Information System; HIRAM, High Resolution Atmospheric Model; HMS, Hydrological Modeling System; RBF, Radial Basis Function; HOMER, Hybrid Optimization Model for Electric Renewables; RE, Renewable Energy; RES, Renewable Energy System; HRES, Hybrid Renewable Energy System; RET, Renewable Energy Technologies; IEA, International Energy Agency; SARERD, South African Renewable Energy Resource Database; LFR, Linear Fresnel Reflector; LLP, Loss of Load Probability; SHP, Small Hydropower; LP, Linear Programing; TRNSYS, Transient System Simulation; MAPE, Mean Absolute Percentage Error

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1. Introduction

Renewable Energy technologies (RET) such as solar (PV and Concentrating Solar Power (CSP)), wind (offshore and onshore), hydropower (small and large scale), and etc. have been developed and commercially well-established in the latest years [1–3]. The majority of Renewable Energy Sources (RES) are variable and not reliable for generating 24 h electricity. Thus, they have not been employed to produce electricity continuously. Combinations of two or more RES production such as wind/solar plus storage (which called Hybrid Renewable Energy System (HRES)) can complement each other and can address efficiency, reliability, emissions and economic constraints [4]. Some advantages of the HRES are as follows: (a) predictable cost (unlike common fuels i.e. oil) (b) reduced carbon emission (it does not need fossil fuels except sometimes as a supporter) (c) autonomous HRES can generate enough electrical power without connecting to the national grid (d) employment opportunity and enhance the local people life (e) simple installation, maintenance and utilization (f) ability of changing demand capacity according to electricity demand [5]. In addition, the HRES is a proper solution for islands and remote area which impossible or expensive to connect national grid [6–10].

Nowadays, approximately 29% population of the world [11] and 0.7% of Malaysian people who usually live in remote regions, do not have accessibility to the electrical grid [12]. In this situation, diesel generator (DG) is usually known as a temporary solution to produce electricity power, while DG is not considered as a suitable energy harvester in terms of environmental (CO_2 and harmful emissions) and economic issues (expensive fuel and generator maintenance). Indeed, although the capital cost of the renewable energy generators (i.e. wind turbines or PV) are higher than DG and it is available all the time, contrariwise the operation and maintenance cost of the HRES is lower than the DG [13].

Alternatively, the stand-alone HRES usually has more reliability and lower costs than autonomous PV or wind [14], henceforth the HRES is a proper technology for the remote area. The HRES usually consists of two or more RES with battery, and a supporter generator (usually DG) which is employed to improve the total system reliability. Commonly, the aim of using HRES is to produce reliable 24 h electricity, so efficient and reliable performances are the main goal. A conventional HRES contain a back-up DG as a supporter for rush electricity hours and throughout poor RES hours in a period [15]. An example of a simple PV-wind-DG HRES is shown in Fig. 1.

As mentioned, currently DG sometimes is employed as a supporter, so if an RES is used in this combination instead of DG as a supporter, this system would be comprised with all RE and also has the required reliability. Among the RES, hydropower energy is an appropriate alternative for DG, because it can be generated electricity by capturing energy water flow, so it does not a variable resource and can produce 24 h reliable electricity [16]. Moreover, these streams are typically abundant in a remote area in Malaysia (future targeted case study) and these sources are near to the community who live in these areas. Hence, it does not need long and expensive distribution system. In addition, hydropower resources are divided into small and large scales which use to produce power based on the amount of the consumption. Accordingly, a suitable scale of hydropower, wind, and solar PV energy configuration for HRES can be the most appropriate integration based on resource assessment in a different area [17]. However, the review of the previous titles in this context show that a few number of reports were investigated a HRES system with a renewable energy supporter as a reliable source [18], so some of the future studies can be focused on this issue.

Typically, the HRES should be designed with a well-defined and standardized frame-work which was listed by Negi et al. [19] for rural electrification as below:

1. Demand Forecast
2. Resource Assessment
3. Constraints or Barriers
4. Hybrid renewable system configuration

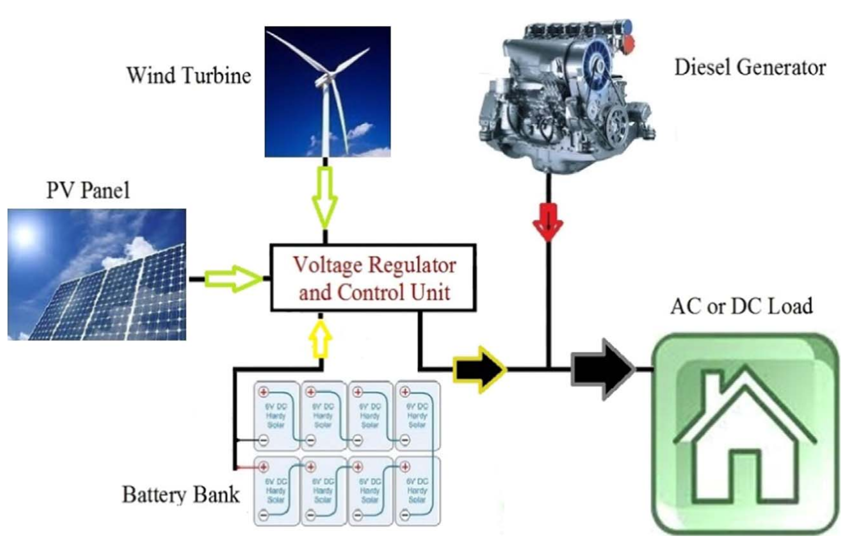

Fig. 1. Conventional HRES combined with a DG as a supporter.