Estimating Solar Power Potential

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1. Executive Summary

Renewable energy plays a large part in reduction of carbon emissions and non-renewable resources. Renewable energy systems rely on natural resources that are continually replenished and are thus less polluting. As technology advances so does the ability to harness these renewable resources. To fully utilise the potential of renewable energy sources, it is necessary to analyse resource availability both spatially and temporally. This project will attempt to identify rooftops in the City of Melbourne suitable for tapping solar energy based on global solar radiation data and solar installation requirements providing a picture of the city's solar potential. The top 10 buildings were identified and 4 of which were selected for analysis, showing that these buildings together receive 102,258.68 MWh useable solar radiation and have a 13,191.37 MWh electric production output.

2. Introduction

Australia has the highest solar radiation per quare metre of any continent, receiving on average 58 million PJ of solar radiation per year, yet solar power only represents 0.1% of total primary energy consumption. (Solar Energy | Geoscience Australia, 2021) While the regions with the highest solar radiation are the desert regions, they are also the most inaccessible. Land that is both appropriate in size and without shadowing is simply not available in built up accessible areas… unless we look up. Rooftops are abundant in cities, accessible, provide appropriate square footage, are generally not constrained by shadowing and are often underutilised. This in turn, with Australia's incoming solar radiation levels, gives rise to significant potential.

Locally generated renewable energy plays an important part in delivering on the City of Melbourne's zero net emissions vision and it is valuable for businesses to offset their often large and significant electricity costs. Installation of solar panels lowers electrical bills, demonstrates commitment to sustainability, and reduces reliance on a carbon-intensive electricity grid.

3. Objective

The objective of this study is to investigate and analyse solar energy potential in the City of Melbourne. Treating CoM as the client, this project will aim to identify and deliver buildings in the Melbourne LGA that the city can target for solar installation to maximise the client's benefit-cost ratio through effective and efficient positioning analysis including each buildings approximate electric power output.

4. Study Area:

The City of Melbourne (CoM) is a local government area located in the state of Victoria, Australia. The city has a population of 169,961 people and covers 37 square kilometres. (City of Melbourne - Wikipedia, 2021). Initial analysis of Victoria's solar power potential at a commercial level, identifies the Melbourne LGA as one of the top ranked LGA's in Victoria (fig. 1)

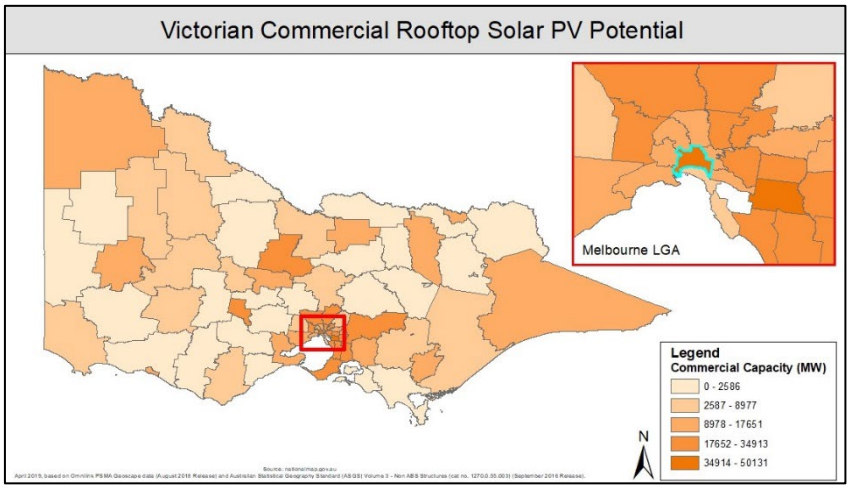

Figure 1 - Map of Victorian Commercial Rooftop Solar PV Potential

The LiDAR tile overlay of the City of Melbourne LGA is shown in fig. 2 using Google Earth to give a visual representation of the LiDAR point cloud data coverage.

Figure 2 - LiDAR tile datasets projected with Google Earth.

5. Methodology

The methodology workflow was inspired and based on the ESRI lesson 'Estimate Solar Power Potential' (Estimate solar power potential, 2021)

5.1 Building Selection and Masking Layer

The analysis of the City of Melbourne Rooftop Project was used to identify the best buildings in Melbourne and eventually became the masking layer in the area solar radiation calculation. This data was created using a spatial multi-criteria analysis (MCA) developed by GHD known as InDeGo (Infrastructure Development – Geospatial Options) and maps rooftop suitability based on 5 criteria: usable roof area, roof pitch (slope), insolation (radiation), access for use & maintenance, and access for construction. The resulting 119,530 rooftop polygons are given a rating based on the criteria.

The data was then run through further selection criteria; buildings rated excellent would only be considered for analysis which results in a reduction to 18,195 rooftops. This was further reduced by sorting by largest area (sq. m). The top 9 were selected and extracted for analysis (table 1). Of these top 9, a manual assessment of each building was conducted, including visual shadow analysis and aerial image evaluation through nearmaps.com to ensure the rooftops were still appropriate for solar installation at the most current date. Two buildings were noted to be inappropriate for further analysis. Tasmanian Freight services located at Footscray Rd is involved in the West Gate Tunnel project and likely subject to future demolition or significant renovation. The other building excluded from analysis was Crown Melbourne. Aerial images showed a now installed green roof (fig. 3). For these reasons, both buildings were eliminated leaving 7 buildings for processing.

Table 1 - Buildings identified for solar radiation calculation.

Object ID	Rating	Shape Length	Shape Area	x-coord	y-coord	Building Name	Street Address	Suburb	Post Code	LAS Tile 1	LAS Tile 2	Accept
9	Excellent	1216	33604	316346.151	5811251.604	Leonardo Australia Pty	130-188 Todd Road	Port Melbourne	3207	COM_G2.tif	COM_F2.tif	Yes
4	Excellent	2332	32180	319695.086	5812708.379	Spencer Outlet Centre	201 Spencer Street	Docklands	3008	COM_E5.tif		Yes
2	Excellent	1184	21620	317168.757	5813730.990	Tasmanian Freight Services	542 Footscray Road	West Melbourne	3003			No
6	Excellent	704	20668	317701.532	5811805.145	Winc Australia	111 Turner Street	Port Melbourne	3207	COM_F3.tif		Yes
7	Excellent	2660	20304	320305.320	5811812.918	Crown Melbourne	8 Whiteman Street	Southbank	3006			No
8	Excellent	816	20300	317436.155	5811499.889	Aramex	2 Douglas Street	Port Melbourne	3207	COM_F3.tif		Yes
1	Excellent	1920	16944	319451.269	5815138.014	Royal Childrens Hospital	50 Flemington Road	North Melbourne	3051	COM_C5.tif	COM_B5.tif	Yes
3	Excellent	800	16924	318408.897	5813177.423	Costco Wholesale	381 Footscray Road	Docklands	3008	COM_E4.tif	COM_D4.tif	Yes
5	Excellent	1616	16252	317211.120	5811817.209	USG Boral Distribution Centre	674-702 Lorimer Street	Port Melbourne	3207	COM_F3.tif		Yes

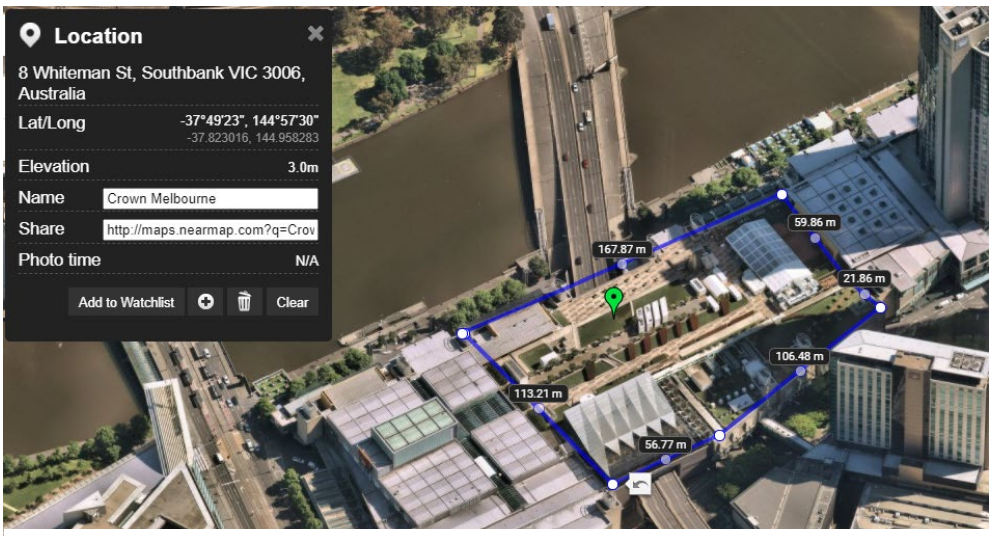

Figure 3- Aerial Imagery showing installed Green Roof at Crown Melbourne

5.2 Digital Surface Model and Hillshade

The LiDAR point cloud was transformed into a digital surface model resulting in 1km x 1km tiles at 1m resolution. To better visualise the DSM, a hillshade was created and set at 40% transparency. Allowing the viewer to better see the relief and DSM details.

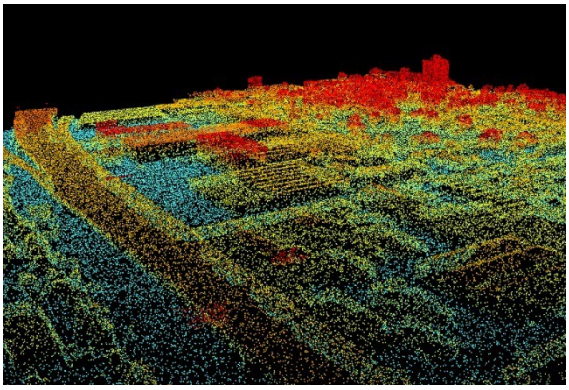

Figure 4 – LiDar Point Cloud

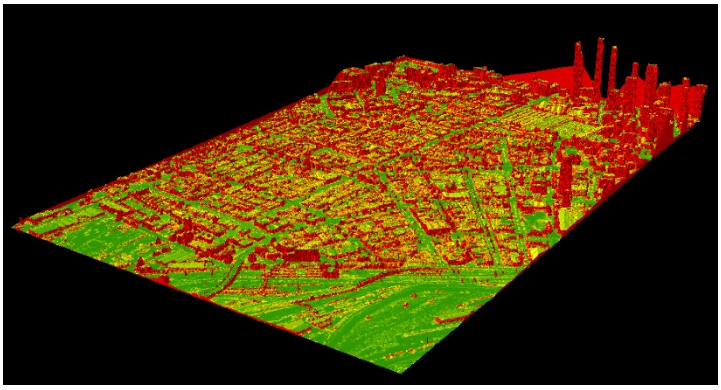

Figure 5 – 3D elevation point cloud

Figure 6 – DSM with 40% hillshade

5.3 Solar Area Radiation

Solar radiation was calculated using the solar radiation tool in ArcMap. The radiation is calculated based on a sophisticated model which considers the following.

- Position of the sun
- Obstacles
- Slope
- Orientation

The digital surface model provides the tool the required information and the output is a resulting raster where each cell is the amount of solar radiation in watt-hours per square meter.

5.4 Aspect and Slope

To remove and/or include the solar criteria(s) in the next step, both aspect and slope raster's need to be created. This was done through the slope and aspect tools in ArcMap using their default properties.

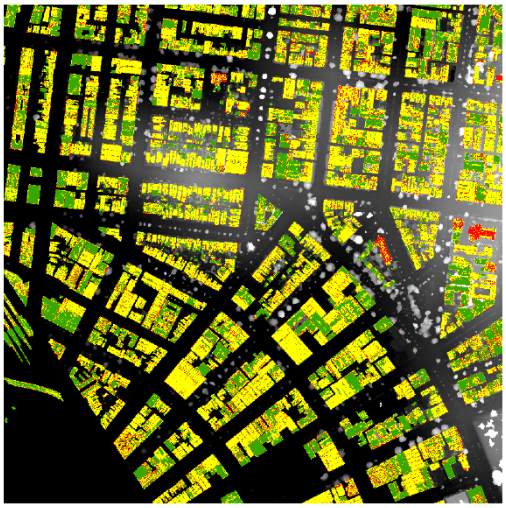

Figure 8 - DSM Slope (<10°, 10°-45°,>45°)

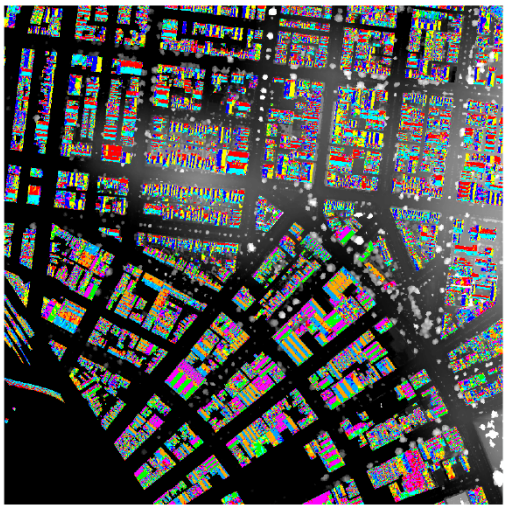

Figure 7 - DSM Aspect

5.5 Conditional Reduction/Inclusion

Rooftops appropriate for installation must meet four spatial requirements. (Table 2)

Table 2 - Rooftop Spatial Requirements

Type	Requirement
Aspect	In the southern hemisphere, south facing rooftops should be excluded.
Slope	Rooftops must not exceed a slope of greater than 45°.
Slope	Rooftops with less than 10° slope can be included no matter the rooftops aspect.
Incoming solar radiation	Rooftops should receive at least 800 kWh/m^2

To exclude or include specific rooftops, the area solar radiation (ASR) raster was run through 4 conditional processes (table 3) using the slope and aspect raster as the conditional and true raster.

Table 3 - Conditional Processes

Process	Conditional Raster	True Raster	False Raster
Remove slopes ≥45°	Slope	ASR	
Remove radiation <800 kWh/m2	Area Solar Radiation	ASR of slopes <45°	
Include or keep slopes ≤10°	Slope	ASR of slopes <45° and radiation >800 kWh/m^2	
Remove rooftops facing south	Aspect	ASR of slopes <45° and radiation >800 kWh/m^2	Slopes ≤10°

5.6 Conversion to electric power

Conversion of solar radiation values is required to give electric power production potential. The power solar panels can produce depends not only on the incoming solar radiation but also the solar panels efficiency and its performance ratio or degradation. This differs between manufacturer and models. The United States Environmental Protection Agency gives a conservative best estimate of 15% efficiency and 86% performance ratio. Skybridge Group Pty Ltd Australia was consulted to see if this was also an accurate representation of Australian solar panels. These conversions are a high-level estimate, but for this project was deemed appropriate.

Useable Solar Radiation

Usable_SR_MWh = Rooftop Area * Mean Solar Radiation / 1000

Electric Production MWh

Elec_Prod_MWh = Usable_SR_MWH * 0.15 * 0.86

6. Datasets

Dataset	Source	URL
LiDAR Point Cloud	City of Melbourne Open Data	https://data.melbourne.vic.gov.au/Environment/Rooftops-with-environmental-retrofitting-opportuni/3927-sgfc
Rooftop Project	City of Melbourne Open Data	https://data.melbourne.vic.gov.au/Environment/Rooftops-with-environmental-retrofitting-opportuni/3927-sgfc
Rooftop Solar PV Potential	National Map	https://www.nationalmap.gov.au/
LGA Polygons	ABS	https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1270.0.55.003July%202016?OpenDocument#Data

7. Coordinate System

GDA 1994 MGA Zone 55.

8. Results

Due to the extensive processing time, high performance system requirements and resulting crashes, unfortunately the processing was not able to be fully completed before deadline of all 7 buildings. 4 buildings were successfully processed in the Port Melbourne area. The results can be viewed in table 4 for the calculated usable solar radiation (MWh) and the electric production output (MWh).

Table 4 - Port Melbourne buildings successfully processed.

Building Name	Street Address	Suburb	PostCode	Usable Solar Radiation (MWh)	Electric Production (MWh)
Leonardo Australia Pty	130-188 Todd Road	Port Melbourne	3207	38286.05	4938.90
Winc Australia	111 Turner Street	Port Melbourne	3207	24352.43	3141.46
Aramex	2 Douglas Street	Port Melbourne	3207	23558.30	3039.02
USG Boral Distribution Centre	674-702 Lorimer Street	Port Melbourne	3207	16061.90	2071.99

9. Discussion and recommendation

Rooftop Project: It should be note that the criteria relate to technical feasibility. There will be a range of other relevant design considerations that need to be considered when considering an individual rooftop opportunity. The key limiting dataset is the 3D city model, which is from 2012. Due to the nature of construction in built up areas, it is likely that has been significant changes since this data capture.

Equation of conversion: Conversion to electric output is a best guess estimation. Factors influencing these numbers are the panels silicone degradation, level of soiling and frequency of cleaning of the panels, as well as converter and invertor capabilities and quality.

Project: If the city wanted to examine these rooftops more closely, then sourcing a panel manufacturer and obtaining its specific efficiency and degradation values would allow for a more accurate electric power output result.

The workflow and methodology have the potential to be applied to a much larger area, however, the project is significantly limited by the ArcMap Area Solar Radiation tool which is a very time and process intensive tool.

10. References

Ga.gov.au. 2021. Solar Energy | Geoscience Australia. [online] Available at: <https://www.ga.gov.au/scientific-topics/energy/resources/other-renewable-energy-resources/solar-energy> [Accessed 10 June 2021].

En.wikipedia.org. 2021. City of Melbourne - Wikipedia. [online] Available at: <https://en.wikipedia.org/wiki/City_of_Melbourne> [Accessed 10 June 2021].

Learn.arcgis.com. 2021. Estimate solar power potential. [online] Available at: <https://learn.arcgis.com/en/projects/estimate-solar-power-potential/#map-solar-energy> [Accessed 11 June 2021].