INTERGRATION OF LiDAR DATA WITH AERIAL IMAGERY FOR ESTIMATING ROOFTOP SOLAR PHOTOVOLTAIC POTENTIALS IN CITY OF CAPE TOWN

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ABSTRACT:

Apart from the drive to reduce carbon dioxide emissions by carbon-intensive economies like South Africa, the recent spate of electricity load shedding across most part of the country, including Cape Town has left electricity consumers scampering for alternatives, so as to rely less on the national grid. Solar energy, which is adequately available in most part of Africa and regarded as a clean and renewable source of energy, makes it possible to generate electricity by using photovoltaics technology. However, before time and financial resources are invested into rooftop solar photovoltaic systems in urban areas, it is important to evaluate the potential of the building rooftop, intended to be used in harvesting the solar energy. This paper presents methodologies making use of LiDAR data and other ancillary data, such as high-resolution aerial imagery, to automatically extract building rooftops in City of Cape Town and evaluate their potentials for solar photovoltaics systems. Two main processes were involved: (1) automatic extraction of building roofs using the integration of LiDAR data and aerial imagery in order to derive its' outline and areal coverage; and (2) estimating the global solar radiation incidence on each roof surface using an elevation model derived from the LiDAR data, in order to evaluate its solar photovoltaic potential. This resulted in a geodatabase, which can be queried to retrieve salient information about the viability of a particular building roof for solar photovoltaic installation.

1. INTRODUCTION

Countries around the world are grappling with the challenge of finding and promoting various sources of sustainable energy, which will align their attitude towards energy consumption with their environmental, social and economic targets (IEA, 2012). Likewise, both developed and emerging countries face similar energy and environmental challenges. South Africa, being among the developing countries is no exception. As a matter of fact, South Africa's energy demand is projected to double its current levels by 2030 (SA GCIS, 2013).

Various studies have shown that renewable energy sources, especially the solar energy using photovoltaic systems, offer a viable and expedient means of meeting shortfalls in electricity production within a short period of time (Timilsina et al., 2012; Krupa & Burch 2011; Pegels 2010). Also, it has been discovered that in most part of the world, the technical potential of solar energy often exceeds the prevailing total primary energy consumption of such areas, when evaluated (De Vries et al., 2007). The viability of solar energy was recently further made obvious with its implementation in powering an aircraft (Solar Impulse 2): for the first time in history, an aircraft was able to fly day and night, even for longer periods of time, up to 100 hours, without using fuel.

This study was aimed at demonstrating how remote sensing and GIS techniques can be integrated to automatically extract building roofs, and evaluate its potentials for solar photovoltaics in the city of Cape Town. Considering the huge number of buildings involved, the automatic roof extraction process becomes a vital aspect of rooftop solar photovoltaic evaluation, especially when existing building roof outlines are not readily available as input. In achieving this, LiDAR-derived surface models were integrated with aerial imagery to detect and automatically extract each building roof outline. Then the global solar radiation over each roof surface was estimated using a LiDAR-derived DSM. The final stage involved combining the outputs of the automatic roof extraction process, the solar radiation estimation with other energy exploitation parameters, such as solar panel efficiency to determine an estimate of electricity each building roof can harvest through the solar photovoltaic systems.

2. BACKGROUND

2.1 Solar Energy

Solar radiation can be harnessed and converted to electricity using the photovoltaic cells, which absorbs photons and then release electrons, these can then be captured in the form of an electric current (Knier, 2002). However, there are some key issues affecting the wider use of solar energy, these includes strong spatial and temporal variations, as well as the ability to efficiently quantify the amount of solar radiation incident over a surface (Hofierka & Kanuk, 2009).

Three sets of factors mainly determine the amount of solar radiation passing through the atmosphere to reach any surface

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