Summary of Significant Equations for Determining Shadow Length
A Reference Guide for Solar Access Evaluations

1. Procedure for determining height of shadow up a south wall

Formula (see Figure A):

SH= H- (Tangent θ x D)

Where

SH= Shadow length of the wall

H= Height of Object casting shadow

D = Distance from the wall to the obstruction

θ = Sun Altitude Angle

Example: A 30-foot tree is located 20 feet due south of the south wall of a passive solar energy system. The land is flat and the site is located at 40^{o} north latitude. What will be the shadow height on the wall at noon solar time on December 21st?

The noon altitude angle for December 21st at 40^{o} north latitude = 26.6^{o}. By substitution into the formula we arrive at the following result:

SH= 30 – (TAN 26.6^{o} x 20)

= 30 – (.501 x 20)

= 30- 10.02

SH= 19.98 feet

2. Procedure for Determining Height of Shadow up a rooftop

Formula (See Figure B):

$$RSH = (SH - WH) \times \frac{\sin A_1}{\sin A_2}$$

Where:

RSH = Roof shadow height

SH = Shadow height at Wall (determined in equation 1)

WH = Wall Height

$A_1 = 90^o$ - Solar Altitude

$A_2 = 90^o - A_1$ + roof pitch

Example: A 30-foot tree is located 20 feet due south of the south wall of a dwelling unit with an active solar energy system located on the lowest level of the roof edge. The wall is 8 feet high, the roof has a 20^o degree pitch and the building is located on flat land at 40^o north latitude. What will be the shadow height on the rooftop at noon solar time?

From equation 1 we determined that the shadow height at the wall = 19.98 feet. The noon altitude angle for December 21st at 40^o north latitude = 26.6^o.

By substitution into the formula we arrive at the following result:

$A_1 = 90^o - 26.6^o = \sin 63.4^o = .894$

$A2 = (90^o - 63.4^o) + 20^o = \sin 46.6^o = .726$

$RSH = (19.98 - 8) \times (.894/.726)$

$= 11.98 \times 1.23$

$= 14.73$ feet

3. Procedure for Determining the Maximum Height Limit for Trees to protect rooftop collectors

Formula (See Figure C):

$H = X + (D_1 + D_2) \text{ Tan } \theta$

Where

H = Height of Object Casting Shadow

X = Height from ground to bottom of collector

D_1 = Distance from property line to the collector

D_2 = Distance from property line to Tree

Θ = Sun Altitude Angle

Example: A solar collector is located 10 feet above ground level and 20 feet due north of a tree. The land is flat and the site is located at 40^o north latitude. What is the maximum allowable height of a tree at that distance at noon on December 21^{st}?

The noon altitude angle for December 21^{st} at 40^o north latitude = 26.6^o. By substitution into the formula we arrive at the following result:

$H = (10) + (20) \text{ TAN } 26.6^o$

$H = (10) + (20) \times .501$

$H = 30 \times .501 = 15.03$ feet

Figure A: Minimum Clearance for obstructions for no effect on South Wall Solar Access

SH= H - (Tangent θ x D)
SH= Shadow length of the wall
H= Height of Object casting shadow
D = Distance from the wall to the obstruction
θ = Sun Altitude Angle

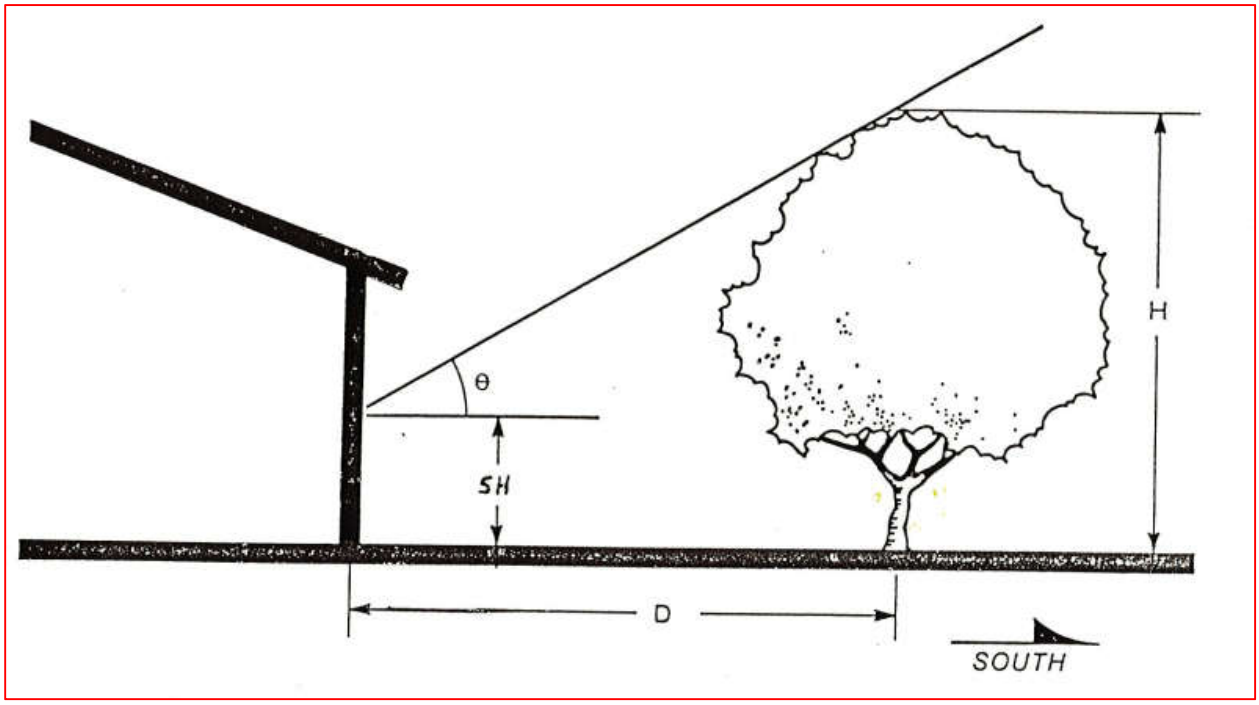


Figure B: Procedure for Determining Height of shadow up a rooftop

$$RSH = (SH - WH) \times \frac{\sin A_1}{\sin A_2}$$

Where:

RSH = Roof shadow height
SH = Shadow height at Wall (determined in equation 1)
WH = Wall Height
$A_1 = 90^o$ - Solar Altitude
$A_2 = 90^o - A_1$ + roof pitch

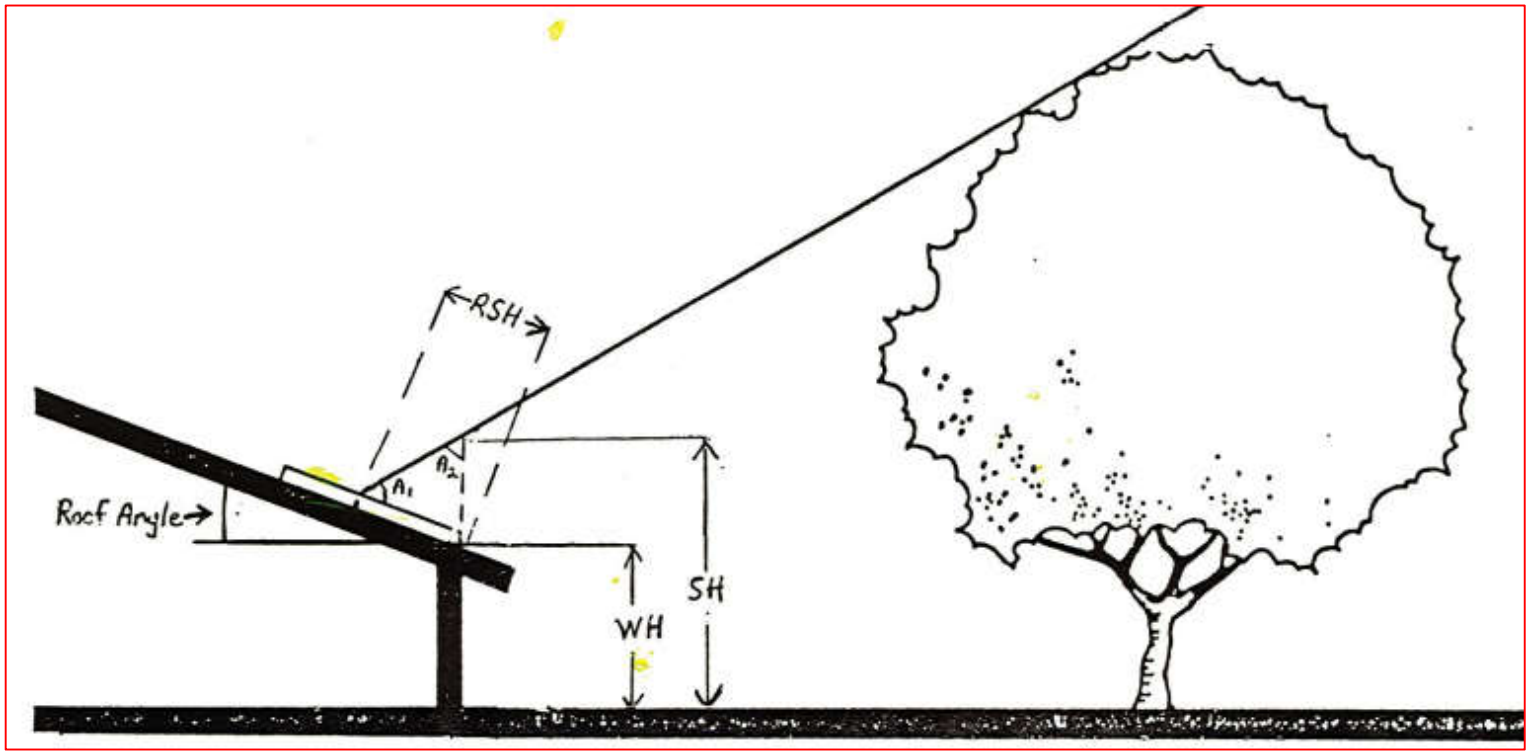
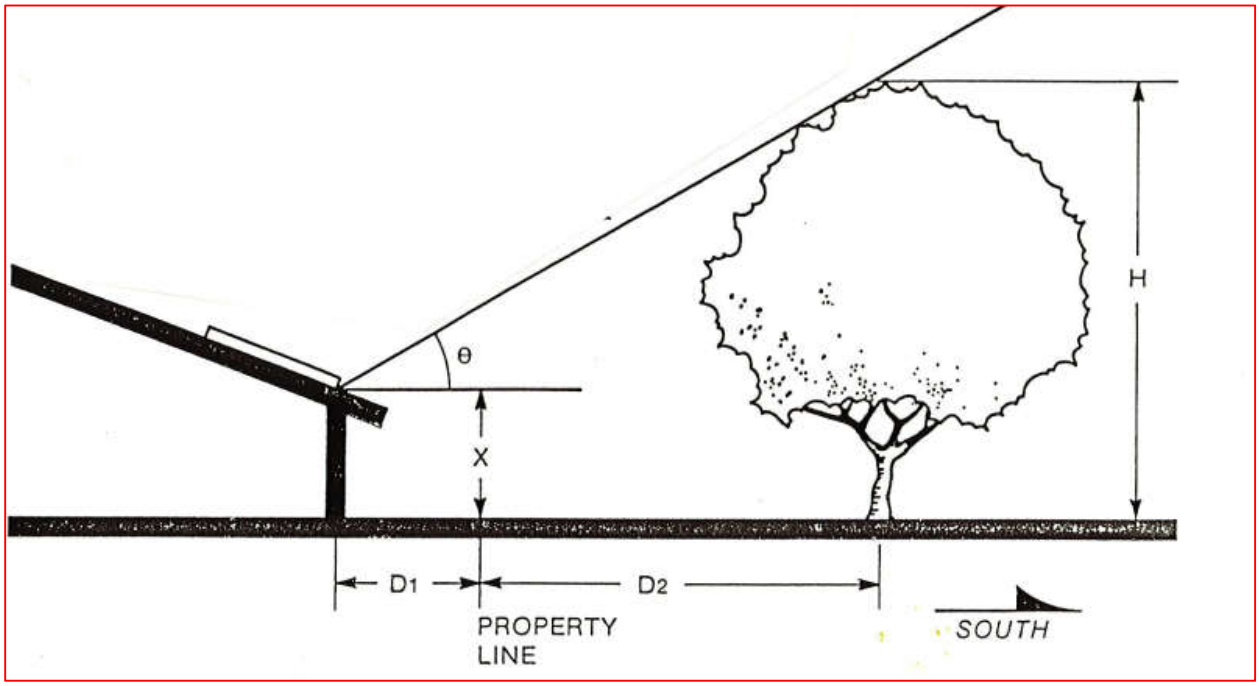


Figure C: Establishing Height Limits for Trees to Protect Rooftop Solar Access

$H = X + (D_1 + D_2) \text{ Tan } \theta$

Where

H = Height of Object Casting Shadow
X = Height from ground to bottom of collector
D_1 = Distance from property line to the collector
D_2 = Distance from property line to Tree
Θ = Sun Altitude Angle



To determine the latitude and longitude for your municipality, see the attached summary table that identifies these parameters by zip code areas within the region. The attached table also provides the sun's altitude on December 21st at 12 Noon solar time since this is the worst day of the year for access to solar energy. The shadow cast by a one-meter object is presented for each zip code area in the region and this information can be used to estimate the shadows cast by larger objects located to the south of a solar energy collector.

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Latitude and Longitude of Municipalities in Western Connecticut by Zip Code

ZIP Code	Municipality	State	Latitude (North)	Longitude (West)	Solar Altitude on December 21st (degree/ minutes)	Solar Noon	Shadow Cast by 1 meter pole Solar Noon December 21st on flat land (Meters)
06801	Bethel	CT	41.3759	73.3933	25.19	11:51:37	2.13
06752	Bridgewater	CT	41.5211	73.3597	23.03	11:51:29	2.14
06804	Brookfield	CT	41.4668	73.3928	25.09	11:51:40	2.14
06810	Danbury	CT	41.3768	73.4601	25.17	11:51:51	2.13
06811	Danbury	CT	41.4236	73.4845	25.14	11:52:00	2.13
06820	Darien	CT	41.0804	73.4823	25.49	11:51:53	2.1
06830	Greenwich	CT	41.0502	73.6235	25.55	11:52:31	2.09
06831	Greenwich	CT	41.0864	73.6612	25.55	11:52:41	2.09
06870	Greenwich	CT	41.2234	73.3353	25.55	11:52:17	2.09
06878	Greenwich	CT	41.5364	73.3517	25.54	11:52:23	2.09
06807	Greenwich	CT	41.4641	73.3644	25.54	11:52:28	2.09
06840	New Canaan	CT	41.1589	73.4989	25.42	11:52:00	2.1
06812	New Fairfield	CT	41.4862	73.4974	25.11	11:51:58	2.13
06776	New Milford	CT	41.6202	73.4053	24.99	11:51:40	2.15
06470	Newtown	CT	41.3932	73.3201	25.15	11:51:15	2.13
06850	Norwalk	CT	41.1272	73.4433	25.45	11:51:40	2.1
06851	Norwalk	CT	41.1388	73.4037	25.42	11:51:37	2.1
06853	Norwalk	CT	41.0695	73.4379	25.51	11:51:38	2.1
06854	Norwalk	CT	41.0941	73.4328	25.48	11:51:42	2.1
06855	Norwalk	CT	41.1001	73.3971	25.47	11:51:36	2.1
06856	Norwalk	CT	41.6145	73.2455	25.47	11:51:41	2.1
06877	Ridgefield	CT	41.3064	73.5024	25.29	11:52:01	2.12
06896	Redding	CT	41.3054	73.393	25.27	11:51:33	2.12
06784	Sherman	CT	41.5795	73.4985	24.99	11:52:00	2.15
06901	Stamford	CT	41.0531	73.5379	25.52	11:52:11	2.09
06902	Stamford	CT	41.061	73.5493	25.5	11:52:13	2.1
06903	Stamford	CT	41.1356	73.571	25.43	11:52:12	2.1
06904	Stamford	CT	41.0537	73.539	25.51	11:52:10	2.1
06905	Stamford	CT	41.0876	73.5444	25.51	11:52:09	2.1
06906	Stamford	CT	41.0697	73.522	25.5	11:52:07	2.1
06907	Stamford	CT	41.1005	73.521	25.47	11:52:06	2.1
06883	Weston	CT	41.2268	73.373	25.37	11:51:33	2.11
06880	Westport	CT	41.1454	73.3462	2.543	11:51:27	2.1
06897	Wilton	CT	41.207	73.4401	25.37	11:51:46	2.11

For precise latitude and longitude for your site go to the following:
https://www.esrl.noaa.gov/gmd/grad/solcalc/

https://keisan.casio.com/exec/system/1224682331

Source: CD Light LLC and Suncal.org. July 16, 2019