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Solar-energy collecting potential in urban Honolulu

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A novel method to assess the intensity of solar radiation on existing rooftops uses a combination of aerial images and geographic information systems software.

The Helianthus solar-energy assessment (HSEA) method was developed to evaluate the solar-radiation intensity striking existing buildings in urban areas. It uses aerial images, geographic information systems (GIS) software, and field observations, as well as a robust assessment protocol and additional patented processes. The HSEA method doubles as a powerful design tool aiding the orientation and solar integration of buildings. The Mapunapuna district of Honolulu was selected for the technique's validation study. This urban area, immediately to the northeast of the Honolulu international airport, comprises a mix of industrial, commercial, and residential buildings, thus offering a representative cross-section of building types (see Figure 1). The assessment guidelines were tested for feasibility and accuracy, refined, and adjusted to facilitate an efficient and reasonably accurate evaluation. At present, the research protocols include nine steps, identified below, and a verification procedure.

First, aerial photographs at a scale of 1:48,000 (1in=4000ft) were used. Although not offering the same level of accuracy as larger scales, they allow simultaneous analysis and assessment of insolation of large areas. Since most aerial images must subsequently be scaled and georeferenced to a GIS layer (step 2), the use of a single small-scale photograph speeds up the assessment process. GIS layers also provide helpful information about the area of study, such as land use and zoning, Hawaii-specific tax-map key numbers, and property areas. In addition, a 3D digital elevation model (DEM) of the island of Oahu was acquired, containing elevation information for any point on the map.

Next, we scaled and georeferenced the aerial photographs to the GIS layers. Georeferencing is the spatial alignment of the photograph to known geographical features. Scaling within the GIS program is necessary to identify and calculate surface areas corresponding to actual dimensions.

Figure 1. *The Mapunapuna district of Honolulu. The yellow shading corresponds to our study area.*

We identified building rooftop areas from six specific, homogeneous neighborhoods in the study district (step 4). These sectors were defined by their land use and zoning characteristics, as well as their roof-surface distinctiveness, identified from field surveys and aerial photographs.

The orientation of single building rooftops can be determined through georeferencing to GIS layers (step 5). However, roof-slope angle (or pitch) could not be identified using aerial photography combined with image-recognition software. Field surveys in the study area (step 6) were an important part of the protocol. A pitch factor was tagged to the total surface area for each sector of the study district (step 7).

Global insolation on a horizontal surface (or flat) includes both direct and diffuse solar-radiation values.[1] While this important

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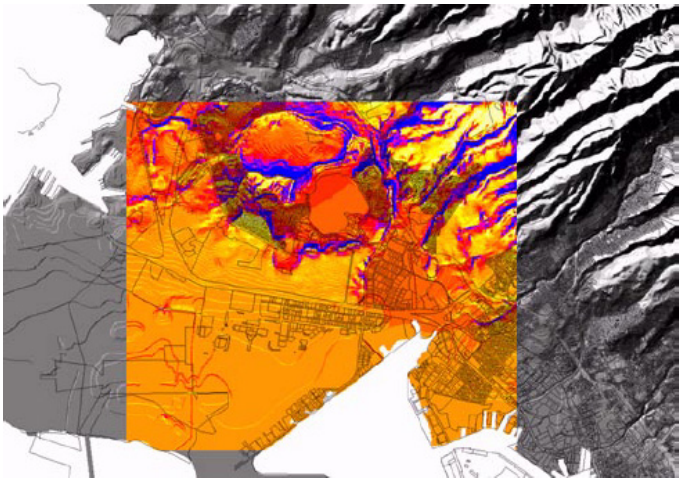

Figure 2. *Insolation map of the Mapunapuna district, with orange and blue representing high and low incident radiation, respectively.*

information is readily available for numerous cities,[2] it does not account for mesoclimatic factors such as orographic overshadowing, which is particularly prominent within the deep valleys surrounding Honolulu.[3] We acquired a GIS extension, Solar Analyst, which enables the identification of solar radiation incident on any terrain[4] (step 8). It also accounts for the shadow effect caused by its topography[5] (see Figure 2). This allowed us to assess the insolation on existing building rooftops (step 9).

Four input variables affect the overall radiation incident on a surface. The first two relate to the clearness index, which quantifies how much cloud cover should be implemented into the model.[5] The third input parameter is linked to the shading coefficient. Shading might be produced by rooftop mechanical equipment, adjacent buildings, parapets, or other obstructions. The final variable is driven by the albedo factor, which can potentially increase the insolation received by a given surface.[1]

We conclude that the roofs in our study area could potentially supply enough electrical power for 250–300 nearby homes per year. While the main purpose of the solar-radiation modeling program is to estimate incident insolation, we can also produce design guidelines pertaining to surface tilt and orientation to optimize solar collection on future structures. This includes considerations of terrain features and shading, and is extendable to locations worldwide if DEMs (and other relevant information) are available.

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