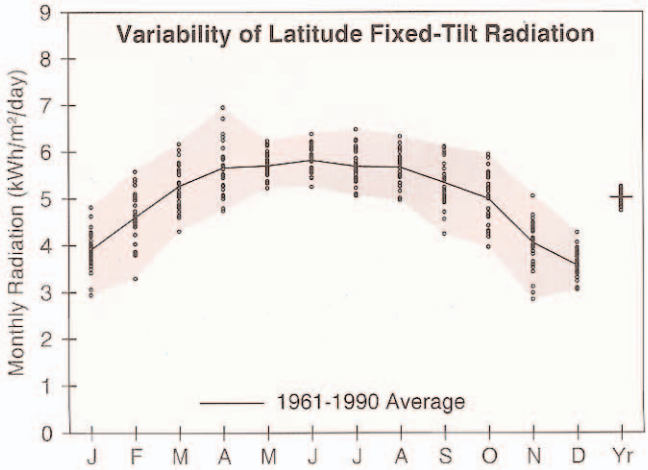


Lynchburg, VA

WBAN NO. 13733

LATITUDE: 37.33° N
LONGITUDE: 79.20° W
ELEVATION: 279 meters
MEAN PRESSURE: 984 millibars

STATION TYPE: Secondary

Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.4	3.2	4.3	5.4	6.0	6.5	6.2	5.6	4.7	3.7	2.6	2.1	4.4
	Min/Max	2.0/2.7	2.6/3.7	3.7/4.9	4.6/6.5	5.5/6.6	5.8/7.1	5.5/7.0	5.0/6.2	3.9/5.2	3.2/4.3	2.0/3.0	1.9/2.3	4.2/4.5
Latitude -15	Average	3.4	4.2	5.1	5.8	6.1	6.3	6.1	5.9	5.3	4.6	3.6	3.1	5.0
	Min/Max	2.7/4.1	3.1/5.0	4.2/5.9	4.8/7.1	5.5/6.6	5.7/6.9	5.4/7.0	5.2/6.5	4.3/6.0	3.8/5.5	2.6/4.4	2.7/3.6	4.7/5.2
Latitude	Average	3.9	4.6	5.3	5.7	5.7	5.8	5.7	5.7	5.3	5.0	4.0	3.6	5.0
	Min/Max	2.9/4.8	3.3/5.6	4.3/6.2	4.7/6.9	5.2/6.2	5.3/6.4	5.1/6.5	5.0/6.3	4.2/6.1	4.0/5.9	2.8/5.1	3.0/4.3	4.7/5.2
Latitude +15	Average	4.2	4.8	5.2	5.3	5.1	5.0	5.0	5.2	5.1	5.0	4.3	3.8	4.8
	Min/Max	3.1/5.2	3.3/5.8	4.2/6.1	4.4/6.5	4.6/5.5	4.6/5.5	4.4/5.7	4.5/5.8	4.0/5.9	3.9/6.0	2.9/5.4	3.2/4.6	4.5/5.0
90	Average	3.8	4.0	3.7	3.2	2.6	2.4	2.5	2.9	3.4	4.0	3.7	3.5	3.3
	Min/Max	2.6/4.9	2.7/4.8	3.0/4.5	2.7/3.8	2.4/2.8	2.2/2.5	2.3/2.7	2.6/3.2	2.7/4.0	3.0/4.8	2.5/4.8	2.9/4.3	3.1/3.5

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.4	4.6	5.9	7.2	7.7	8.2	7.8	7.2	6.2	5.1	3.7	3.0	5.8
	Min/Max	2.6/4.3	3.2/5.6	4.7/7.0	5.7/9.3	7.0/8.6	7.1/9.3	6.7/8.9	6.1/8.1	4.9/7.2	4.1/6.2	2.5/4.6	2.6/3.6	5.5/6.1
Latitude -15	Average	4.2	5.3	6.5	7.5	7.8	8.2	7.8	7.5	6.7	5.9	4.4	3.8	6.3
	Min/Max	3.1/5.3	3.6/6.5	5.1/7.8	5.9/9.8	7.0/8.8	7.1/9.2	6.7/8.9	6.2/8.4	5.2/7.8	4.5/7.1	3.0/5.6	3.2/4.6	5.9/6.6
Latitude	Average	4.6	5.6	6.6	7.4	7.6	7.8	7.5	7.3	6.7	6.1	4.8	4.1	6.4
	Min/Max	3.3/5.9	3.8/6.9	5.2/8.0	5.9/9.7	6.8/8.5	6.8/8.9	6.4/8.6	6.1/8.3	5.2/7.9	4.7/7.5	3.2/6.1	3.5/5.1	6.0/6.7
Latitude +15	Average	4.8	5.7	6.6	7.1	7.1	7.3	7.0	7.0	6.6	6.2	5.0	4.4	6.2
	Min/Max	3.4/6.2	3.8/7.1	5.1/7.9	5.6/9.4	6.4/8.0	6.3/8.3	6.0/8.0	5.8/7.9	5.0/7.7	4.7/7.5	3.3/6.4	3.6/5.4	5.9/6.6

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	4.9	5.7	6.7	7.5	7.9	8.3	7.9	7.5	6.8	6.2	5.0	4.4	6.6
	Min/Max	3.5/6.3	3.8/7.1	5.2/8.0	6.0/9.8	7.1/8.9	7.2/9.4	6.8/9.1	6.3/8.5	5.2/7.9	4.7/7.6	3.3/6.4	3.7/5.5	6.2/6.9

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	2.9	3.2	3.4	3.6	3.7	3.9	3.6	3.4	3.2	3.4	2.9	2.7	3.3
	Min/Max	1.7/4.1	1.6/4.3	2.2/4.3	2.3/5.3	2.9/4.5	3.0/4.8	2.8/4.5	2.5/4.2	2.1/4.1	2.2/4.5	1.7/4.1	2.0/3.6	3.0/3.6
1-Axis, N-S Horiz Axis	Average	2.3	3.0	3.9	4.7	4.8	5.1	4.7	4.4	3.9	3.4	2.4	2.0	3.7
	Min/Max	1.4/3.2	1.5/4.1	2.5/5.0	2.9/7.0	3.8/5.9	4.0/6.3	3.6/5.7	3.2/5.4	2.6/5.1	2.2/4.6	1.3/3.3	1.4/2.6	3.3/4.0
1-Axis, N-S Tilt=Latitude	Average	3.2	3.9	4.5	4.9	4.7	4.8	4.5	4.5	4.3	4.2	3.3	2.9	4.1
	Min/Max	1.9/4.6	2.0/5.3	2.9/5.8	3.1/7.3	3.7/5.8	3.7/5.9	3.4/5.5	3.2/5.5	2.9/5.7	2.8/5.7	1.9/4.6	2.2/3.9	3.8/4.5
2-Axis	Average	3.5	4.0	4.5	5.0	4.9	5.2	4.8	4.6	4.3	4.3	3.5	3.2	4.3
	Min/Max	2.1/4.9	2.0/5.4	2.9/5.8	3.2/7.4	3.9/6.1	4.0/6.4	3.6/5.9	3.3/5.6	2.9/5.7	2.8/5.7	2.0/4.9	2.3/4.2	3.9/4.7

Average Climatic Conditions

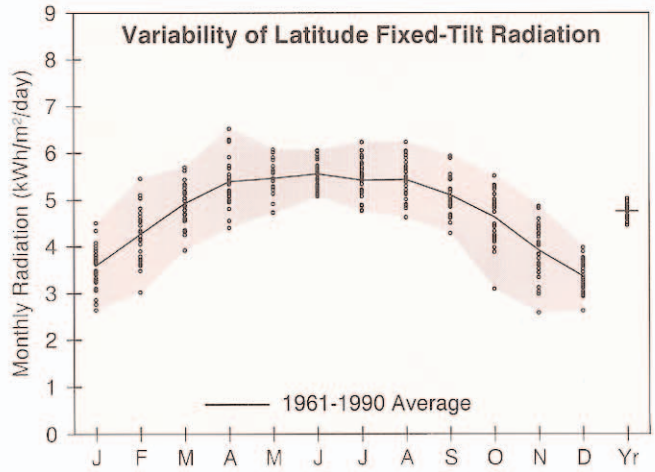
Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	1.2	2.9	8.0	13.2	17.8	22.1	24.2	23.7	20.1	13.9	8.7	3.6	13.3
Daily Minimum Temp	-4.1	-2.6	1.9	6.6	11.4	16.0	18.4	18.0	14.3	7.6	2.9	-1.6	7.4
Daily Maximum Temp	6.4	8.4	14.1	19.8	24.2	28.1	30.0	29.4	25.8	20.2	14.5	8.7	19.1
Record Minimum Temp	-23.3	-17.8	-13.9	-6.7	-0.6	4.4	9.4	7.2	2.2	-6.1	-13.3	-20.0	-23.3
Record Maximum Temp	24.4	26.1	30.6	33.3	33.9	37.8	39.4	38.9	38.3	33.9	28.3	25.6	39.4
HDD, Base 18.3°C	531	432	321	157	53	3	0	0	18	150	288	458	2411
CDD, Base 18.3°C	0	0	0	0	37	115	183	166	69	12	0	0	582
Relative Humidity (%)	65	63	61	58	69	71	73	75	75	69	66	66	68
Wind Speed (m/s)	3.5	3.5	3.8	3.8	3.1	3.0	2.7	2.7	2.8	3.0	3.3	3.4	3.2

Norfolk, VA

WBAN NO. 13737

LATITUDE: 36.90° N
LONGITUDE: 76.20° W
ELEVATION: 9 meters
MEAN PRESSURE: 1017 millibars

STATION TYPE: Secondary



Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.3	3.0	4.1	5.1	5.8	6.2	5.9	5.4	4.5	3.5	2.5	2.0	4.2
	Min/Max	1.9/2.6	2.4/3.6	3.4/4.6	4.3/6.1	5.0/6.4	5.6/6.7	5.2/6.7	4.6/6.1	3.9/5.1	2.6/4.0	1.9/2.9	1.7/2.3	4.0/4.4
Latitude -15	Average	3.2	3.9	4.8	5.5	5.8	6.0	5.8	5.6	5.0	4.3	3.5	2.9	4.7
	Min/Max	2.4/3.9	2.9/4.9	3.8/5.5	4.5/6.6	5.0/6.5	5.5/6.6	5.1/6.7	4.8/6.4	4.3/5.8	3.0/5.1	2.4/4.3	2.3/3.4	4.4/5.0
Latitude	Average	3.6	4.3	4.9	5.4	5.5	5.6	5.4	5.4	5.1	4.6	3.9	3.4	4.8
	Min/Max	2.6/4.5	3.0/5.4	3.9/5.7	4.4/6.5	4.7/6.1	5.1/6.1	4.8/6.2	4.6/6.2	4.3/5.9	3.1/5.5	2.6/4.9	2.6/4.0	4.4/5.0
Latitude +15	Average	3.8	4.4	4.8	5.0	4.8	4.8	4.8	4.9	4.9	4.7	4.1	3.6	4.6
	Min/Max	2.7/4.9	3.0/5.7	3.8/5.6	4.1/6.1	4.2/5.4	4.4/5.2	4.2/5.4	4.2/5.7	4.1/5.7	3.0/5.6	2.6/5.2	2.8/4.3	4.2/4.8
90	Average	3.4	3.6	3.4	3.0	2.5	2.3	2.3	2.8	3.3	3.6	3.6	3.3	3.1
	Min/Max	2.3/4.5	2.4/4.8	2.7/4.0	2.5/3.5	2.2/2.7	2.2/2.4	2.1/2.6	2.4/3.1	2.7/3.8	2.3/4.4	2.2/4.6	2.4/4.0	2.8/3.3

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.2	4.2	5.5	6.7	7.3	7.7	7.4	6.9	5.9	4.8	3.6	2.9	5.5
	Min/Max	2.3/4.0	2.9/5.4	4.2/6.4	5.3/8.4	6.0/8.5	6.8/8.7	6.1/8.7	5.5/8.1	4.8/7.0	3.2/5.8	2.3/4.4	2.2/3.3	5.1/5.8
Latitude -15	Average	3.9	4.9	6.0	7.1	7.4	7.7	7.4	7.1	6.3	5.4	4.3	3.5	5.9
	Min/Max	2.8/4.9	3.3/6.3	4.6/7.1	5.4/8.9	6.0/8.6	6.7/8.6	6.1/8.7	5.7/8.4	5.1/7.6	3.5/6.6	2.7/5.3	2.7/4.2	5.5/6.3
Latitude	Average	4.2	5.1	6.2	7.0	7.1	7.4	7.1	7.0	6.4	5.6	4.6	3.9	6.0
	Min/Max	3.0/5.4	3.4/6.8	4.6/7.2	5.4/8.8	5.8/8.3	6.4/8.3	5.8/8.4	5.6/8.3	5.2/7.7	3.5/6.9	2.9/5.8	2.9/4.7	5.5/6.3
Latitude +15	Average	4.4	5.2	6.1	6.7	6.7	6.9	6.6	6.6	6.2	5.7	4.8	4.1	5.8
	Min/Max	3.0/5.7	3.4/6.9	4.5/7.2	5.1/8.5	5.5/7.9	6.0/7.7	5.4/7.8	5.3/7.9	5.0/7.5	3.5/7.0	2.9/6.1	3.0/4.9	5.4/6.2

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

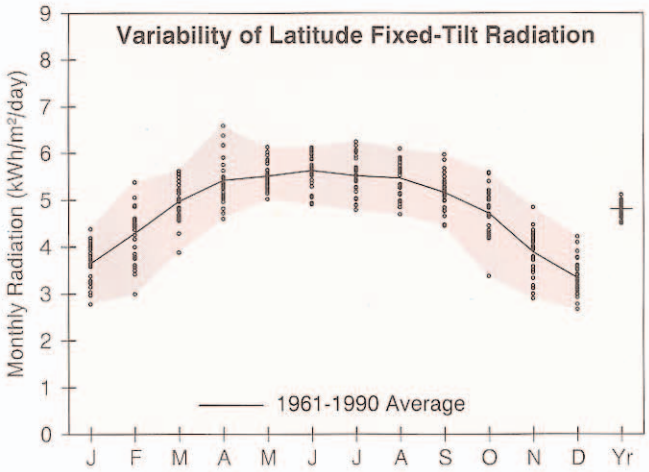
Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	4.4	5.3	6.2	7.1	7.4	7.9	7.5	7.1	6.4	5.7	4.8	4.1	6.2
	Min/Max	3.0/5.8	3.4/6.9	4.7/7.3	5.5/8.9	6.1/8.7	6.9/8.8	6.2/8.9	5.7/8.4	5.2/7.7	3.6/7.0	2.9/6.1	3.1/5.0	5.7/6.5

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	2.6	2.9	3.1	3.3	3.4	3.6	3.4	3.2	3.0	3.0	2.9	2.5	3.1
	Min/Max	1.5/3.8	1.4/4.3	2.0/3.9	2.0/4.9	2.4/4.3	2.8/4.4	2.4/4.4	2.3/4.2	2.2/4.1	1.5/4.1	1.3/4.0	1.6/3.3	2.7/3.4
1-Axis, N-S Horiz Axis	Average	2.1	2.7	3.6	4.3	4.5	4.7	4.3	4.1	3.6	3.1	2.3	1.8	3.4
	Min/Max	1.1/3.0	1.3/4.1	2.3/4.5	2.6/6.3	3.1/5.7	3.6/5.8	3.0/5.9	2.8/5.5	2.6/5.0	1.5/4.2	1.0/3.3	1.1/2.3	3.0/3.8
1-Axis, N-S Tilt=Latitude	Average	2.9	3.5	4.1	4.5	4.3	4.4	4.1	4.2	4.0	3.8	3.2	2.7	3.8
	Min/Max	1.6/4.2	1.7/5.3	2.6/5.2	2.7/6.6	3.0/5.6	3.4/5.4	2.9/5.6	2.9/5.5	2.9/5.5	1.9/5.1	1.5/4.5	1.7/3.5	3.3/4.2
2-Axis	Average	3.1	3.6	4.1	4.6	4.6	4.8	4.4	4.3	4.0	3.8	3.4	2.9	4.0
	Min/Max	1.7/4.5	1.7/5.4	2.6/5.2	2.8/6.7	3.2/5.9	3.7/5.9	3.1/6.0	2.9/5.7	2.9/5.5	1.9/5.2	1.5/4.8	1.8/3.8	3.5/4.4

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	3.9	5.0	9.2	13.9	18.9	23.4	25.7	25.1	22.2	16.2	11.4	6.6	15.1
Daily Minimum Temp	-0.6	0.2	4.1	8.4	13.8	18.4	21.1	20.8	17.9	11.6	6.6	1.9	10.3
Daily Maximum Temp	8.5	9.8	14.4	19.4	24.1	28.3	30.2	29.5	26.4	20.8	16.2	11.2	19.9
Record Minimum Temp	-19.4	-13.3	-7.8	-2.2	2.2	7.2	12.2	9.4	7.2	-2.8	-6.7	-13.9	-19.4
Record Maximum Temp	25.6	27.2	31.1	36.1	37.8	38.3	39.4	40.0	37.2	35.0	30.0	26.7	40.0
HDD, Base 18.3°C	446	373	282	138	28	0	0	0	6	91	211	365	1942
CDD, Base 18.3°C	0	0	0	5	47	154	227	210	121	26	0	0	790
Relative Humidity (%)	66	66	65	63	69	71	73	75	74	72	69	67	69
Wind Speed (m/s)	5.1	5.4	5.6	5.3	4.8	4.5	4.1	4.0	4.4	4.6	4.8	5.1	4.8



Richmond, VA

WBAN NO. 13740

LATITUDE: 37.50° N
LONGITUDE: 77.33° W
ELEVATION: 50 meters
MEAN PRESSURE: 1012 millibars

STATION TYPE: Secondary

Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.3	3.0	4.1	5.2	5.8	6.3	6.0	5.4	4.5	3.5	2.5	2.0	4.2
	Min/Max	2.0/2.5	2.4/3.5	3.4/4.6	4.5/6.1	5.3/6.4	5.5/6.8	5.2/6.7	4.8/6.0	4.0/5.1	2.8/4.1	2.0/2.9	1.8/2.3	4.0/4.4
Latitude -15	Average	3.2	3.9	4.8	5.5	5.8	6.1	5.9	5.7	5.1	4.4	3.5	2.9	4.7
	Min/Max	2.5/3.8	2.9/4.8	3.8/5.4	4.7/6.7	5.3/6.5	5.3/6.6	5.2/6.7	4.9/6.3	4.4/5.9	3.3/5.2	2.7/4.3	2.4/3.6	4.5/5.0
Latitude	Average	3.6	4.3	5.0	5.4	5.5	5.6	5.5	5.5	5.2	4.7	3.9	3.3	4.8
	Min/Max	2.8/4.4	3.0/5.4	3.9/5.6	4.6/6.6	5.0/6.1	4.9/6.1	4.8/6.3	4.7/6.1	4.4/6.0	3.4/5.6	2.9/4.8	2.7/4.2	4.5/5.1
Latitude +15	Average	3.9	4.4	4.9	5.0	4.9	4.9	4.8	5.0	4.9	4.8	4.1	3.6	4.6
	Min/Max	2.9/4.7	3.0/5.6	3.7/5.5	4.3/6.1	4.5/5.4	4.3/5.3	4.2/5.5	4.3/5.6	4.2/5.8	3.3/5.7	3.0/5.2	2.8/4.6	4.3/4.9
90	Average	3.5	3.7	3.5	3.1	2.6	2.4	2.4	2.8	3.3	3.7	3.6	3.3	3.2
	Min/Max	2.5/4.4	2.4/4.7	2.7/4.1	2.7/3.7	2.4/2.7	2.2/2.5	2.2/2.7	2.5/3.1	2.8/3.9	2.5/4.5	2.6/4.6	2.5/4.3	2.9/3.4

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.2	4.2	5.5	6.8	7.3	7.9	7.5	6.9	5.9	4.8	3.5	2.8	5.5
	Min/Max	2.5/3.8	2.9/5.3	4.3/6.3	5.5/8.5	6.5/8.5	6.6/8.9	6.3/8.6	5.7/8.0	4.9/7.0	3.5/5.8	2.6/4.4	2.2/3.5	5.1/6.0
Latitude -15	Average	3.9	4.9	6.1	7.1	7.4	7.8	7.5	7.1	6.4	5.5	4.2	3.5	6.0
	Min/Max	3.0/4.8	3.2/6.3	4.6/7.0	5.8/9.0	6.5/8.6	6.5/8.8	6.3/8.6	5.8/8.2	5.3/7.6	3.8/6.7	3.1/5.4	2.7/4.5	5.5/6.5
Latitude	Average	4.3	5.2	6.2	7.0	7.2	7.5	7.2	7.0	6.5	5.7	4.6	3.8	6.0
	Min/Max	3.2/5.3	3.3/6.7	4.6/7.1	5.7/8.9	6.3/8.3	6.3/8.5	6.0/8.3	5.7/8.1	5.3/7.7	3.9/7.0	3.3/5.8	3.0/5.0	5.5/6.5
Latitude +15	Average	4.5	5.3	6.1	6.7	6.8	7.0	6.7	6.7	6.3	5.8	4.8	4.1	5.9
	Min/Max	3.2/5.5	3.3/6.9	4.5/7.1	5.4/8.6	5.9/7.8	5.8/7.9	5.6/7.7	5.4/7.7	5.1/7.5	3.9/7.1	3.4/6.1	3.1/5.3	5.4/6.4

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	4.5	5.3	6.2	7.1	7.5	8.0	7.6	7.2	6.5	5.8	4.8	4.1	6.2
	Min/Max	3.3/5.6	3.4/6.9	4.6/7.2	5.8/9.0	6.6/8.7	6.7/9.0	6.4/8.7	5.9/8.3	5.3/7.7	3.9/7.1	3.4/6.1	3.1/5.3	5.7/6.8

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	2.6	2.8	3.0	3.2	3.3	3.6	3.3	3.1	3.0	3.1	2.8	2.4	3.0
	Min/Max	1.5/3.5	1.2/4.3	1.7/3.7	2.1/4.6	2.5/4.3	2.6/4.5	2.4/4.2	2.2/4.0	2.2/3.8	1.5/4.1	1.7/3.9	1.6/3.5	2.6/3.5
1-Axis, N-S Horiz Axis	Average	2.0	2.7	3.5	4.2	4.3	4.7	4.3	4.0	3.6	3.1	2.3	1.7	3.4
	Min/Max	1.2/2.7	1.2/4.0	2.0/4.4	2.7/6.0	3.3/5.6	3.3/5.8	3.1/5.5	2.8/5.2	2.5/4.6	1.6/4.3	1.3/3.2	1.1/2.5	2.9/3.9
1-Axis, N-S Tilt=Latitude	Average	2.9	3.4	4.1	4.4	4.2	4.4	4.1	4.1	4.0	3.8	3.1	2.6	3.8
	Min/Max	1.7/3.9	1.5/5.2	2.4/5.1	2.9/6.3	3.2/5.4	3.1/5.5	2.9/5.2	2.8/5.2	2.8/5.1	2.0/5.2	1.9/4.4	1.6/3.7	3.2/4.3
2-Axis	Average	3.1	3.5	4.1	4.5	4.5	4.7	4.4	4.2	4.0	3.9	3.3	2.8	3.9
	Min/Max	1.9/4.2	1.5/5.3	2.4/5.1	2.9/6.4	3.4/5.7	3.4/5.9	3.1/5.6	2.9/5.4	2.8/5.1	2.0/5.3	2.0/4.7	1.8/4.1	3.3/4.5

Average Climatic Conditions

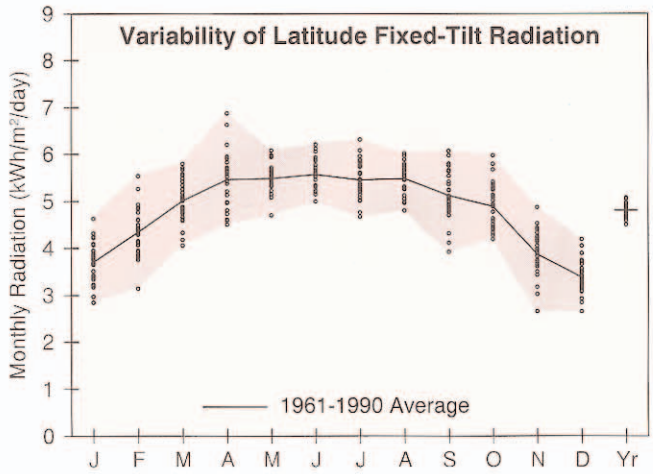
Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	2.1	3.7	8.9	14.1	18.9	23.3	25.6	24.9	21.1	14.8	9.8	4.5	14.3
Daily Minimum Temp	-3.5	-2.2	2.4	7.0	12.3	17.1	19.7	19.1	15.0	8.1	3.3	-1.2	8.1
Daily Maximum Temp	7.6	9.6	15.3	21.1	25.4	29.5	31.3	30.6	27.2	21.5	16.3	10.1	20.4
Record Minimum Temp	-24.4	-23.3	-11.7	-5.0	-0.6	4.4	10.6	7.8	1.7	-6.1	-12.2	-18.3	-24.4
Record Maximum Temp	26.7	28.3	33.9	35.6	37.8	40.0	40.6	38.9	39.4	37.2	30.0	26.7	40.6
HDD, Base 18.3°C	504	409	293	134	34	0	0	0	13	129	257	429	2202
CDD, Base 18.3°C	0	0	0	6	51	150	224	203	96	19	0	0	749
Relative Humidity (%)	68	66	63	61	70	72	75	77	77	74	69	69	70
Wind Speed (m/s)	3.7	3.9	4.2	4.1	3.6	3.4	3.1	2.9	3.0	3.2	3.4	3.6	3.5

Roanoke, VA

WBAN NO. 13741

LATITUDE: 37.32° N
LONGITUDE: 79.97° W
ELEVATION: 358 meters
MEAN PRESSURE: 976 millibars

STATION TYPE: Secondary



Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.3	3.1	4.1	5.2	5.8	6.2	5.9	5.5	4.5	3.6	2.5	2.0	4.2
	Min/Max	2.0/2.7	2.5/3.7	3.5/4.6	4.4/6.4	5.1/6.4	5.6/6.9	5.1/6.8	4.9/5.9	3.7/5.2	3.3/4.3	1.9/2.9	1.8/2.3	4.0/4.4
Latitude -15	Average	3.3	4.0	4.8	5.6	5.8	6.0	5.9	5.7	5.1	4.6	3.5	2.9	4.8
	Min/Max	2.6/4.0	3.0/5.0	4.0/5.5	4.6/7.0	5.0/6.5	5.4/6.8	5.0/6.8	5.0/6.2	4.0/6.0	4.0/5.5	2.5/4.3	2.4/3.6	4.4/5.0
Latitude	Average	3.7	4.3	5.0	5.5	5.5	5.6	5.5	5.5	5.1	4.9	3.9	3.4	4.8
	Min/Max	2.8/4.6	3.1/5.5	4.1/5.8	4.5/6.9	4.7/6.1	5.0/6.2	4.7/6.3	4.8/6.0	3.9/6.1	4.2/6.0	2.7/4.9	2.7/4.2	4.5/5.1
Latitude +15	Average	3.9	4.5	4.9	5.1	4.9	4.8	4.8	5.0	4.9	4.9	4.1	3.6	4.6
	Min/Max	3.0/5.0	3.2/5.8	3.9/5.7	4.2/6.4	4.2/5.4	4.4/5.4	4.1/5.5	4.4/5.5	3.7/5.8	4.2/6.1	2.7/5.2	2.8/4.5	4.3/4.9
90	Average	3.6	3.7	3.6	3.1	2.5	2.3	2.4	2.8	3.3	3.9	3.6	3.3	3.2
	Min/Max	2.6/4.6	2.5/4.8	2.8/4.2	2.6/3.8	2.3/2.7	2.2/2.5	2.1/2.6	2.5/3.1	2.5/3.9	3.3/4.8	2.3/4.6	2.5/4.2	3.0/3.4

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.3	4.3	5.5	6.8	7.3	7.8	7.4	7.0	5.9	5.0	3.5	2.9	5.6
	Min/Max	2.5/4.1	3.1/5.6	4.4/6.5	5.3/9.0	6.1/8.3	6.7/9.0	6.1/8.8	6.1/7.8	4.5/7.1	4.3/6.3	2.4/4.5	2.3/3.5	5.1/5.9
Latitude -15	Average	4.0	5.0	6.1	7.2	7.4	7.7	7.4	7.2	6.4	5.7	4.2	3.6	6.0
	Min/Max	3.0/5.1	3.5/6.6	4.8/7.2	5.5/9.5	6.1/8.4	6.7/9.0	6.1/8.9	6.2/8.1	4.7/7.7	4.9/7.2	2.8/5.4	2.8/4.5	5.5/6.4
Latitude	Average	4.3	5.2	6.2	7.1	7.2	7.4	7.2	7.1	6.4	6.0	4.6	3.9	6.1
	Min/Max	3.2/5.6	3.6/7.0	4.8/7.4	5.4/9.4	5.9/8.2	6.4/8.6	5.9/8.5	6.1/7.9	4.7/7.8	5.1/7.6	3.0/5.9	3.0/4.9	5.6/6.5
Latitude +15	Average	4.5	5.3	6.1	6.8	6.7	6.9	6.7	6.7	6.2	6.0	4.7	4.1	5.9
	Min/Max	3.3/5.9	3.6/7.1	4.7/7.4	5.1/9.1	5.5/7.7	5.9/8.1	5.5/8.0	5.8/7.5	4.5/7.6	5.1/7.6	3.0/6.2	3.1/5.3	5.4/6.3

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

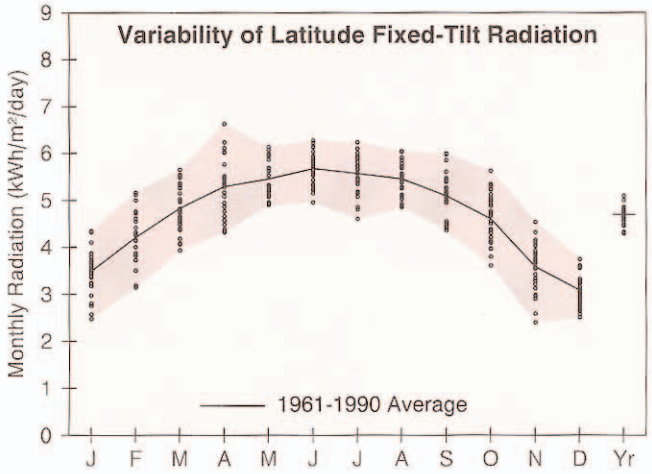
Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	4.6	5.4	6.2	7.2	7.5	7.9	7.6	7.2	6.4	6.0	4.7	4.2	6.3
	Min/Max	3.3/6.0	3.6/7.1	4.8/7.5	5.5/9.5	6.2/8.5	6.8/9.2	6.2/9.0	6.2/8.1	4.7/7.8	5.1/7.6	3.0/6.2	3.1/5.3	5.8/6.7

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W	Average	2.7	2.9	3.1	3.3	3.3	3.5	3.3	3.2	3.0	3.3	2.7	2.5	3.1
Horiz Axis	Min/Max	1.7/3.9	1.5/4.4	2.0/3.9	1.9/5.1	2.2/4.1	2.7/4.5	2.3/4.4	2.3/3.8	1.7/4.1	2.5/4.5	1.4/3.9	1.6/3.6	2.7/3.4
1-Axis, N-S	Average	2.1	2.7	3.5	4.3	4.4	4.6	4.3	4.1	3.6	3.3	2.2	1.8	3.4
Horiz Axis	Min/Max	1.3/3.0	1.5/4.2	2.3/4.6	2.4/6.7	2.9/5.4	3.5/5.9	3.1/5.7	3.1/5.0	2.2/4.9	2.6/4.7	1.1/3.2	1.2/2.6	3.0/3.9
1-Axis, N-S	Average	2.9	3.5	4.1	4.5	4.3	4.3	4.1	4.2	4.0	4.1	3.1	2.7	3.8
Tilt=Latitude	Min/Max	1.9/4.3	1.9/5.4	2.7/5.3	2.6/7.0	2.8/5.3	3.3/5.6	2.9/5.4	3.1/5.1	2.4/5.4	3.2/5.7	1.6/4.5	1.8/3.8	3.4/4.3
2-Axis	Average	3.2	3.6	4.1	4.6	4.5	4.7	4.4	4.3	4.0	4.2	3.3	2.9	4.0
	Min/Max	2.0/4.6	1.9/5.5	2.7/5.3	2.6/7.1	3.0/5.6	3.5/6.0	3.1/5.8	3.2/5.2	2.4/5.5	3.2/5.8	1.7/4.7	1.9/4.2	3.5/4.5

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	1.4	2.9	8.2	13.1	17.8	21.9	24.2	23.7	19.8	13.6	8.6	3.5	13.2
Daily Minimum Temp	-3.9	-2.7	2.1	6.6	11.4	15.7	18.2	17.7	13.8	7.1	2.8	-1.7	7.2
Daily Maximum Temp	6.6	8.5	14.3	19.6	24.3	28.3	30.2	29.6	25.8	20.1	14.4	8.7	19.2
Record Minimum Temp	-23.9	-17.2	-12.2	-6.7	-0.6	3.9	8.3	5.6	1.1	-5.6	-12.8	-20.0	-23.9
Record Maximum Temp	25.6	26.7	30.6	35.0	35.6	37.8	40.0	40.6	38.3	33.9	28.3	24.4	40.6
HDD, Base 18.3°C	526	431	313	161	58	3	0	0	22	157	292	460	2422
CDD, Base 18.3°C	0	0	0	4	43	111	183	166	67	11	0	0	584
Relative Humidity (%)	61	60	57	57	66	69	71	73	74	68	65	64	65
Wind Speed (m/s)	4.2	4.1	4.3	4.3	3.4	3.1	2.9	2.7	2.7	3.0	3.5	3.8	3.5



Sterling, VA

WBAN NO. 93738

LATITUDE: 38.95° N
LONGITUDE: 77.45° W
ELEVATION: 82 meters
MEAN PRESSURE: 1006 millibars

STATION TYPE: Primary

Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.1	2.9	4.0	5.0	5.8	6.3	6.0	5.4	4.4	3.4	2.3	1.8	4.1
	Min/Max	1.6/2.5	2.3/3.4	3.3/4.5	4.2/6.2	5.2/6.4	5.5/6.9	5.0/6.7	4.9/5.9	4.0/5.1	2.8/4.0	1.8/2.7	1.5/2.1	3.7/4.4
Latitude -15	Average	3.1	3.9	4.7	5.4	5.8	6.1	6.0	5.7	5.0	4.3	3.2	2.7	4.7
	Min/Max	2.3/3.8	3.0/4.7	3.8/5.4	4.4/6.7	5.2/6.5	5.4/6.8	4.9/6.7	5.1/6.3	4.4/5.9	3.4/5.2	2.3/4.0	2.3/3.2	4.2/5.0
Latitude	Average	3.5	4.2	4.8	5.3	5.5	5.7	5.6	5.5	5.1	4.6	3.6	3.1	4.7
	Min/Max	2.5/4.3	3.1/5.2	3.9/5.7	4.3/6.6	4.9/6.1	4.9/6.3	4.6/6.2	4.8/6.0	4.4/6.0	3.6/5.6	2.4/4.5	2.5/3.7	4.3/5.1
Latitude +15	Average	3.7	4.3	4.7	4.9	4.8	4.9	4.9	5.0	4.9	4.6	3.7	3.3	4.5
	Min/Max	2.5/4.7	3.2/5.4	3.8/5.6	4.0/6.1	4.4/5.4	4.3/5.4	4.1/5.5	4.4/5.5	4.1/5.8	3.6/5.7	2.4/4.8	2.6/4.0	4.1/4.9
90	Average	3.4	3.7	3.5	3.1	2.6	2.5	2.6	2.9	3.3	3.7	3.3	3.0	3.1
	Min/Max	2.2/4.5	2.7/4.6	2.8/4.1	2.5/3.8	2.4/2.9	2.3/2.7	2.3/2.8	2.7/3.2	2.8/4.0	2.8/4.5	2.0/4.3	2.3/3.8	2.8/3.4

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	3.0	4.1	5.3	6.5	7.2	7.8	7.4	6.8	5.8	4.6	3.2	2.5	5.4
	Min/Max	2.2/3.8	3.0/5.0	4.3/6.3	5.1/8.7	6.4/8.3	6.7/9.0	5.8/8.4	5.8/7.8	4.9/7.0	3.6/5.7	2.2/4.0	2.0/3.1	4.8/5.8
Latitude -15	Average	3.7	4.8	5.9	6.9	7.3	7.8	7.5	7.0	6.3	5.3	3.9	3.2	5.8
	Min/Max	2.6/4.7	3.5/6.0	4.7/7.1	5.3/9.2	6.5/8.5	6.6/8.9	5.8/8.4	5.9/8.1	5.2/7.6	4.1/6.7	2.5/5.0	2.6/4.0	5.2/6.4
Latitude	Average	4.0	5.0	6.0	6.8	7.1	7.4	7.2	6.9	6.3	5.6	4.2	3.5	5.8
	Min/Max	2.7/5.2	3.6/6.4	4.7/7.2	5.2/9.1	6.3/8.2	6.3/8.6	5.6/8.1	5.8/8.0	5.2/7.7	4.2/7.0	2.6/5.4	2.8/4.4	5.3/6.4
Latitude +15	Average	4.2	5.1	5.9	6.5	6.7	6.9	6.7	6.5	6.1	5.6	4.3	3.7	5.7
	Min/Max	2.8/5.5	3.7/6.5	4.6/7.1	4.9/8.8	5.9/7.7	5.9/8.0	5.2/7.6	5.4/7.6	5.1/7.5	4.2/7.0	2.6/5.6	2.9/4.6	5.1/6.3

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	4.3	5.1	6.0	6.9	7.4	7.9	7.6	7.1	6.3	5.6	4.3	3.7	6.0
	Min/Max	2.8/5.5	3.7/6.5	4.7/7.2	5.3/9.2	6.5/8.6	6.8/9.1	5.9/8.6	5.9/8.1	5.3/7.7	4.3/7.0	2.7/5.7	2.9/4.7	5.5/6.6

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	2.4	2.7	2.9	3.1	3.2	3.4	3.2	3.0	2.9	3.0	2.4	2.2	2.9
	Min/Max	1.2/3.4	1.3/4.0	2.0/3.9	1.7/4.8	2.6/4.1	2.7/4.2	1.9/4.0	2.0/3.8	2.0/3.9	2.0/4.1	1.0/3.5	1.5/3.0	2.5/3.3
1-Axis, N-S Horiz Axis	Average	1.8	2.5	3.3	4.0	4.2	4.4	4.1	3.8	3.4	2.9	1.9	1.5	3.2
	Min/Max	0.9/2.5	1.3/3.6	2.2/4.5	2.2/6.3	3.4/5.4	3.5/5.5	2.5/5.3	2.5/5.0	2.5/4.7	2.0/4.1	0.8/2.8	1.1/2.1	2.8/3.7
1-Axis, N-S Tilt=Latitude	Average	2.7	3.3	3.8	4.2	4.1	4.2	3.9	3.9	3.9	3.7	2.7	2.3	3.6
	Min/Max	1.4/3.7	1.7/4.8	2.6/5.3	2.3/6.6	3.3/5.2	3.3/5.2	2.3/5.1	2.5/5.1	2.7/5.2	2.5/5.1	1.2/4.0	1.6/3.2	3.1/4.1
2-Axis	Average	2.8	3.4	3.8	4.3	4.3	4.5	4.2	4.0	3.9	3.8	2.9	2.5	3.7
	Min/Max	1.5/4.0	1.7/4.9	2.6/5.3	2.3/6.7	3.5/5.5	3.6/5.7	2.5/5.4	2.6/5.2	2.8/5.3	2.5/5.1	1.2/4.2	1.8/3.5	3.2/4.3

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	-0.8	0.9	6.2	11.5	16.8	21.7	24.2	23.4	19.5	12.8	7.4	1.9	12.1
Daily Minimum Temp	-6.1	-4.8	-0.1	4.6	10.0	15.1	17.8	17.1	13.0	5.8	1.2	-3.4	5.8
Daily Maximum Temp	4.5	6.6	12.6	18.4	23.5	28.2	30.6	29.7	26.1	19.8	13.7	7.2	18.4
Record Minimum Temp	-27.8	-25.6	-14.4	-8.3	-2.2	2.2	5.0	3.3	-1.1	-9.4	-12.8	-20.0	-27.8
Record Maximum Temp	23.9	26.1	31.7	33.3	36.1	37.8	40.0	40.0	37.2	32.2	28.9	25.6	40.0
HDD, Base 18.3°C	592	488	376	205	78	4	0	0	24	177	327	510	2781
CDD, Base 18.3°C	0	0	0	0	29	104	183	158	59	7	0	0	541
Relative Humidity (%)	68	66	63	62	70	72	73	74	75	73	70	69	70
Wind Speed (m/s)	3.7	3.8	4.1	3.9	3.4	3.0	2.8	2.6	2.7	3.0	3.4	3.5	3.4