Location-based Solar Energy Potential Prediction Algorithm for Mountainous Rural Landscapes

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Abstract. -- *The* ***world is facing critical energy crisis today. As a result the conventional grid energy supplies are not enough to meet the present demand. Many advance researches are in progress to overcome this energy predicament. Power generation and management in disconnected rural villages is challenging. The situation is even more challenging when landscape structure in such environment are irregular. Forces of diffusion, ground reflectance and sky view factor among others, affect the quality of final solar radiation incident on a solar panel. This paper describes the implementation of an algorithm that can be used to predict solar energy potential of irregular landscapes. Location-based Solar Energy Potential Prediction Algorithm (LOSEPPA) takes as input, the geographic latitude and longitude of the location of interest to compute the Solar Irradiance Factor (SIF). Geographic latitude plays an important role in the availability of sufficient solar radiation as well as the state of the atmosphere. Therefore, SIF value serves as a guide to the state of the atmosphere in terms of degree of cloud cover, temperature, humidity and landscape structure; which determines the feasibility of the solar energy implementation. The approach described in this paper can be used for rapidly computing the amount of solar radiation generated on a mountainous landscape surface and in the atmosphere as a function of height parameters. With SIF value known, solar panel can be mounted along specific angle of inclination to the sun. The algorithm design covers one year period and is based on the Digital Elevation Model (DEM) of the location under investigation. The proposed system was simulated using MATLAB[1].***

Result show that the more irregular the landscape is, the lower the solar irradiance factor. SIF value of 400 and above predicts well enough sunshine for solar PV implementation in mountainous landscapes. Sample results show that solar radiation per kernel per day for a given landscape is highest between 12noon and 2.00PM local time; and the radiation per kernel per year for a given landscape have highest sunshine hours in January and December.

Keywords-Geographic latitude**, **Diffusion, Solar Panel, Landscape, DEM

SYMBOLS AND ABBREVIATIONS

α - Geographic Latitude

$\in$ - Angle of rotation of the XYZ coordinates

δ - Solar declination angle

β - Angle between the earth's axis and the XYZ coordinate Z axis

t_0, t_1 – Time of rotation of the XYZ coordinate from t_0 to t_1

n – Vector normal to the grid cell surface

S_0 – Solar vector at noon local time

S_v – Solar vector at time t

S_C – Solar Constant (1367 Wm^{-2})

Kernel – 3X3 Grid Window

SKV – Sky View Factor

DEM – Digital Elevation Model

SIF – Solar Irradiance Factor

FCN - Four Closest Neighbors

MAPE – Mean Absolute Percentage Error

ANN – Artificial Neural Network

MBE – Mean Bias Error

RMSE – Root Mean Square Error

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I. INTRODUCTION

This paper is the first of two papers describing the implementation of intelligent algorithms useful in solar energy potential prediction, generation and management in topographically challenging rural areas. In response to the growing concern over the use of fossil fuels, renewable energy industries are becoming significant economic drivers in different parts of the world. Disconnected rural communities are cut off from government economic transformation agenda as a result of not being connected to the national grid. Many remote residences, businesses and communities located in the sparsely populated and rugged terrains; faces serious challenge in accessing uninterruptible wireless broadband as a result of intermittent electricity supply. An alternative energy supply system in the form of solar electricity, supported by indigenous communities has been widely accepted as a provisional escape route for the rural folks from abject poverty caused by digital divide. The stand-alone photo-voltaic energy system is a well tested energy alternative in an environment where grid electricity is completely absent. However, in mountainous areas, amount of solar radiation obtained on a landscape surface is impacted by numerous environmental factors such as cloud cover, humidity, zenith angle of the sun, diffusion, ground reflectance, air-mass ratio, sky view factor (SVF) and the general albedo of the land surface among others; that must be taken into consideration in order to get the net solar radiation incidence on the solar panel. Terrain parameters derived from DEMs, such as slope, aspect and

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