A Methodology for Assessment of Rooftop Solar Potential for Widely Distributed Property Holdings: Challenges, Lessons Learned and Future Directions

Andrew Miles*[1] and Lesley Browne†[2]

[1]Department of Geography and Development Studies, University of Chester
[2]ESGP Ltd

December 20, 2014

Summary

A methodology has been developed to enable detailed assessments of rooftop solar potential to be carried out for large numbers of buildings, distributed across very wide areas (regional or national scale). This process is driven primarily by high resolution elevation data and small scale vector mapping data, integrated into a geoprocessing model in order to analyse widely distributed buildings in an iterative fashion. Work so far has produced a viable model for assessing rooftops across England and Wales, but has also identified a number of avenues for improvement both in terms of the efficiency of the methodology and the accuracy of its outputs.

KEYWORDS: renewables, solar, geoprocessing, large scale

1. Introduction

In recent years the renewables agenda has continued to gain prominence, driven by predictions of future climate change and the need for low carbon energy sources (IPCC, 2014). Within this field GIS techniques have played a key role in identifying suitable sites for a range of renewables technologies, most notably wind and solar. However, studies have largely focused on one of three scales. Firstly the detailed analysis of individual sites (Appleton & Lovett, 2003), driven by landowners desiring an understanding of the potential offered by their property as well as the need for detailed understanding of the sites for planning purposes. Analysis of this type generally takes advantage of high resolution datasets and detailed mapping data, possibly enhanced by primary data collection. Secondly assessment at citywide scales. This approach takes advantage of high resolution datasets such as airborne LiDAR along with the computational efficiency of analysing a compact area to provide very detailed analysis of a large number of buildings (Brito *et al.,* 2012; Nguyen & Pearce, 2012). Finally national or international scale assessments have been carried out to estimate the potential renewable resource available for long term development. These types of assessment make use of much coarser datasets in order to reduce the computational load (Šúri *et al.* 2005) or require significant assumptions in order to produce their estimates (DECC, 2010).

However, many organisations possess land and property holdings which do not easily fit into any of these categories. Large corporations, government departments or charitable organisations may own property with significant potential for renewable energy generation, but spread over hundreds or thousands of sites which are distributed nationally. Therefore an approach to site suitability

* a.miles@chester.ac.uk
† lesley@esgp.co.uk

assessment which allows for an accurate assessment of solar potential for these widely distributed sites may encouraging the uptake of renewable energy generation among such organisations, with the benefits including reductions in their operational costs, generation carbon savings and contributing to national targets for reducing emissions.

This study outlines the creation of a GIS work flow to allow for assessment of rooftop solar potential at this scale, along with lessons learnt and avenues for future research. This is achieved through the production of a geoprocessing model which utilises LiDAR data and Ordnance Survey MasterMap in an iterative fashion

2. Methodology

The greatest challenge in producing a methodology for assessment of solar potential across widely distributed sites is doing so in a manner which is computationally efficient enough to run within feasible timescales. Airborne LiDAR data has widely become the dataset of choice for assessing solar potential of rooftops due to its relatively high resolution (c. 1m) and good vertical accuracy (± 0.1m), making it possible to generate accurate 3D models of the urban landscape (Nguyen, Pearce *et al.*, 2012). In addition it now has widespread availability across many areas, particularly within the UK. However, this resolution comes at a cost in terms of dataset size. While modern computers can often comfortably handle datasets or several gigabytes in size, national LiDAR coverage of the UK would run into many tens or hundreds of gigabytes and therefore could not feasibly be handled by standard computers and software. Therefore for each site under consideration, it is necessary to identify the required extent of the data, merge or clip relevant datasets as appropriate, undertake a series of analysis steps in order to identify the proportion of each site suitable for solar generation, generate meaningful outputs and ultimately combine this information from all of the sites considered into a format which can be used to direct the installation of solar PV generation.

However, it is equally unfeasible to carry out such operations manually over hundreds or thousands of sites; therefore an efficient method of automation must be used. In the first instance this operation has been carried out using the ESRI ArcGIS software suite. The ModelBuilder tool within ArcGIS was used to construct a model to carry out all of the main functions of a solar suitability assessment, and was then expanded to identify particular locations of interest from the datasets provided and undertake the assessment iteratively for each site of interest. A summary of the steps involved is shown in Figure 1.

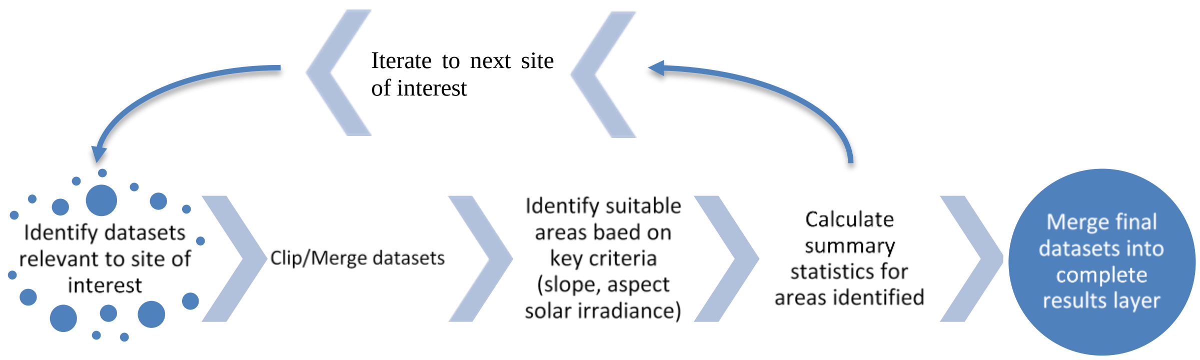

Figure 1 Broad stages of the geoprocessing model constructed in ModelBuilder

For the purposes of limiting analysis to relevant rooftops, small scale building polygon data from Ordnance Survey MasterMap was used to select and mask buildings of interest. This represents a significant saving in processing time compared to analysing the full extent of the LiDAR elevation model. Utilising this methodology it was possible to undertake a detailed solar suitability assessment for several hundred buildings widely distributed across England within a few hours.

3. Results & Lessons Learned

The method outlined above allowed for the analysis of one or more buildings falling within a 1 kilometre grid square to be carried out on the order of 3-5 minutes, and can be easily iterated through hundreds of grid squares with no need for further manual intervention. This demonstrates the feasibility of undertaking such assessments for organisations with considerable assets, but with a wide spatial distribution, which is a scenario not addressed by previous methods for site suitability assessment.

Preliminary validation of the results has been undertaken through discussion with property owners and comparison of solar irradiance values with established databases of solar irradiance such as PVGIS (Šúri *et al.* 2005). Findings so far indicate that suitable roof areas identified are realistic for the majority of rooftops and that calculated values of solar irradiance broadly agree with those anticipated for the latitudes of the buildings being assessed.

Although the analysis process itself is relatively rapid, considerable work is required in data preparation and cleansing in order to ensure that the geoprocessing model can run without encountering errors. Currently error handling within the ModelBuilder environment is limited and certain scenarios, such as encountering a tile in which none of the buildings assessed contain suitable roof areas, can lead to premature termination of the model. This is currently being addressed by conversion of the model to a Python script, which offers the potential for more robust handling of errors as well as other benefits discussed below. As a result the undertaking of assessments of this type is not trivial and still represents a significant undertaking. Another issue which has been encountered is the difficulty in accurately identifying suitable areas on very complex roofs, for example those containing numerous air conditioning units or other equipment which may be smaller than or similar to the resolution of the LiDAR data.

4. Conclusions

While this methodology may not achieve the accuracy that would be possible by undertaking detailed assessments on a building by building basis, it provides a valuable and robust estimate of rooftop solar potential which will allow managers of estates consisting of hundreds or thousands of properties to identify those which they should be focusing their efforts on for the greatest returns.

A number of avenues for future development and refinement of this methodology exist. As well as improving error handling, conversion of the workflow to a Python script offers significant increases in performance, with tests indicating up to a 33% reduction in the time taken for some processing tasks. The development of metrics for identifying the complexity of rooftops is also planned in order to identify those rooftops most likely to require further checking and validation. Finally the accuracy of the solar model used is critical in generating reliable estimates of energy outputs and cost/carbon savings. A priority for future work lies in improving the tools being used for solar modelling to increase the reliability of these estimates as far as possible.

5. Acknowledgements

The authors would like to acknowledge colleagues at ESGP Ltd. who have given considerable effort to developing, refining and checking the tools and outputs discussed in this paper.

6. Biography

Dr. Andrew Miles completed his PhD at Lancaster University in 2014 and is now a Lecturer in Physical Geography and GIS at the University of Chester. He has a broad range of interests in GIS and geospatial analysis, as well as a focus on its application for monitoring coastal processes.

Lesley Browne is a Senior Geospatial Analyst at ESGP Ltd. She is involved in the commercial development and operation of GIS models, primarily for site suitability assessment of renewables.

References

Appleton, K., and Lovett, A. (2003). GIS-based visualisation of rural landscapes: defining ‘sufficient’realism for environmental decision-making. *Landscape and Urban Planning*, 65(3), 117-131.

Brito, M. C., Gomes, N., Santos, T., and Tenedório, J. A. (2012). Photovoltaic potential in a Lisbon suburb using LiDAR data. *Solar Energy*, 86(1), 283-288.

DECC (2010). Renewable and Low-Carbon Energy Capacity Methodology for the English Regions

IPCC (2014). *Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Nguyen, H. T., and Pearce, J. M. (2012). Incorporating shading losses in solar photovoltaic potential assessment at the municipal scale. *Solar Energy*, 86(5), 1245-1260.

Nguyen, H. T., Pearce, J. M., Harrap, R., and Barber, G. (2012). The application of LiDAR to assessment of rooftop solar photovoltaic deployment potential in a municipal district unit. *Sensors*, 12(4), 4534-4558.

Šúri, M., Huld, T. A., & Dunlop, E. D. (2005). PV-GIS: a web-based solar radiation database for the calculation of PV potential in Europe. International Journal of Sustainable Energy, 24(2), 55-67.