Environmental Systems I

Assignemnt

Shih-Kai Lin

2017 Sep 1

WEATHER DATA SUMMARY	LOCATION:	Philadelphia Ne Philadelphia, PA, USA
	Latitude/Longitude:	40.08° North, 75.02° West, **Time Zone from Greenwich** -5
	Data Source:	TMY3 724085 WMO Station Number, **Elevation** 98 ft

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	52	100	87	105	114	124	147	114	100	89	77	52	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	62	129	83	85	79	87	141	83	88	98	110	71	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	29	40	42	49	58	61	47	57	48	40	33	28	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	164	221	261	295	313	301	305	285	258	228	182	143	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	298	281	304	268	296	256	277	252	251	268	265	280	Btu/sq.ft
Diffuse Radiation (Max Hourly)	110	100	131	136	187	139	173	130	119	114	87	96	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	493	1044	1031	1386	1631	1837	2142	1547	1230	973	760	484	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	590	1353	982	1124	1138	1293	2059	1137	1079	1072	1084	658	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	283	422	497	656	838	916	694	776	586	445	328	261	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	1655	3101	2786	3328	3647	3939	4606	3621	3180	2789	2406	1665	footcandles
Direct Normal Illumination (Avg Hourly)	1652	3573	2356	2446	2332	2555	4093	2445	2528	2745	2989	1868	footcandles
Dry Bulb Temperature (Avg Monthly)	26	34	44	54	61	71	76	78	70	56	46	40	degrees F
Dew Point Temperature (Avg Monthly)	17	18	33	43	48	58	64	65	57	45	35	29	degrees F
Relative Humidity (Avg Monthly)	70	51	65	71	65	66	70	67	67	69	67	65	percent
Wind Direction (Monthly Mode)	300	280	310	200	320	240	280	210	310	350	290	330	degrees
Wind Speed (Avg Monthly)	8	8	10	9	8	6	7	5	7	6	7	7	mph
Ground Temperature (Avg Monthly of 3 Depths)	40	37	38	42	52	61	68	72	70	65	56	47	degrees F

COMFORT MODEL	LOCATION:	Philadelphia Ne Philadelphia, PA, USA
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COMFORT MODELS:

Human Thermal comfort can be defined primarily by dry bulb temperature and humidity, although different sources have slightly different definitions. Select the model you wish to use:

◉ **California Energy Code Comfort Model, 2013 (DEFAULT)**

For the purpose of sizing residential heating and cooling systems the indoor Dry Bulb Design Conditions should be between 68°F (20°C) to 75°F (23.9°C). No Humidity limits are specified in the Code, so 80% Relative Humidity and 66°F (18.9°C) Wet Bulb is used for the upper limit and 27°F (-2.8°C) Dew Point is used for the lower limit (but these can be changed on the Criteria screen).

○ **ASHRAE Standard 55 and Current Handbook of Fundamentals Model**

Thermal comfort is based on dry bulb temperature, clothing level (clo), metabolic activity (met), air velocity, humidity, and mean radiant temperature. Indoors it is assumed that mean radiant temperature is close to dry bulb temperature. The zone in which most people are comfortable is calculated using the PMV (Predicted Mean Vote) model. In residential settings people adapt clothing to match the season and feel comfortable in higher air velocities and so have wider comfort range than in buildings with centralized HVAC systems.

○ **ASHRAE Handbook of Fundamentals Comfort Model up through 2005**

For people dressed in normal winter clothes, Effective Temperatures of 68°F (20°C) to 74°F (23.3°C) (measured at 50% relative humidity), which means the temperatures decrease slightly as humidity rises. The upper humidity limit is 64°F (17.8°C) Wet Bulb and a lower Dew Point of 36F (2.2°C). If people are dressed in light weight summer clothes then this comfort zone shifts 5°F (2.8°C) warmer.

○ **Adaptive Comfort Model in ASHRAE Standard 55-2010**

In naturally ventilated spaces where occupants can open and close windows, their thermal response will depend in part on the outdoor climate, and may have a wider comfort range than in buildings with centralized HVAC systems. This model assumes occupants adapt their clothing to thermal conditions, and are sedentary (1.0 to 1.3 met). There must be no mechanical Cooling System, but this method does not apply if a Mechanical Heating System is in operation.

CRITERIA: (Imperial Units)

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California Energy Code Comfort Model, 2013 (select Help for definitions)

1. COMFORT: (using California Energy Code Model)

68.0	Comfort Low - Min. Comfort Dry Bulb Temp (°F)
75.0	Comfort High - Max. Comfort Dry Bulb Temp, up to 50% RH (°F)
80.0	Max. Relative Humidity (measured at Min. Comfort Temp) (%)
66.0	Max. Wet Bulb Temperature (°F)
27.0	Min. Dew Point Temperature (°F)

2. SUN SHADING ZONE: (Defaults to Comfort Low)

68.0	Min. Dry Bulb Temperature when Need for Shading Begins (°F)
100.0	Min. Global Horiz. Radiation when Need for Shading Begins (Btu/sq.ft)

3. HIGH THERMAL MASS ZONE:

15.0	Max. Outdoor Temperature Difference above Comfort High (°F)
3.0	Min. Nighttime Temperature Difference below Comfort High (°F)

4. HIGH THERMAL MASS WITH NIGHT FLUSHING ZONE:

30.0	Max. Outdoor Temperature Difference above Comfort High (°F)
3.0	Min. Nighttime Temperature Difference below Comfort High (°F)

5. DIRECT EVAPORATIVE COOLING ZONE: (Defined by Comfort Zone)

63.8	Max. Wet Bulb set by Max. Comfort Zone Wet Bulb (°F)
48.8	Min. Wet Bulb set by Min. Comfort Zone Wet Bulb (°F)

6. TWO-STAGE EVAPORATIVE COOLING ZONE:

50.0	% Efficiency of Indirect Stage

7. NATURAL VENTILATION COOLING ZONE:

2.0	Terrain Category to modify Wind Speed (2=suburban)
40.0	Min. Indoor Velocity to Effect Indoor Comfort (fpm)
300.0	Max. Comfortable Velocity (per ASHRAE Std. 55) (fpm)
6.6	Max. Perceived Temperature Reduction (°F)
90.0	Max. Relative Humidity (%)
73.0	Max. Wet Bulb Temperature (°F)

8. FAN-FORCED VENTILATION COOLING ZONE:

160.0	Max. Mechanical Ventilation Velocity (fpm)
5.4	Max. Perceived Temperature Reduction (°F)
	(Min Vel, Max RH, Max WB match Natural Ventilation)

9. INTERNAL HEAT GAIN ZONE (lights, people, equipment):

55.0	Balance Point Temperature below which Heating is Needed (°F)

10. PASSIVE SOLAR DIRECT GAIN LOW MASS ZONE:

50.0	Min. South Window Radiation for 10° F Temperature Rise (Btu/sq.ft)
3.0	Thermal Time Lag for Low Mass Buildings (hours)

11. PASSIVE SOLAR DIRECT GAIN HIGH MASS ZONE:

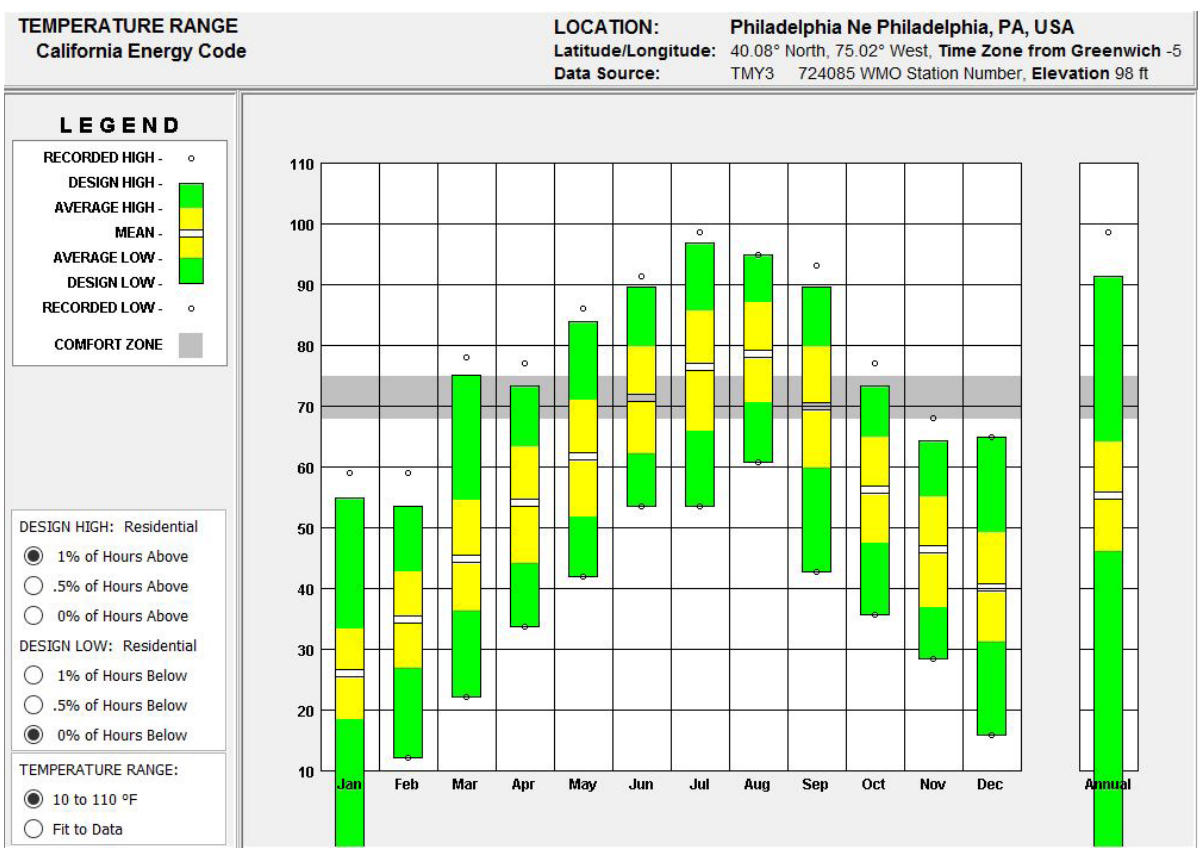
100.0	Min. South Window Radiation for 10° F Temperature Rise (Btu/sq.ft)
12.0	Thermal Time Lag for High Mass Buildings (hours)

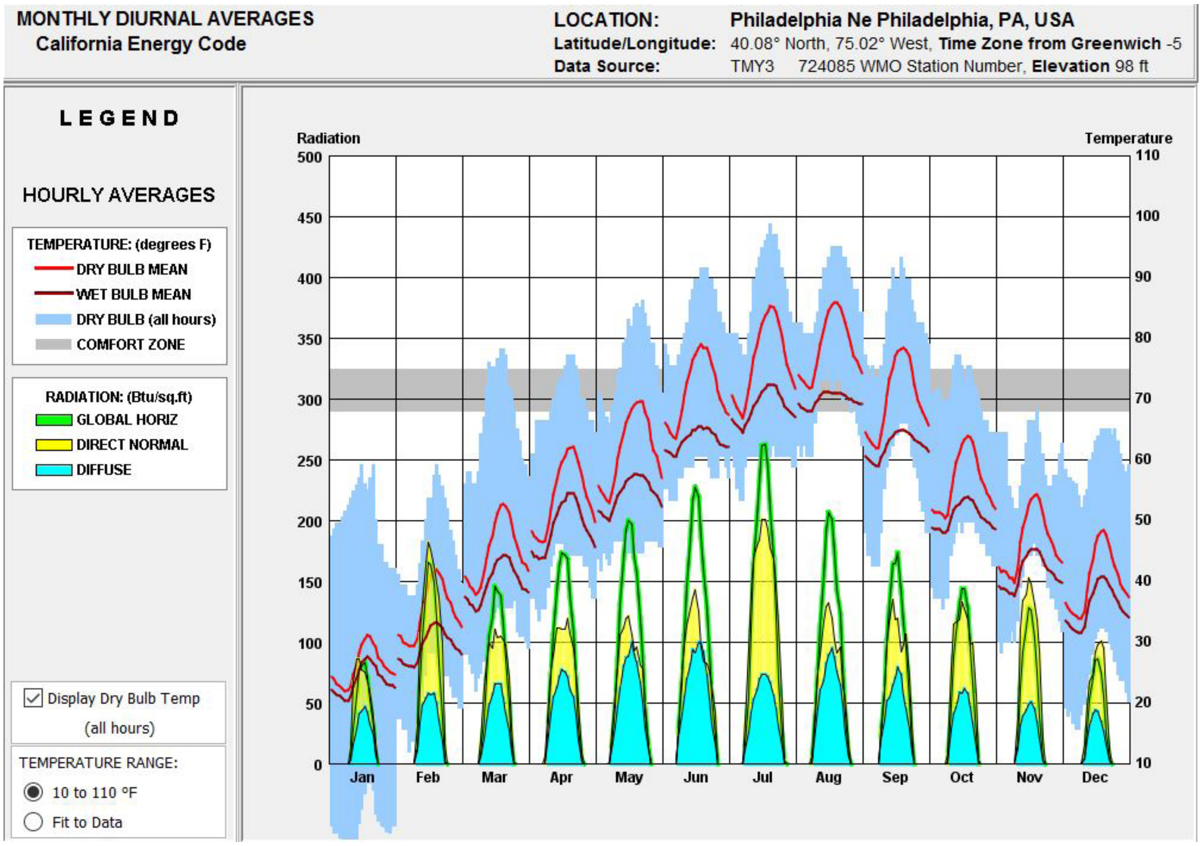
12. WIND PROTECTION OF OUTDOOR SPACES:

19.0	Velocity above which Wind Protection is Desirable (mph)
20.0	Dry Bulb Temperature Above or Below Comfort Zone (°F)

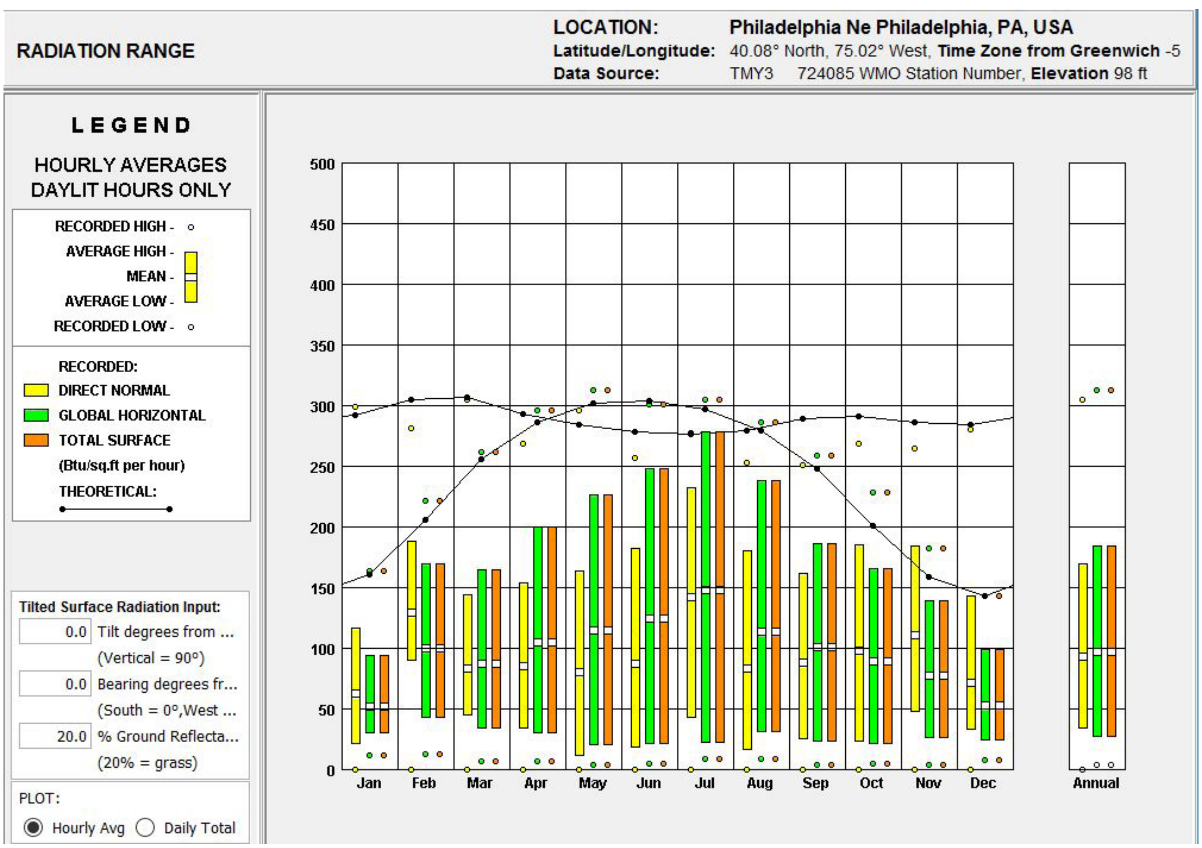
13. HUMIDIFICATION ZONE: (defined by and below Comfort Zone)

14. DEHUMIDIFICATION ZONE: (defined by and above Comfort Zone)

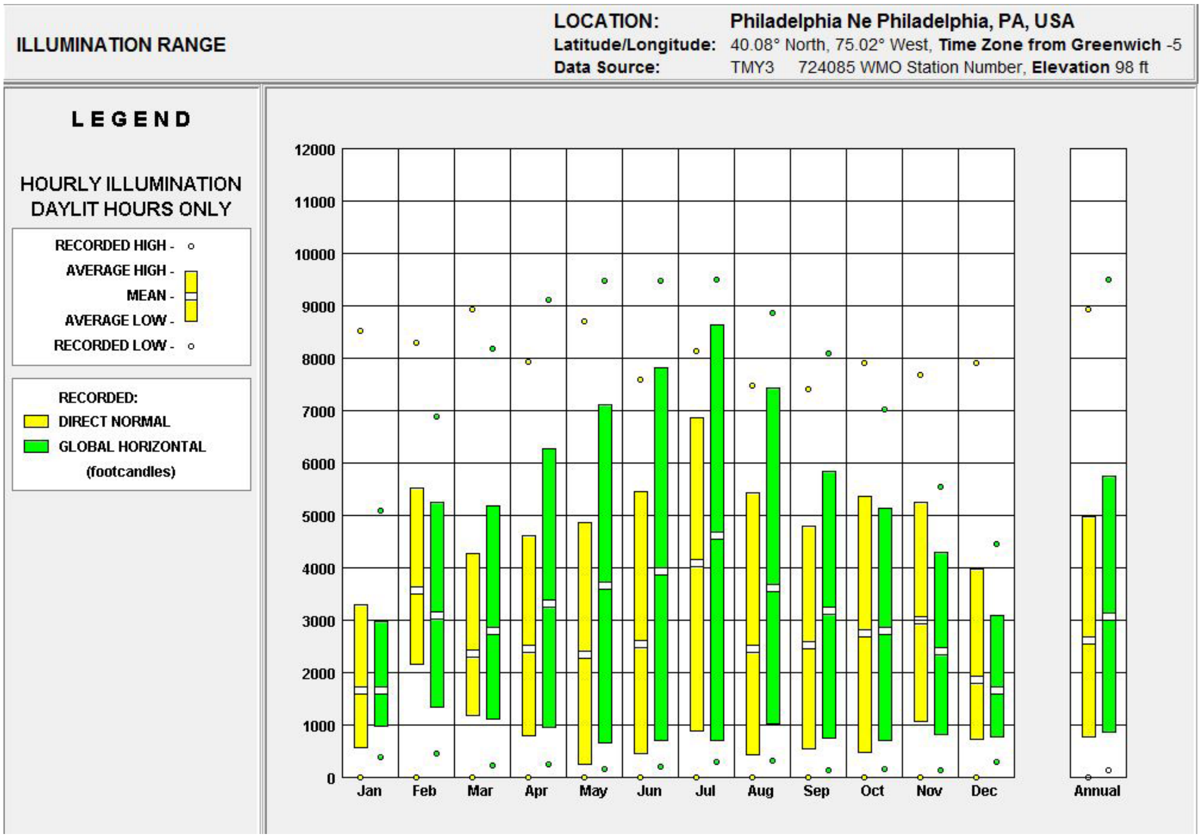


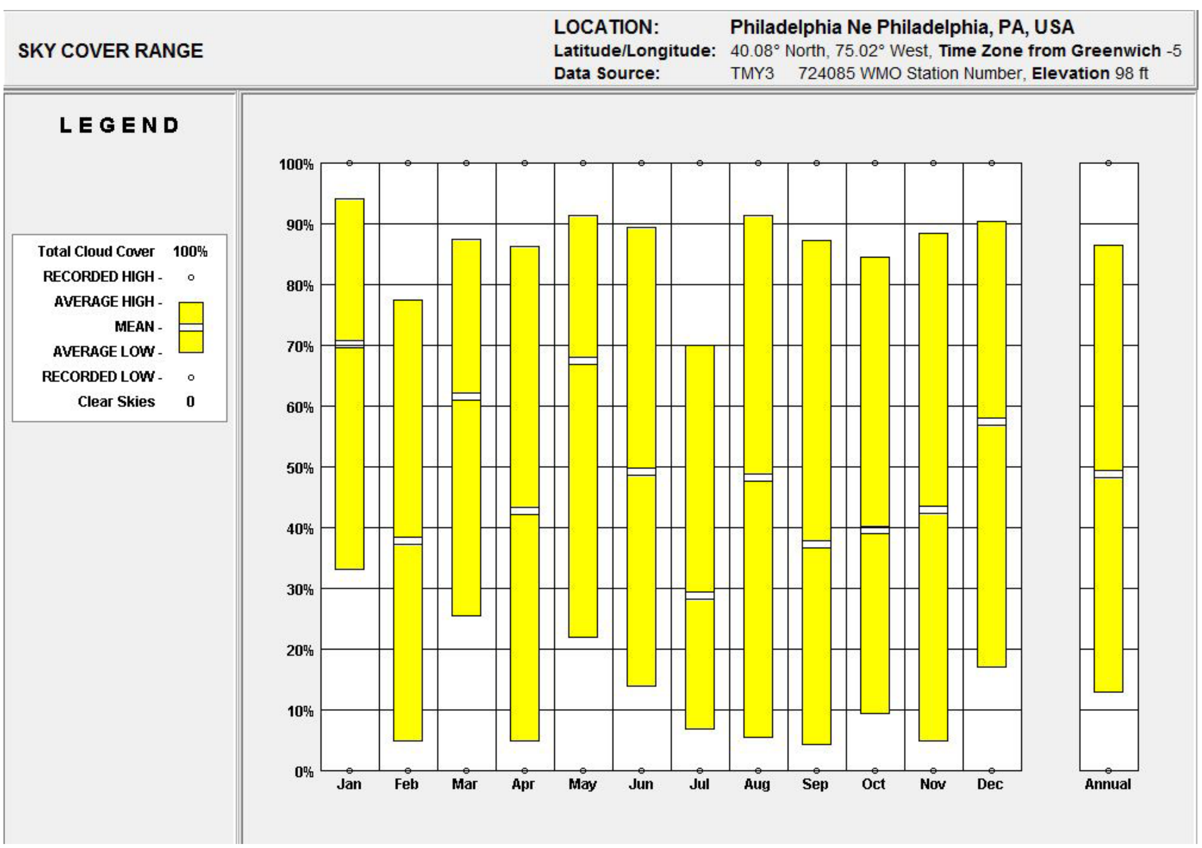


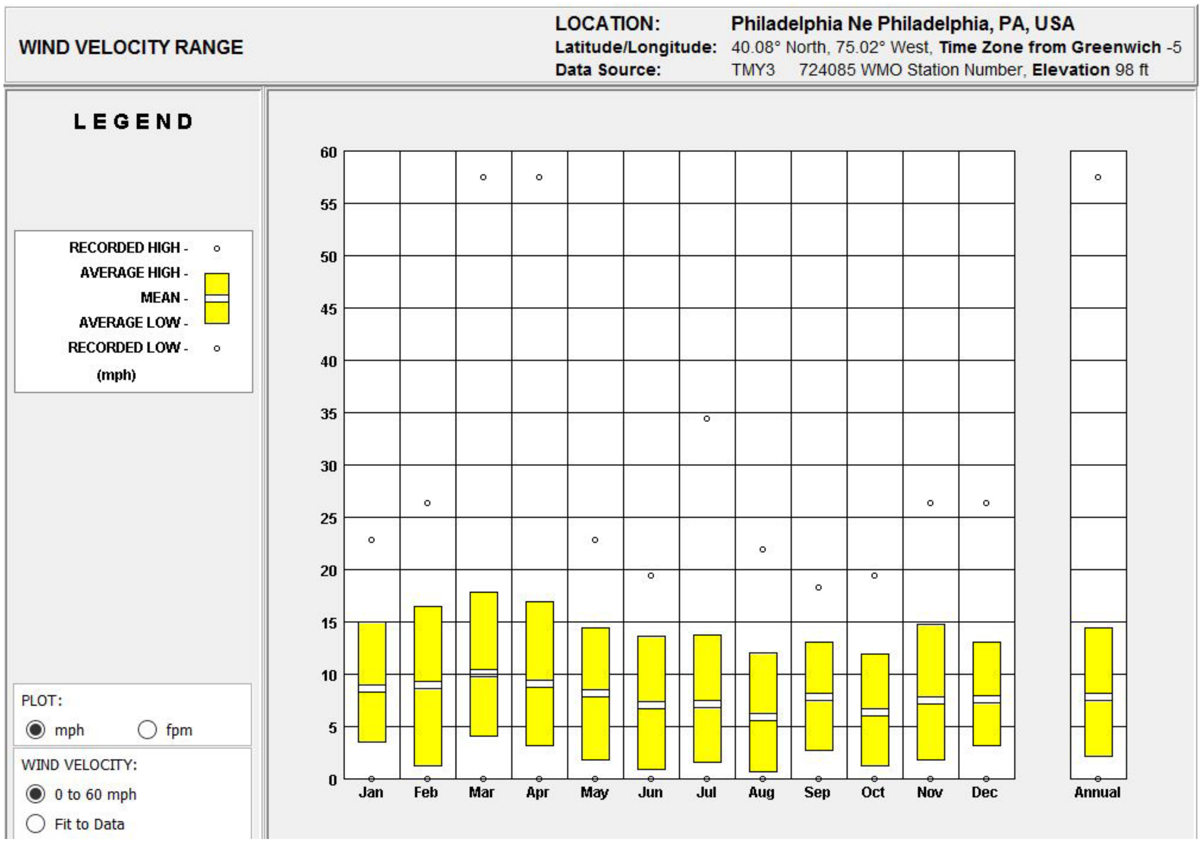
MONTHLY DIURNAL AVERAGES
California Energy Code
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
HOURLY AVERAGES
TEMPERATURE: (degrees F)
DRY BULB MEAN
WET BULB MEAN
DRY BULB (all hours)
COMFORT ZONE
RADIATION: (Btu/sq.ft)
GLOBAL HORIZ
DIRECT NORMAL
DIFFUSE
Display Dry Bulb Temp (all hours)
TEMPERATURE RANGE:
10 to 110 °F
Fit to Data
Radiation
Temperature
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

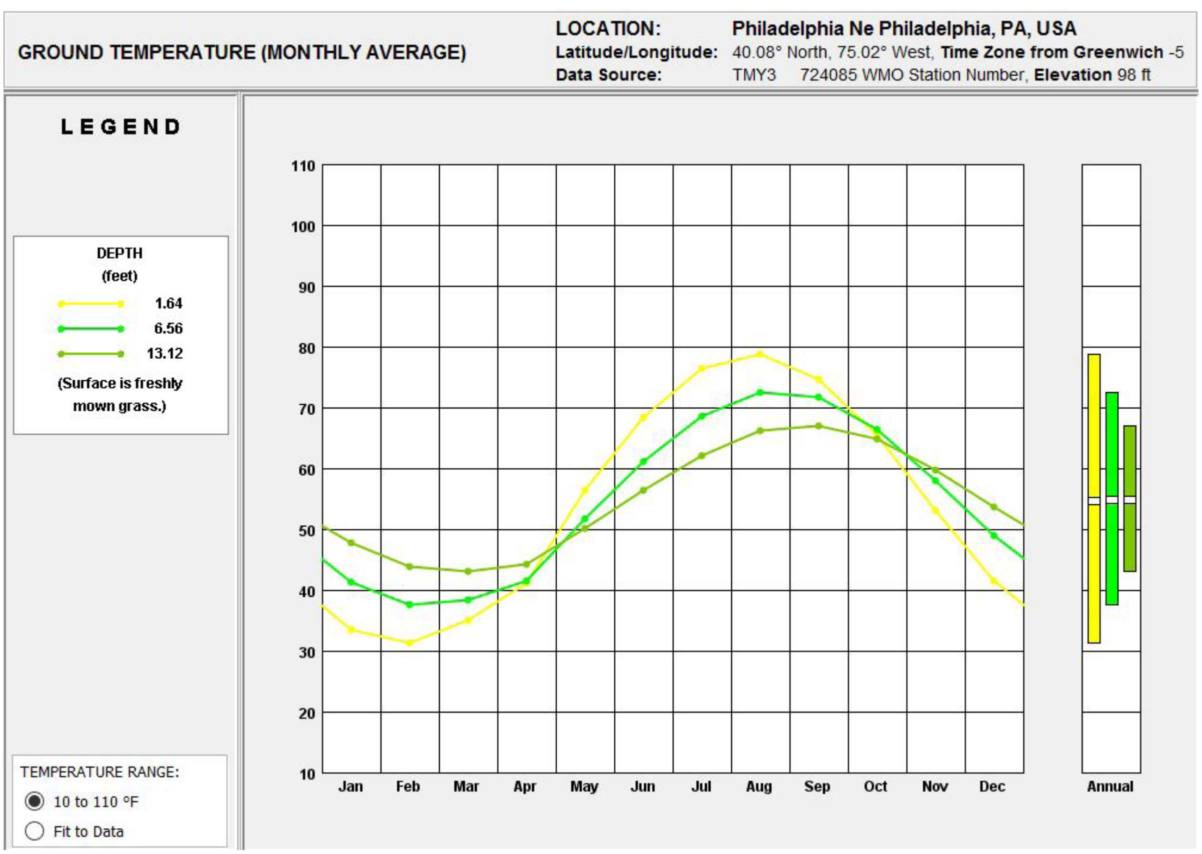


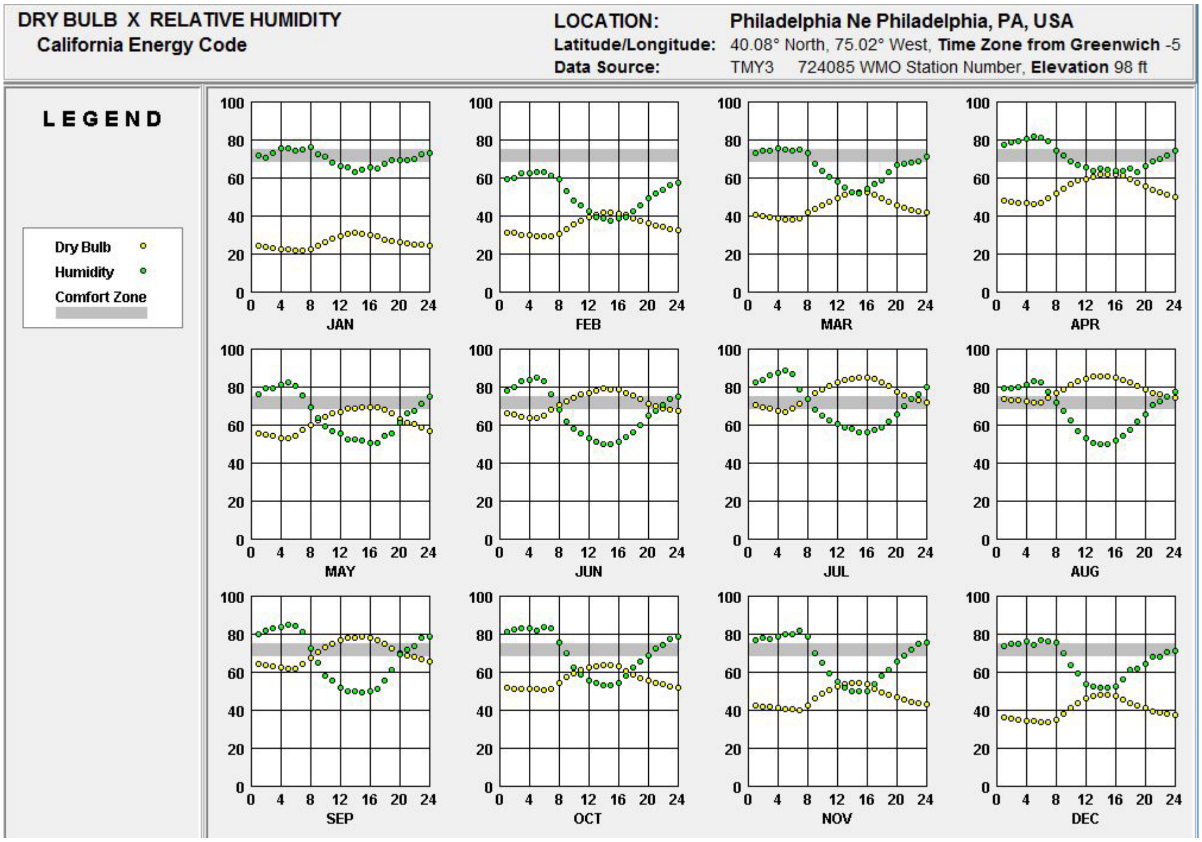
RADIATION RANGE
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
HOURLY AVERAGES
DAYLIT HOURS ONLY
RECORDED HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORDED LOW -
RECORDED:
DIRECT NORMAL
GLOBAL HORIZONTAL
TOTAL SURFACE
(Btu/sq.ft per hour)
THEORETICAL:
Tilted Surface Radiation Input:
0.0 Tilt degrees from ...
(Vertical = 90°)
0.0 Bearing degrees fr...
(South = 0°,West ...
20.0 % Ground Reflecta...
(20% = grass)
PLOT:
Hourly Avg
Daily Total
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Annual

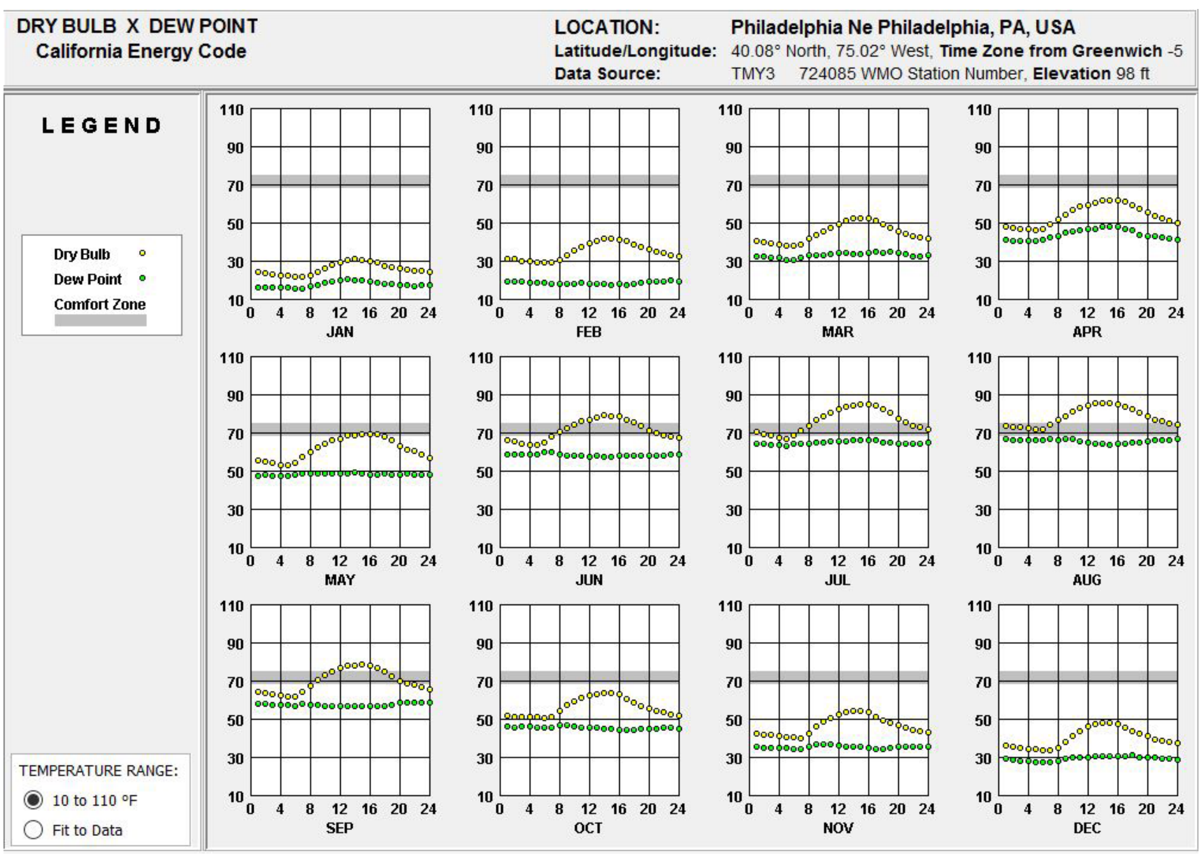

ILLUMINATION RANGE
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
HOURLY ILLUMINATION
DAYLIT HOURS ONLY
RECORDED HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORDED LOW -
RECORDED:
DIRECT NORMAL
GLOBAL HORIZONTAL
(footcandles)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Annual

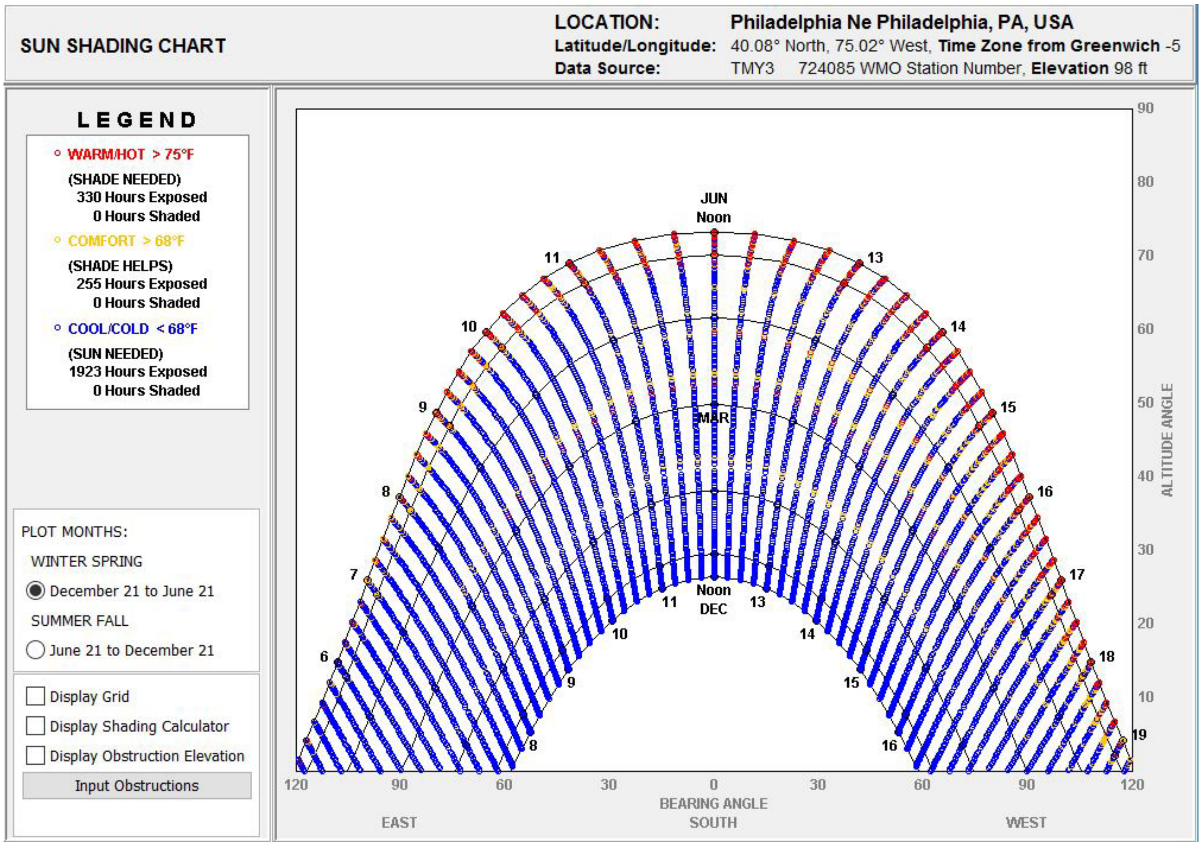

SKY COVER RANGE
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
Total Cloud Cover 100%
RECORDED HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORDED LOW -
Clear Skies 0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Annual

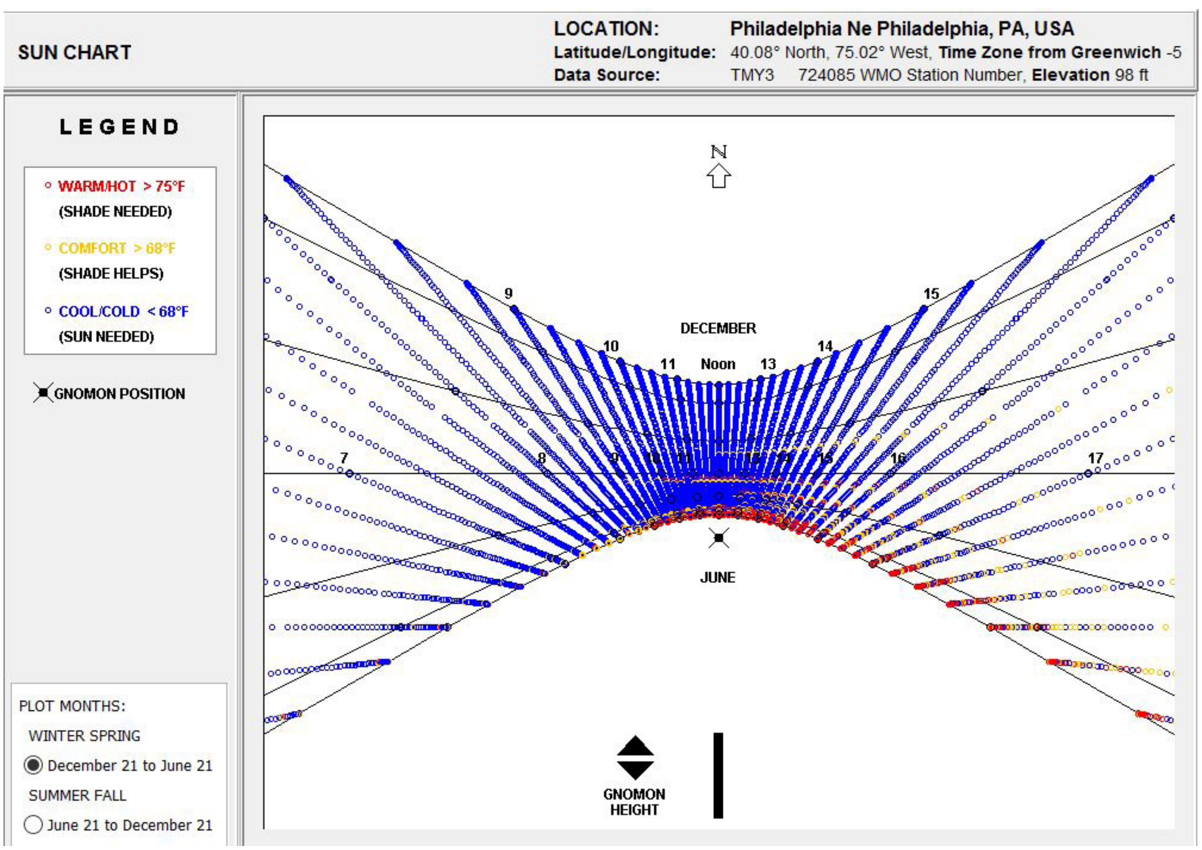

WIND VELOCITY RANGE
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
RECORDED HIGH -
AVERAGE HIGH -
MEAN -
AVERAGE LOW -
RECORDED LOW -
(mph)
PLOT:
mph
fpm
WIND VELOCITY:
0 to 60 mph
Fit to Data
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Annual

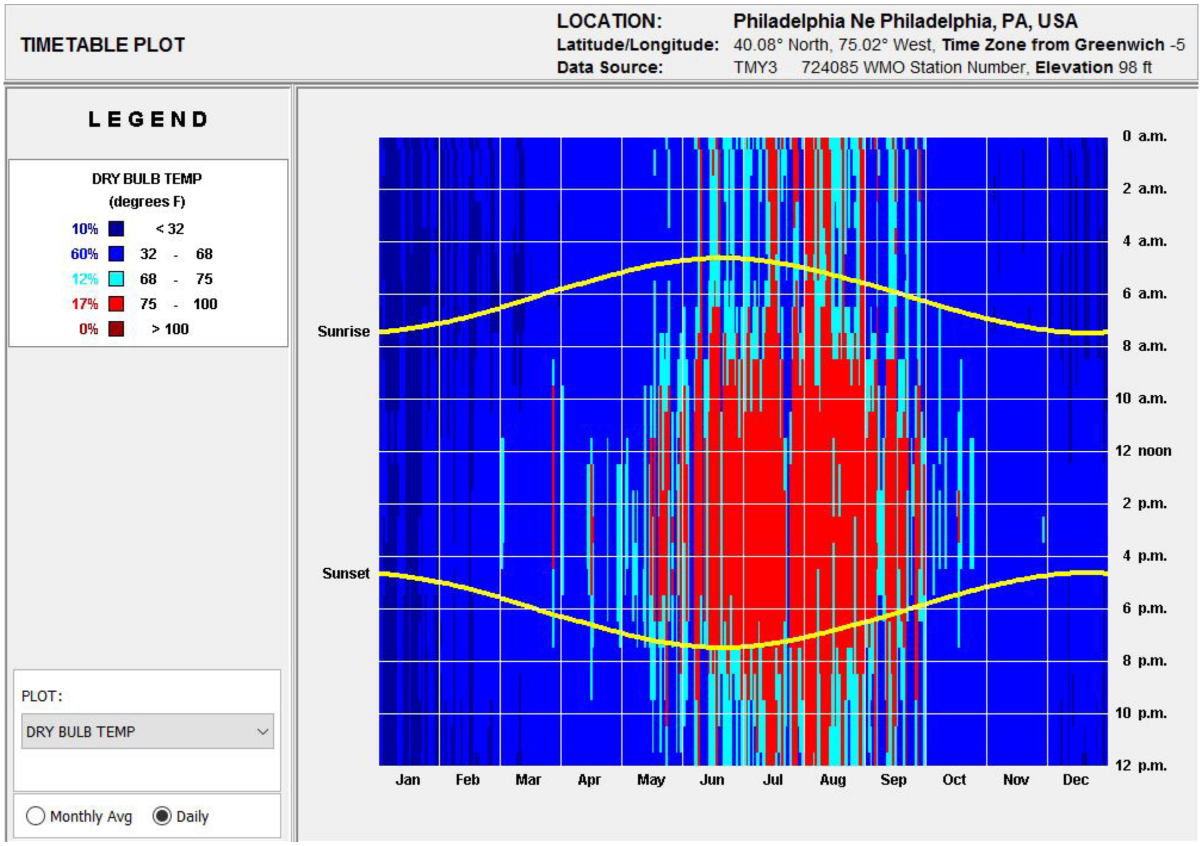

GROUND TEMPERATURE (MONTHLY AVERAGE)
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
DEPTH
(feet)
1.64
6.56
13.12
(Surface is freshly mown grass.)
TEMPERATURE RANGE:
10 to 110 °F
Fit to Data
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Annual

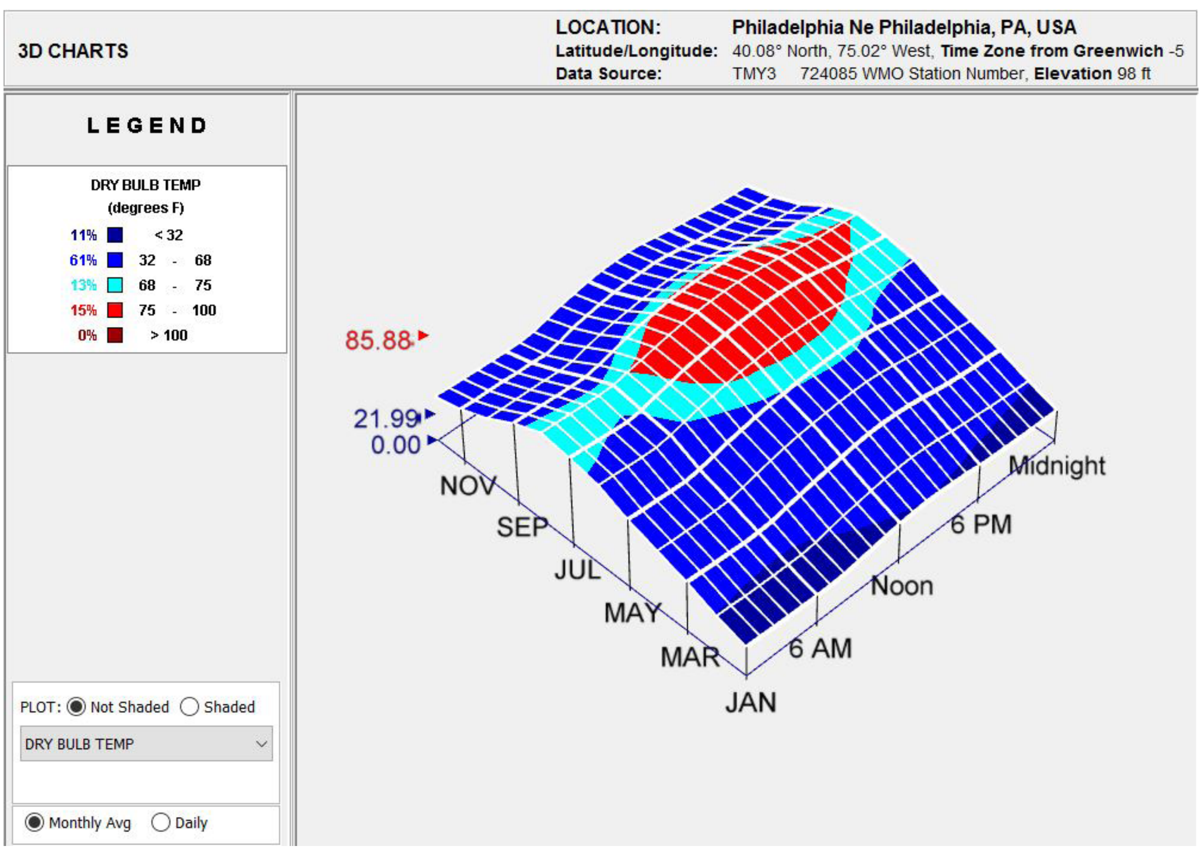

DRY BULB X RELATIVE HUMIDITY
California Energy Code
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
Dry Bulb
Humidity
Comfort Zone
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

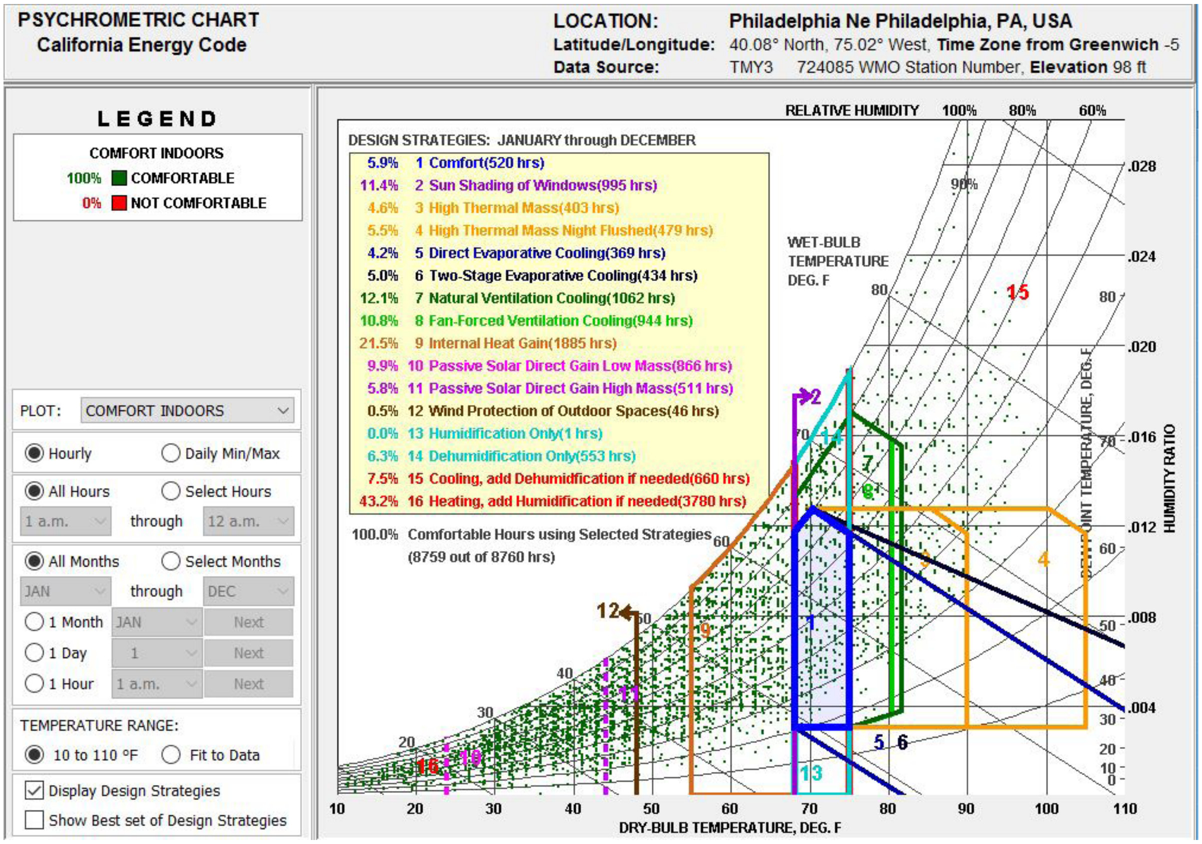

DRY BULB X DEW POINT
California Energy Code
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
Dry Bulb
Dew Point
Comfort Zone
TEMPERATURE RANGE:
10 to 110 °F
Fit to Data
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


SUN SHADING CHART
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
WARM/HOT > 75°F
(SHADE NEEDED)
330 Hours Exposed
0 Hours Shaded
COMFORT > 68°F
(SHADE HELPS)
255 Hours Exposed
0 Hours Shaded
COOL/COLD < 68°F
(SUN NEEDED)
1923 Hours Exposed
0 Hours Shaded
PLOT MONTHS:
WINTER SPRING
December 21 to June 21
SUMMER FALL
June 21 to December 21
Display Grid
Display Shading Calculator
Display Obstruction Elevation
Input Obstructions
JUN
Noon
MAR
Noon
DEC
ALTITUDE ANGLE
BEARING ANGLE
EAST
SOUTH
WEST


SUN CHART
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
WARM/HOT > 75°F
(SHADE NEEDED)
COMFORT > 68°F
(SHADE HELPS)
COOL/COLD < 68°F
(SUN NEEDED)
GNOMON POSITION
PLOT MONTHS:
WINTER SPRING
December 21 to June 21
SUMMER FALL
June 21 to December 21
N
DECEMBER
Noon
JUNE
GNOMON
HEIGHT


TIMETABLE PLOT
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
DRY BULB TEMP
(degrees F)
10% < 32
60% 32 - 68
12% 68 - 75
17% 75 - 100
0% > 100
PLOT:
DRY BULB TEMP
Monthly Avg
Daily
Sunrise
Sunset
0 a.m.
2 a.m.
4 a.m.
6 a.m.
8 a.m.
10 a.m.
12 noon
2 p.m.
4 p.m.
6 p.m.
8 p.m.
10 p.m.
12 p.m.
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


3D CHARTS
LOCATION: Philadelphia Ne Philadelphia, PA, USA
Latitude/Longitude: 40.08° North, 75.02° West, Time Zone from Greenwich -5
Data Source: TMY3 724085 WMO Station Number, Elevation 98 ft
LEGEND
DRY BULB TEMP
(degrees F)
11% < 32
61% 32 - 68
13% 68 - 75
15% 75 - 100
0% > 100
PLOT: Not Shaded Shaded
DRY BULB TEMP
Monthly Avg
Daily
85.88
21.99
0.00
NOV
SEP
JUL
MAY
MAR
JAN
6 AM
Noon
6 PM
Midnight



Passive Design Strategies

1. According to the graph of Temperature Range, the monthly temperatures are colder than the comfort temperature most of the time in winter in Philadelphia. By adding operable external shading would increase the indoor temperature, and reduce the energy consumed during active heating in winter, while it would also shade the building in summer, as a design strategy of passive solar heating.

2. By adding wind tower would create naturally occurring air flow in the building and bring the fresh air from exterior to interior as a design strategy of passive ventilation.

3. Using building materials that could absorb and save heat energy would increase the thermal mass of a building and keep the building from overheating due to solar gain or internal heat gain as a design strategy of passive cooling.