WEB-BASED SOLAR ROOF CADASTRE GOES INTERNATIONAL

AS GLOBAL $C0_2$ EMISSIONS CONTINUE TO RISE, AND AS THE UN CHALLENGED THE WORLD TO AGREE TOUGHER TARGETS AT LAST MONTH'S CLIMATE CHANGE SUMMIT IN BONN, THE FOCUS ON RENEWABLES IS SET TO SHARPEN. HERE, MARTINA KLÄRLE, SANDRA LANIG AND KATHARINA MEIK EXPLORE HOW A WEB-BASED SOLAR ROOF CADASTRE CAN HELP MUNICIPAL AUTHORITIES AND CITIZENS INVESTIGATE THE POTENTIAL FOR SOLAR PLANTS

While the sun generates a large and virtually inexhaustible supply of energy, many questions must be answered before individuals are convinced of its practical value to them. Is my roof suitable for electricity production by a photovoltaic (PV) plant? How much electricity can I produce? Where on my roof does my solar plant produce the highest performance?

A web-based solar roof cadastre has an enormous advantage for disseminating information about PV and solar thermal plants. Equally, it can help public sector authorities and private sector suppliers select the most suitable areas for such plants.

Solar potential analyses can determine the most suitable roof areas. It can help planning and support appropriate strategies (e.g. the use of large industrial buildings) for the use of solar power as well as inform the design of solar plants. In so doing, important environmental and energy policy tasks are fulfilled with a positive external impact.

SUN-AREA conquers the UK!

Bristol is the first city in UK to opt for a solar roof cadaster as an independent assessment tool for the Council and its residents. The pilot project is based on the SUN-AREA approach (www.sun-area.net) adopted in several German municipalities such as Worms (Fig.4) and is being conducted by its developer, Ingenieurbüro Prof. Dr. Klärle of Weikersheim (www.klaerle.de) in partnership with Blom UK (www.blom-uk.co.uk).

Last year, Bristol was one of 30 pioneering councils across the nation to receive government grants to help develop its climate change plans and share best practice with other councils. And while it might be thought that England has less than its fair share of sunshine, the fact remains that considerable electricity yields can still be achieved from solar energy. The goal of this green initiative is to encourage property owners to adopt solar panels, both to save them money and to reduce CO_2 emissions on a nation-wide scale.

In order to accurately calculate the electricity yields for each roof in Bristol, the SUN-AREA method was adapted to suit local climate and political conditions, e.g. regional parameters relating to investments costs.

Methodology

SUN-AREA calculates the solar potential for large urban areas based on high-resolution LiDAR data. Using a WebGIS application, Site-related factors such as the shape, inclination, exposition and shading for each rooftop are considered, as well as ecological factors such as a determination of the CO_2-equivalent. The daily, monthly and annual variation curve of solar radiation is calculated and the results presented for each suitable roof as an online solar potential map. An online calculation is made of profitability and investment costs and suitable PV modules are recommended.

Solar analysis parameters

To calculate the suitability of a roof for a solar installation, several factors have to be considered. Some of them are universal; some depend on the specific location.

Calculating solar radiation: Based on LiDAR 3D point cloud data, the total insolation (measure of solar radiation) for a roof surface over one year (excluding the time period of 15th December to 15th January) is calculated. This takes account of the orientation of interconnecting surfaces, the daily and annual transit of the sun with two components – changing intensity and changing angle of incidence – plus the shadowing effect of objects such as other roof structures, trees and so on on, that temporarily obscure the sun's path. The relationship between direct and diffuse radiation is also calculated in generating a "solar radiation map" for the entire city.

Next, those parts of the 3D surface that receive more than 880 kWh/m^2 are identified and classified as "suitable areas". Their size in m^2 and the total amount of energy received in kWh/a are the relevant attributes that determine suitability for a PV installation. The buildings are "cut out" using OS MasterMap footprints, and a classification and color code of the individual buildings with respect to their "suitability level" ("very good", "good" and "reasonable"), are realised (Fig. 1).

Shade: Shadows cast by vertical objects on the solar panels can cause significantly greater power reductions than a sub-optimal orientation of the generator. Therefore, even partial shading of a module can diminish the overall performance of the installation. Any shading of the solar generator should therefore be avoided. The shadow modelling is based on a grid analysis. The input parameters are the 1m Digital Surface Model (DSM), the geographical site, and the daily and seasonal change in sun angle.

Minimum roof size: In principle there is no limitation to the size of a PV-installation. However an installation should be cost-effective. Under UK conditions, a minimum solar panel of 10 m^2 is required. This corresponds to an installed solar power of over 1 kWp. To decide whether a PV-installation is cost-effective or not depends on the amount of energy produced and fed into the grid and for which installers receive a guaranteed tariff per kWh for 25 years.

For solar thermal installations, a minimum collector surface of 5 m^2 has been applied for the investigation area. This size is sufficient for the domestic hot water supply of a typical family.

Slope: The optimum slope of the solar panels depends on the geographical location. For Bristol the theoretical optimum is 30° – 35°.

"Local Councils can play a vital role in cutting carbon because they have unrivalled local knowledge, experience and influence. We want to tap in to this, so we have awarded just over £2 million to be shared between 30 pioneering councils to work with individuals, businesses and communities to find the best and most effective ways to reduce emissions and stimulate their local economy. The results of the project will decide what works best so other councils across the country can benefit and learn." – *Gregory Barker MP, Minister of State for Climate Change*

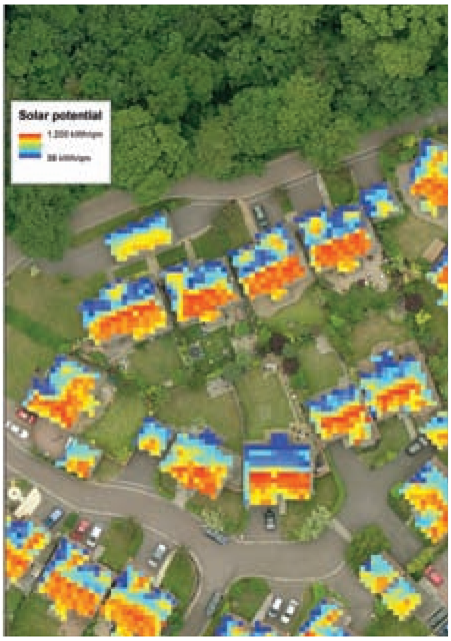

Fig.1: Solar radiation input (in KWh) for various rooftops in Bristol

Global radiance: The intensity of global irradiance depends mainly on geographical location, i.e., position relative to the equator. The input data is the DSM which represents the real surface of the whole city, including buildings with their real roof structures and vegetation. The model calculates the irradiance over a full year, allowing for shading from buildings and vegetation. The result is the irradiance value for every square meter of all roof areas.

Out of these values a weighted average for every roof area is calculated. In our calculation the maximum irradiance onto an undisturbed surface amounts to about 1,200 kWh per m^2 annually. This diminishes considerably if a surface is not well-oriented or is overshadowed. The minimum irradiance which is considered as "well suitable" has been set at 880 kWh per m^2 a year.

For sophisticated analyses of solar radiation over a 12-month period, we chose two different sites to calculate the monthly breakdown. One curve shows the results for a flat undisturbed area (Fig. 2) and the other for an optimal inclined roof area (Fig. 3). The calculation distinguished between the global solar radiation, the direct solar radiation and the diffuse solar radiation.

The results show, that there are no significant differences between the maximum values in summer and the minimum values in winter. In spring and autumn there are higher radiation values for inclined roof areas than for the flat area. This could be an indicator for finding the best places for solar thermal and also PV installations.

Solar Database: Finally the solar database was created with the ID of the property (UPRN) as the lead criteria for interrogating the map. Parameters such as the solar radiation and solar panel area

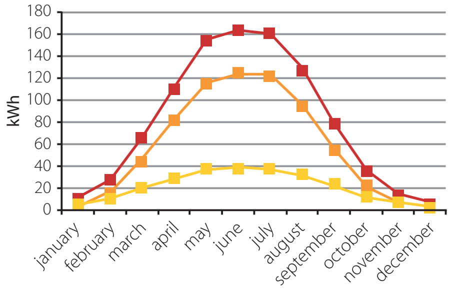

Fig.2: Annual horizontal global radiation

become attributes of each building in the database. This integrated approach accurately calculates the potential power generation capacity of each roof.

Additional attributes are calculated.

- The "power output" assuming a typical PV module efficiency of 15 % (mono-crystalline), 12% (poly-crystalline) and 9% (thin layer techniques) is calculated. The market offers modules with efficiencies from 8% (cheap, thin layer technique) up to 18% (high performance, expensive). At 15% efficiency an active PV area of approximately 7 m^2 is required to generate 1 kWp of electrical power.

- The "CO_2 saving" based on the power generation mix of the UK. Further attributes from other sources can be linked to the database. The savings depend on the CO_2 production rate in the existing mix of power production techniques in UK. We used the average CO_2-equivalent for UK of 543 g CO_2 per kWh.

- Third the investment volume is calculated. The cost of a PV-installation depends on the cost of – mainly imported – components and the local labour content. In coordination with the BCC and Blom UK we have used an average cost of £4.300 per kWp which is typical for medium size installations. This value is flexible and can be re-calculated to take account of price changes.

Fig.4: WebGIS screenshot of an SUN-AREA online solar potential map of Worms (Germany)

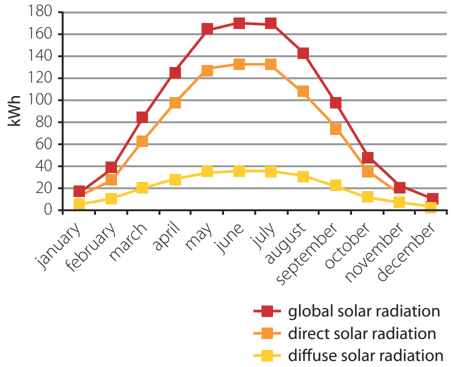

Fig.3: Global radiation for an optimally-inclined and oriented roof

Online solar map

The data are represented in a WebGIS. As an interactive map, it is available for everybody to use online. Just one click and the appropriate information can be retrieved in detail for every building. Each visitor to the website can determine whether a roof is suitable for a PV or solar thermal installtion, how much electricity power or energy could be produced, and how much CO_2 can be saved.

Conclusion

In 2010 the first SUN-AREA solar potential map was published online in Calama (Chile). This shows that the methodology is easily adaptable to other countries. Bristol is the first city in UK to launch an online solar potential map.

SUN-AREA offers a quick and easy way of analysing solar potential. The resulting online solar mapping gives citizens the opportunity to check the suitability of their own roofs for solar installations.

Pictured above (from left) with the 2009 Deutscher Solarpreis for developing SUN-AREA are the authors: Dipl.-Geoinf. Sandra Lanig, engineering consultant, Prof. Dr. Martina Klärle, Vice-dean of the Department of Architecture, Civil Engineering and Geomatics, University of Applied Science Frankfurt Main, and Dipl.-Geogr. Katharina Meik, engineering consultant, all with Ingenieurbüro Prof. Dr. Klärle of Weikersheim


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