F How to Calculate a Building's Rooftop Area

These instructions are to be used with the **Solar PV and Thermal Scoping Tool** on page 64 of this document. The steps below will help you calculate the following:

1. The roof area of your building to estimate the space available for a solar (PV and thermal) installation.

2. Setbacks to estimate the reduction in roof area to conform to safety codes.

3. Usable rooftop to estimate what sized system you can install.

4. System capacity that can be installed to determine how much energy and thermal heat potential can be generated on site.

5. Annual solar PV electricity production and value to determine estimated savings on electricity.

6. Annual solar thermal heat production and value to determine estimated annual savings on gas.

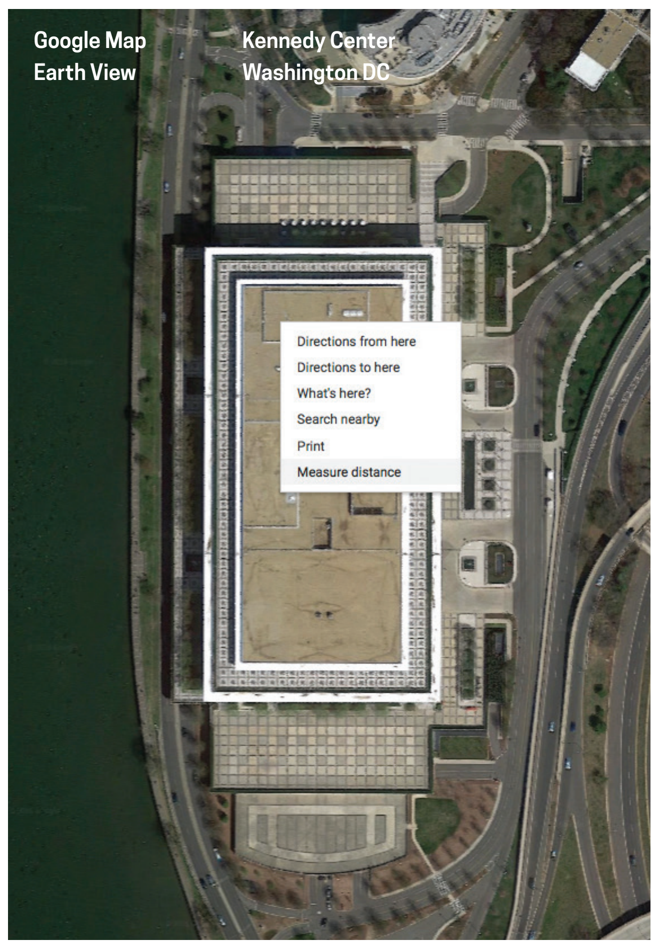
1. Roof area of your building

To estimate how much energy could be generated from the sun on a surface, we first calculate the area to see how many solar panels could be placed on it. There are various rooftop measuring tools online.

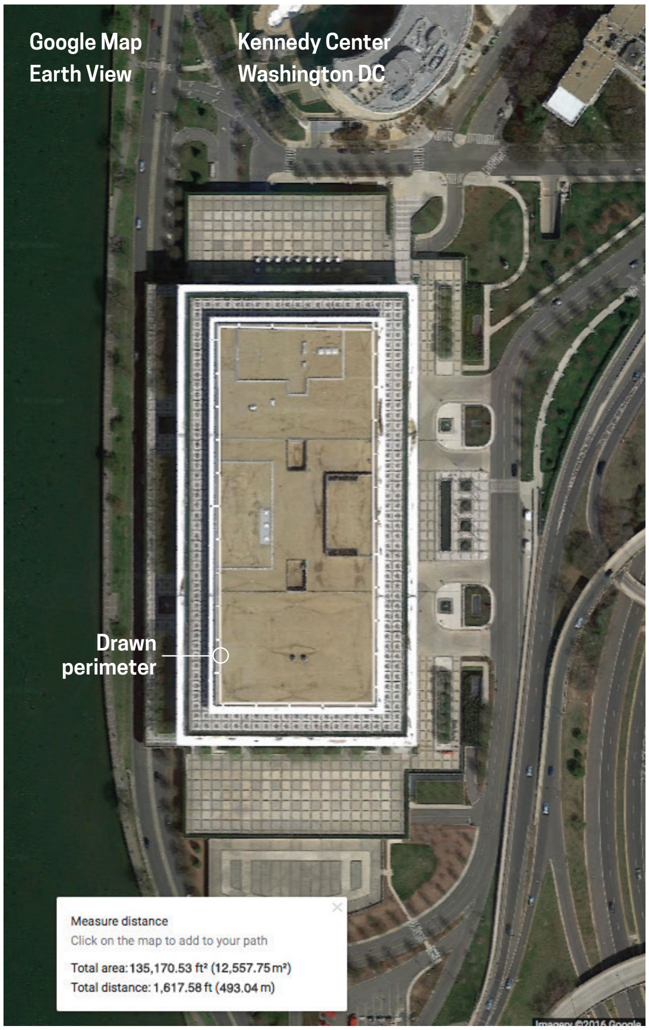
Google Maps provides an area measurement feature. In your web browser, navigate to Google Maps: maps.google.com. To use this feature, be sure you are using the full version of Google Maps and not the "Lite" version. If you see a lightening bolt on the bottom right of your screen, click on it to switch to "Full Maps."

In the search bar enter a building's address, locate your building in "earth view." For the example in this appendix, we will use the Kennedy Center located at 2700 F Street NW in Washington, DC.

Place your mouse on the perimeter of the surface area that you want to measure. Then "Right Click" to reveal the options menu, then select "Measure Distance."



With your mouse, click the corners of the solar installation area. When you have completely drawn the perimeter, Google Maps will automatically provide you with the area of the enclosed space. See the highlighted area below. The roof space of the Kennedy Center is estimated to be **135,170 square feet**.



Note: When using the Google Map "Measure Distance" tool the results will be approximate. Know that each time you calculate the area you will obtain slightly different results.

2. Setbacks

Due to a **4** to **6 foot** fire code setback requirement for solar installations, a portion of the rooftop along the perimeter cannot be used to host solar panels.[1] In the solar PV and thermal scoping tool, this setback reduction is entered as a percentage. We can use Google Maps to calculate the length and width of the roof. The roof area has a width of **240 feet** and a length of **570 feet**.

Therefore, using a **6 foot** setback the setback percentage can be determined by the following formula:

$$\text{percentage} = \frac{1 - [\,\text{width} - (\text{setback} * 2)\,] * [\,\text{length} - (\text{setback} * 2)\,]}{(\,\text{width} * \text{length}\,)}$$

$$= \frac{1 - [\,240 - (\,6 * 2\,)\,] * [\,570 - (6 * 2\,)\,]}{(\,240 * 570\,)}$$

$$= -0.07 \text{ Or } 7\%$$

A six foot safety setback along the perimeter of a **135,170 square foot** roof would reduce the usable roof area by **7%** or **9,462 square feet**, leaving **125,708 square feet** of usable space.

[1] No solar panels should be placed within 6 feet of a building's perimeter. However, a 4 feet setback may be used if either a building's length or width is less than 250 feet long.
Source: osfm.fire.ca.gov/pdf/reports/solarphotovoltaicguideline.pdf, page 10.

3. Usable rooftop

For additional accuracy when calculating your usable roof area you can use the "birds eye" view function in Microsoft's Bing Maps: bing.com/mapspreview to get an aerial view of the building from all four directions. This will help you estimate how much of the remaining rooftop is unobstructed.

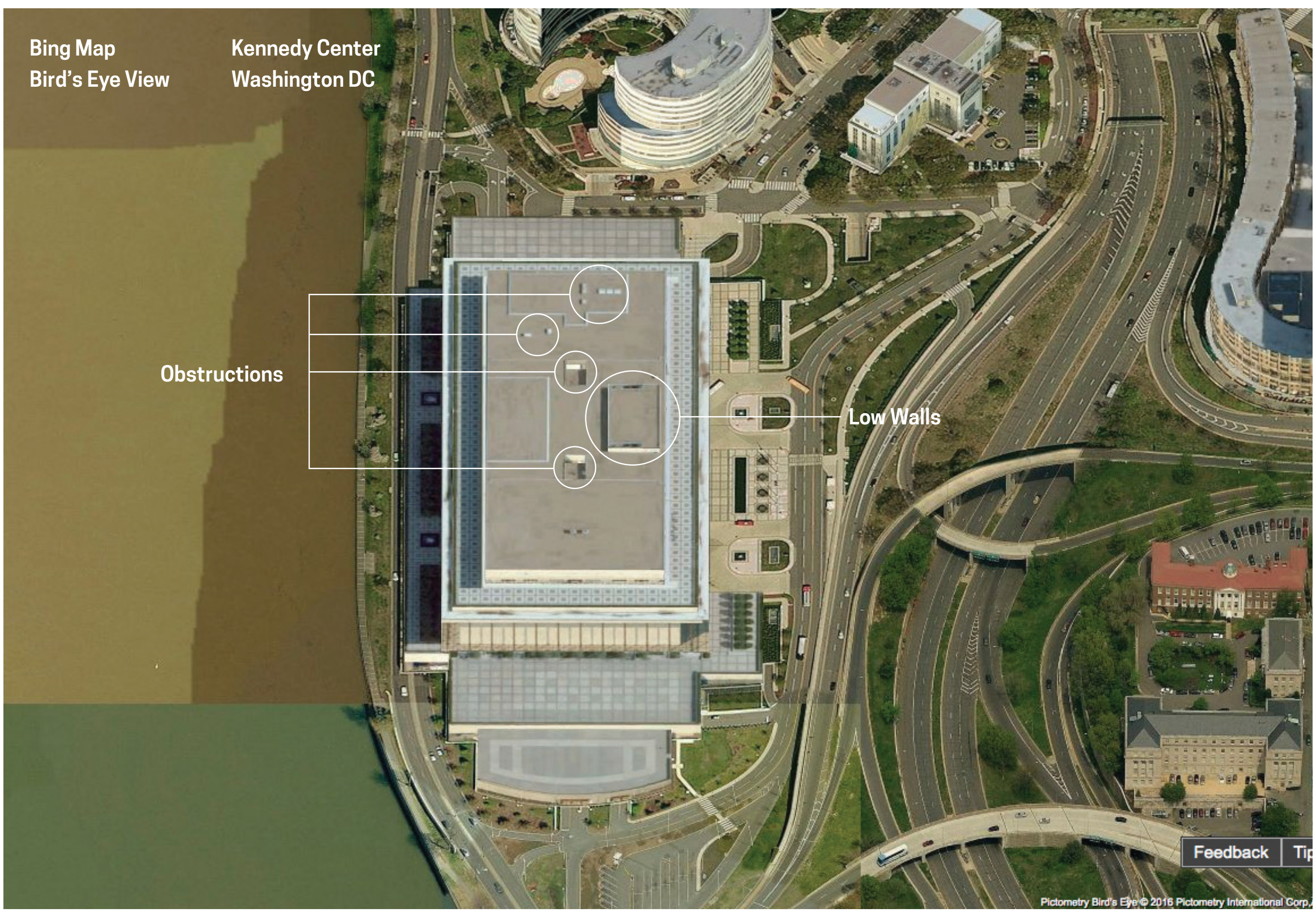
Look for rooftop objects that could be an obstacle for the placement of solar panels. Look for large objects on the roof or in the immediate area that could cast shadows on the roof – and the panels – as the sun moves across the sky from East to West. There also needs to be a **3 foot** wide pathway to any rooftop equipment, like air handlers.

Based on your assessment, use your best judgment to estimate the percentage of the roof that cannot be used because of obstructions. In our example, there are low walls and some objects that could impede solar panel placement. But generally, the roof is fairly clear. We estimate that **15%**, or **18,856 square feet** is unusable for the placement of solar panels. This leaves **106,852 square feet** as usable.

4. System capacity

It takes roughly **100 square feet** of usable rooftop space to install **1kW** of system capacity.

In our Kennedy Center example, we have a usable roof of about **106,852 square feet** (after subtracting **9,462 square feet** for setbacks and **18,856 square feet** for rooftop obstructions). With a system size installation ratio of **1kW** per **100 square feet**, this means that we can install a **1,069 kW** sized system on this rooftop.



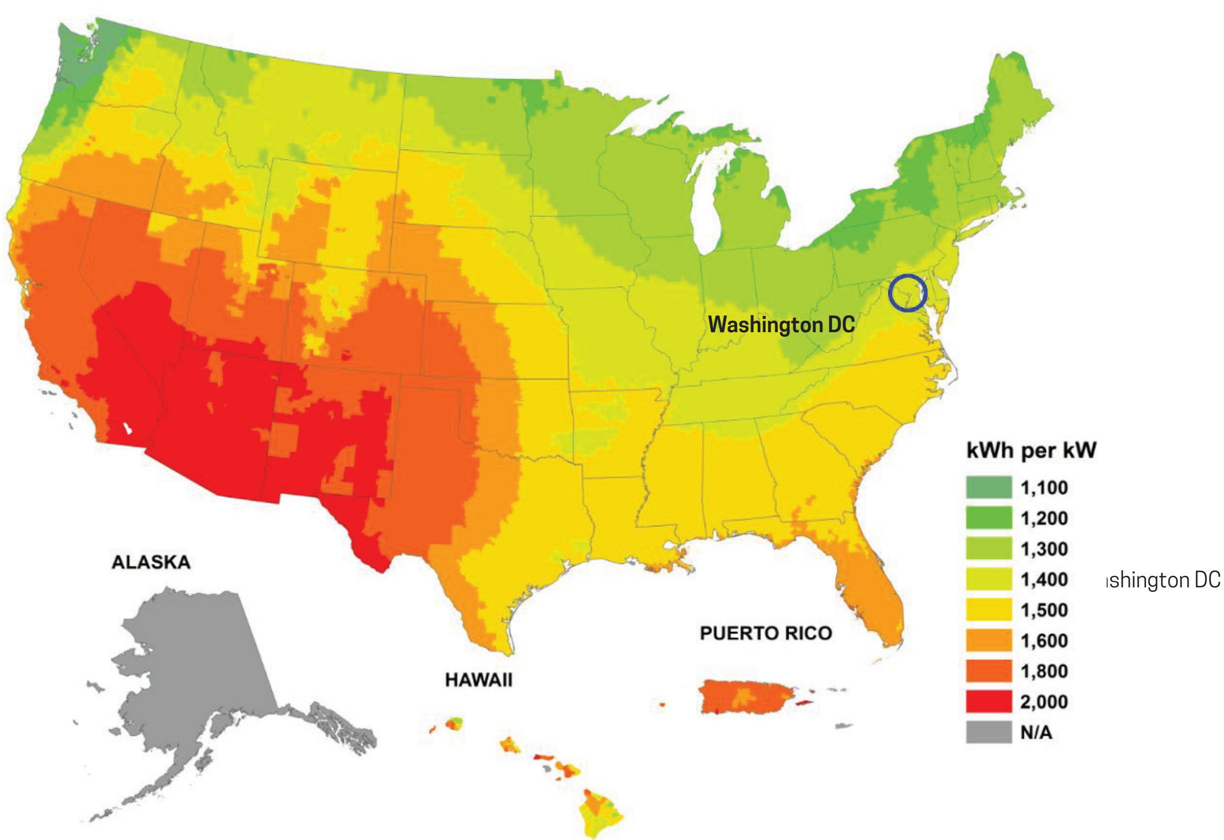
5. Annual Solar PV Electricity Production and Value

To estimate how much energy your solar PV project could generate, simply find its location on the map below. The map color will show the kWh conversion factor for every **1 kW** of installed solar capacity based on its location.

From the map, we see that in Washington, DC it is possible to generate roughly **1,400 kWh** of electricity for every **1 kW** of installed solar capacity. With roughly **106,900** square feet of installable area, we can install **1,067 kW** of solar capacity. And this could generate roughly **1,493,800 kWh** of electricity annually (**1,400 kWh** x **1,067 kW**).

In Washington, DC, the local commercial electricity rate is **$0.12** per kWh. By multiplying the electricity that could be generated annually (**1,493,800 kWh**) by the value of that electricity (**$0.12** per kWh), we estimate that we could reduce the electricity bill by roughly **$179,256** per year.

Annual Solar Electric Generation Factor



[2] Other solar scoping tools exist online like pvwatts.nrel.gov.

6. Annual Solar Thermal Heat Production and Value

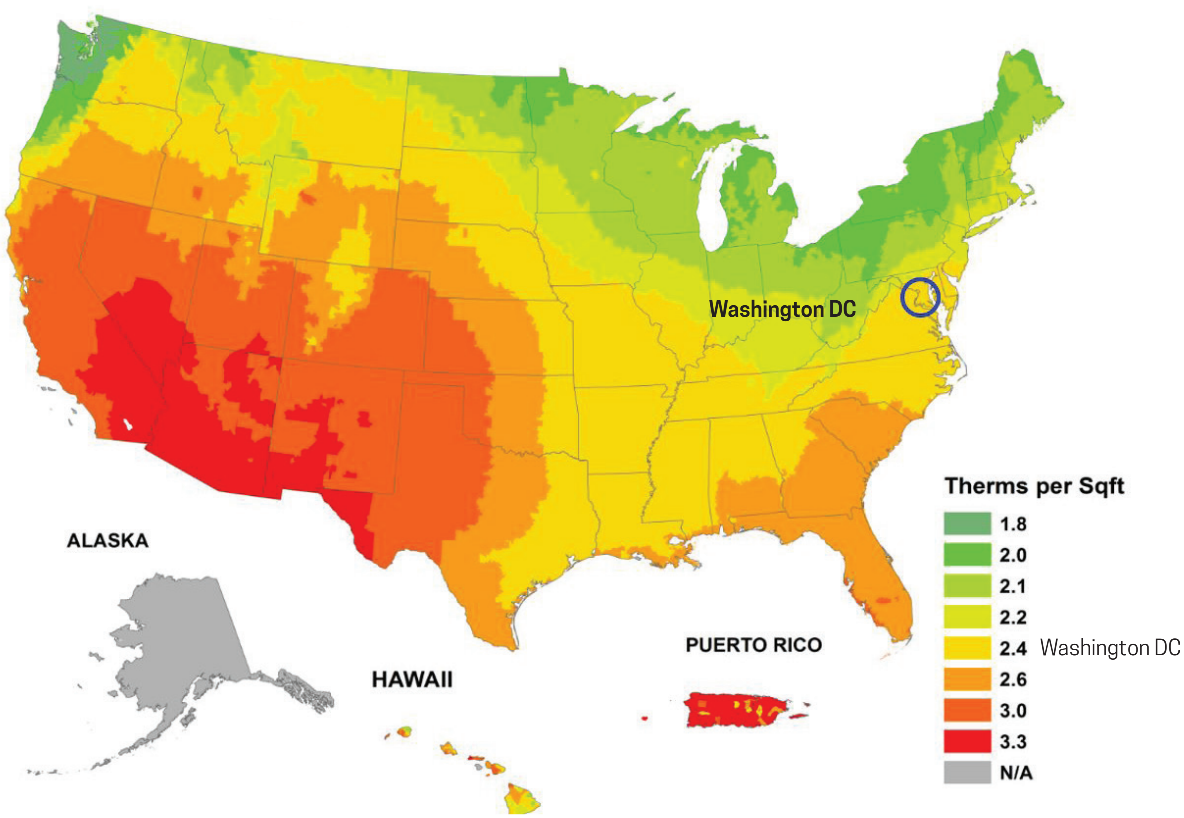
To see how much heat your solar thermal project could generate, simply find its location on the map below. From the map, we can see that in Washington, DC it is possible to generate **2.4 therms** of heat energy for every **1 square foot** of installed solar thermal collector area.

Solar thermal hot water systems are sized to meet a building's hot water demand, and not any larger because the equipment is expensive, and unlike electricity, hot water can not easily be transported offsite and sold.

The scoping tool estimates how many solar thermal collectors would be needed based on the number of housing units in a building and how much sun its gets based on its geographic location.

The hypothetical example in the scoping tool is a **100 unit** housing development in Washington, DC (20566 zip code) with a total gross roof area of **135,000 square feet**.

Annual Solar Thermal Generation Factor



Solar Thermal Example for a 100-Unit Apartment Building

System Scoping

For a **100-unit** apartment building, each unit is estimated to use **38 gallons** of hot water daily, thus the entire building would need **3,800 gallons** of hot water per day. With an average cold water intake temperature of **58 degrees** Fahrenheit, the water temperature would need to be raised by **62 degrees** to reach the **120 degrees** desired for domestic hot water use.

Since it takes **8.34 British Thermal Unit** (BTU)s to increase the temperature of **1 gallon** of water by **1 degree** Fahrenheit, it would thus take **517 BTUs** to increase the temperature of **1 gallon** of water by **62 degrees** (**62 degrees** x **8.34** BTUs = **517 BTUs**. For an entire building, it would take **1,964,904 BTUs** daily (**517** BTUs x **3,800 gallons**). As there are **100,000 BTUs** for every **1 Therm**, it would take **19.6 therms** per day (**1,964,904 BTUs** ÷ **100,000** = **19.6 Therms**). And the building would need **7,172 Therms** per year (**19.6 Therms** x **365 days** = **7,172 Therms**).

Solar Collectors

In the scoping tool, we enter **20566** as the zip code of our hypothetical project to find the average therms received there annually per square foot of collector area (**2.26 therms**) if the panels were tilted toward the sun at the same angle as its latitude. By dividing the total amount of therms needed by the therms available per square foot we find that we would need **3,180 square feet** of collector area (**7,172 therms** ÷ **2.26** = **3,180 square feet**). As each collector is about **40 square feet** in size (**4**' x **10**') it would take almost **80 collectors** to collect the energy needed at the property for hot water (**3,180** ÷ **40** = **79.5**).

Installation Area

The scoping tool will calculate the amount of area needed to install the **80 solar thermal collectors** that would be hypothetically needed while taking account setback requirements for safety, obstructions, and optimal spacing between solar collectors.

Solar Thermal Fraction

This calculates how much of the hot water heating can come from the sun relative to the needs of the building. It provides an important reality check. In reality, there may not be enough space to collect all the heat needed to satisfy 100% of the property's hot water needs.

Water Tank

Domestic hot water is used mostly in the early mornings and evenings, and not when it is being produced, which is during the day. As a result, solar thermal projects need to include a storage tank. The rule of thumb is to install **1.5 gallons** of storage for every **1 square foot** of collector area. In our hypothetical example, we would need a storage tank capable of holding **4,770 gallons** (**3180'** X **1.5 gallons**) or one that is **638 cubic feet** in size to store this much water **(7.5 gallons** per **1 cubic foot**). By taking the cube root of this volume, the storage tank would be roughly **9 feet** in depth, width and length. And it would weigh roughly **40,000 pounds** when full.

The goal of the Department of Housing and Urban Development Community Planning and Development Renewable Energy Toolkit for Affordable Housing is to enable recipients of HUD Community Planning and Development (CPD) grants to integrate renewable energies into their affordable housing development programs under the HOME Investment Partnerships (HOME), Community Development Block Grant (CDBG), Housing Opportunities for People with AIDs (HOPWA), or Emergency Solutions Grant (ESG) programs. Integration of renewable energy into affordable housing is important because it maintains affordability through reduced energy costs, which can facilitate improved operations and maintenance.

In addition, renewable energy has significant, beneficial effects on reducing the impacts of climate change. Renewable energy provides a low-to-no carbon pollution energy source that is necessary if we hope to reduce the impacts of human-caused climate change on our environment. As part of The President's Climate Action Plan, HUD and other federal agencies have pledged to add 300 megawatts of renewable energy on federally-subsidized affordable housing by 2020. This toolkit exists to support these efforts.

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

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