THE BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction
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Technical Notes 43 - Passive Solar Heating with Brick Masonry - Part 1 Introduction

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Abstract: Brick masonry passive solar energy systems can be used to significantly reduce the use of fossil fuels for heating and cooling buildings. The basic concepts and necessary considerations for the design of passive solar heating systems are discussed. The basic concepts involve the incorporation of the passive solar heating system into the architectural design of the intended use and operation of the building. Consideration of environmental factors is also discussed.

Key Words: attached sunspaces, **bricks**, buildings, cavity wall systems, climatology, conservation, direct gain systems, energy, masonry, **passive solar heating systems**, solar radiation, system operation, thermal storage walls.

INTRODUCTION

Energy conservation and fuel consumption have become a major concern in recent years. Much of the nation's fuel is used in the heating of buildings. The use of solar heating systems will help to reduce this consumption of non-renewable energy resources. Solar energy is an immediately available renewable energy source. Most buildings can easily be designed to benefit from solar heating.

Two types of solar energy systems may be used to heat buildings, active and passive. Active solar heating systems are those which require mechanical equipment for operation. Pumps and other mechanical devices are required to circulate liquids or gases through solar collectors, to storage media, and then to transfer the collected heat to the occupied spaces of the building.

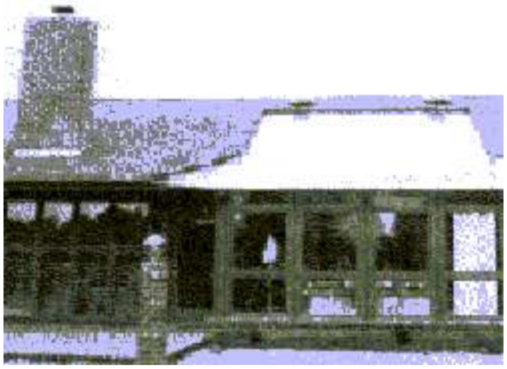
Passive solar heating systems do not require the use of mechanical equipment. The heat flow in passive solar heating systems is by natural means: radiation, convection, and conductance. The thermal storage is in the structure itself. Although passive solar heating systems do not require mechanical equipment for operation, this does not mean that fans or blowers may not, or should not, be used to assist the natural flow of thermal energy. The passive systems assisted by mechanical devices are referred to as ''hybrid'' heating systems.

Passive solar systems utilize basic concepts incorporated into the architectural design of the building. They usually consist of: buildings with rectangular floor plans, elongated on an East-West axis; a glazed South-facing wall; a thermal storage media exposed to the solar radiation which penetrates the South-facing glazing; overhangs or other shading devices which sufficiently shade the South-facing glazing from the summer sun; and windows on the East and West walls, and preferably none on the North walls. Passive solar systems do not have a high initial cost or long-term payback period, both of which are common with many active solar heating systems.

This *Technical Notes* introduces the general features and requirements for the development and application of passive solar heating systems. Passive solar cooling systems are discussed in *Technical Notes* 43C. Due to the variations in building type and environment which must be considered, it is not normally feasible for passive solar systems to be the sole source of heat in most climatological areas. Construction details are provided in *Technical Notes* 43G.

Passive Solar Building with Thermal Storage Wall Under Construction

FIG. 1



Combined Thermal Storage Wall System and Attached Sunspace

FIG. 2

ENVIRONMENTAL DATA AND REQUIREMENTS

Many environmental factors must be considered to fully utilize the concepts of passive solar heating systems. Environmental data is given in Tables 1 and 2 of this *Technical Notes.*

Temperature

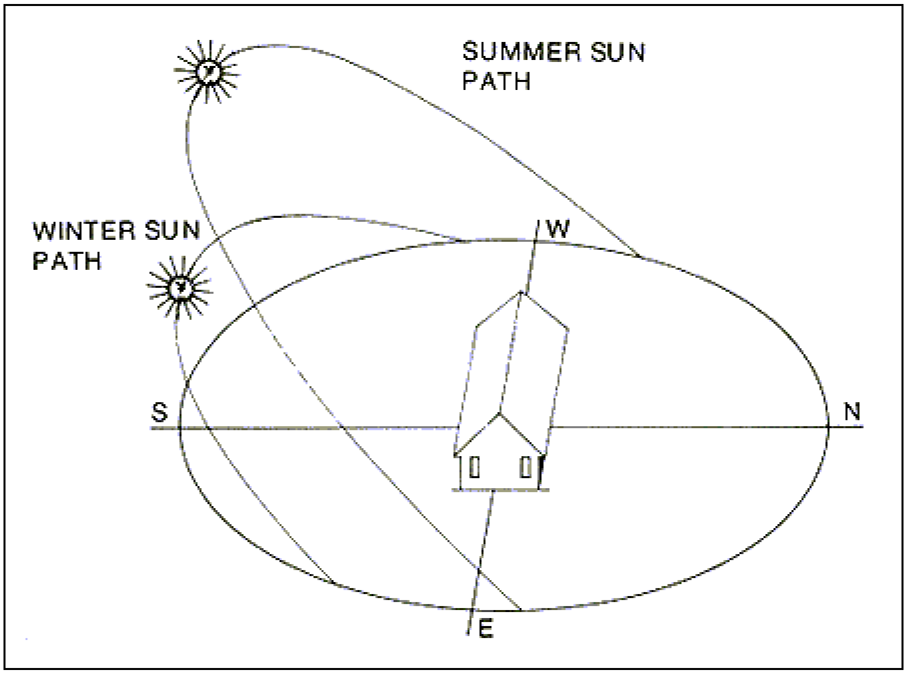
Exterior design temperatures are important considerations in developing passive solar heating systems. The size of the system will depend upon daily, monthly and annual temperature fluctuations. In mild, sunny climates, the required glazing and thermal storage areas may be relatively small. In temperate, cloudy climates, the required glazing area may be small, but the thermal storage requirements may be greater. In colder climates, the amount of glazing and thermal storage is usually large.

The average monthly heating degree days are related to exterior temperature conditions. These values are necessary to determine the total monthly thermal load of the building. Average monthly heating degree days and exterior temperatures are given in Table 2 at the end of this *Technical Notes*.

Latitude

Latitude is important to determine the amount of solar radiation and the appropriate summertime shading provided by overhangs and other devices. The further North the building is to be located, the less winter solar radiation it will receive. This is because the sun is above the horizon for a shorter period of time and the solar radiation must penetrate more of the atmosphere. Values of solar radiation at various latitudes are given in Table 1.

At higher latitudes, the sun appears lower in the sky. At these latitudes, where the position (altitude) of the sun in the sky is low, larger overhangs are required to shade the South-facing wall from the summer sunlight. Figure 3 shows how the altitude of the sun changes from winter to summer, demonstrating how the South-facing wall may be shaded from summer solar radiation and still be exposed to winter solar radiation by using an overhang. The length of projection required to shade a South-facing wall from the summer sun is given in Table 3.



Sun Altitude-Winter and Summer

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bProjection greater than 20 ft required.

Solar Radiation Data

Solar radiation data is required to determine the amount of radiation transmitted through the South-facing glazing. Actual average solar radiation data for various geographical locations is given in Table 2. The amount of solar radiation is dependent on climate, elevation and latitude. Clear day solar radiation for various latitudes is given in Table 1.

Orientation

Orientation is extremely important in the design of passive solar buildings. The best performance will usually result when the passive solar system faces true South. True South may be obtained from isogonic (magnetic variation) charts developed by the United States Department of Commerce, Coast and Geodetic Survey, or by consulting a local land surveyor.

When the passive solar system faces true South, the system will be exposed to the maximum amount of winter solar radiation. Deviations of more than 30° East or West of true South are *not* recommended, especially where maximum performance is desired.

Site Topography

The topography of the site is of major concern. If the South-facing wall of the building is shaded by natural or man-made elements, it will probably not be feasible to consider passive solar systems. An ideal siting for a passive solar building is to be bermed into a South-facing slope. This provides a South wall exposed to the sun, and a North wall protected from environmental changes by the earth berm. Berming the North wall of the building should be done cautiously to avoid problems caused by ground water and earth pressure.

BUILDING TYPE AND USE

In addition to environmental considerations building type and use are very important in developing and applying passive solar heating systems. Building type and use are flexible requirements which allow the designer to make appropriate adaptations to the structure to provide the desired energy performance.

Thermal Load Requirements

Thermal load requirements are important in the selection and sizing of passive solar heating systems. The effects of building type and use on the thermal load are determined by the interior design temperature and the allowable temperature fluctuation. A warehouse may not require the same interior design temperature as a residential structure. Many commercial buildings are only occupied during daylight hours and do not have to maintain the higher interior working hour temperatures overnight. In many applications, the passive solar heating systems may provide similar performance as conventional heating systems with night-time setbacks.

Another aspect which affects the requirements of the building's use is human comfort. Passive solar systems provide conditions which contribute to human comfort. The brick storage areas of the system are warm. When surrounded by warm surfaces, the human body receives radiation from the warm surfaces. This permits the occupants to feel comfortable at lower interior air temperatures because heat is radiated *to* the body rather than *from* the body.

Glazing and Lighting Quality

The amount of natural lighting required will affect the selection of the type of passive solar heating system. Fabrics and even the glazing material itself may suffer from ultraviolet degradation when exposed to direct sunlight. In applications such as studios, admitting large quantities of diffuse solar radiation provides appropriate lighting.

The amount of glazing for most conventional structures is typically determined by the need or desire to provide contact with the exterior or to meet building code egress requirements. This is not usually a primary design consideration for the passive solar heating system

Material Properties

Massive brick masonry is recommended for thermal storage because of its inherent ability to store heat. Typically, brick exposed to direct sunlight should be of a dark color wherever it is to perform as a thermal storage media. The American Society of Heating, Refrigerating and air-conditioning Engineers (ASHRAE) defines dark colors as dark blue, red, brown and green. The properties of brick as related to passive solar applications are discussed in *Technical Notes* 43D.

System Operation

Passive solar heating systems may be shaded from the summer sun by fixed, adjustable or removable shading devices. Adjustable or removable overhangs or shading devices require operation, but permit the optimum use of the winter sun and can completely eliminate any solar exposure on the South-facing glass in the summer.

The performance of passive solar systems may be greatly enhanced by the use of night insulation. The insulation may be applied on the interior in the form of drapes or panels. Insulation may also serve as reflector panels or shading devices. Reflector-insulating panels may be hinged at the base of the South-facing glazing so that, when opened during the day, they reflect additional solar radiation through the glazing and when closed, provide night insulation. Night insulation may be operated manually or automatically.

Building Design and Appearance

There is no reason for passive solar heating systems to have an extremely unconventional design or appearance. The only required variations are: additional South-facing wall glazing, reduced glazing on the East and West walls, and preferably no glazing on the North wall; sufficient overhang or some other shading device to prevent the South-facing glazing from being exposed to the summer sun; and interior brick masonry. The interior brick masonry exposed to direct sunlight is used as the thermal storage component of the passive solar energy system. Additional interior brick masonry unexposed to direct sunlight is used to provide a thermal flywheel which reduces interior temperature fluctuations.

Spatial Requirements

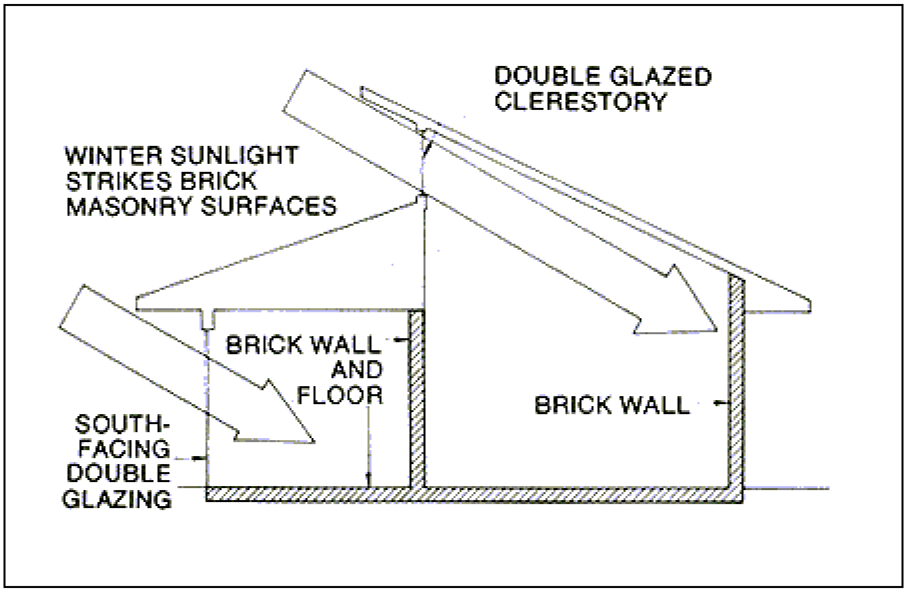
The spatial requirements may dictate the type of system used. The depth of penetration of solar radiation into the structure may affect the system type selected. Buildings should be arranged with a longitudinal East-West orientation to maximize the solar exposure of the South-facing glazing. This minimizes the distance from the South wall to the North wall, across which the thermal energy from the passive solar energy system has to be distributed. Building energy performance may be increased by heating the North wall with solar radiation entering through the South-facing glazing.

DIRECT GAIN SYSTEMS

The direct gain system is simple and often used. The system consists of South-facing glazing which allows winter sunlight to enter the habitable spaces of the building. This thermal energy is stored in brick floors and walls. A schematic of a direct gain system is shown in Fig. 4. The South-facing glazing may be windows (operable or fixed), or glass doors. The brick masonry exposed to the solar radiation should generally be a dark color and 4 to 8 in. thick. All walls or other components not exposed to solar radiation should have light-colored surfaces.

In the direct gain system, the South-facing glazing permits sunlight to strike the brick masonry construction. The brick masonry, because of its color, mass and thermal properties, provides the thermal storage for the system. The brick masonry absorbs the thermal energy from the sunlight striking its surface. The heat, which is stored during the daylight hours, is released gradually. The heat that is reflected from the brick masonry provides heat to the habitable space during the daylight hours. The light-colored surfaces reflect the heat radiated or reflected from the brick masonry to the air and surroundings in the habitable space. If large amounts of heat are required during the daytime hours and less during night-time hours, this may be accomplished by using lighter colors of brick masonry.

Direct gain systems provide rapid temperature increases in the habitable space and may have large temperature fluctuations. This is because such systems often must be designed to prevent overheating. The systems may have limited amounts of brick masonry exposed to the winter sunlight. This is especially true in the lower latitudes where the winter sun has a higher altitude. This may be overcome by providing clerestories to obtain solar radiation on the North wall, as shown in Fig. 4.



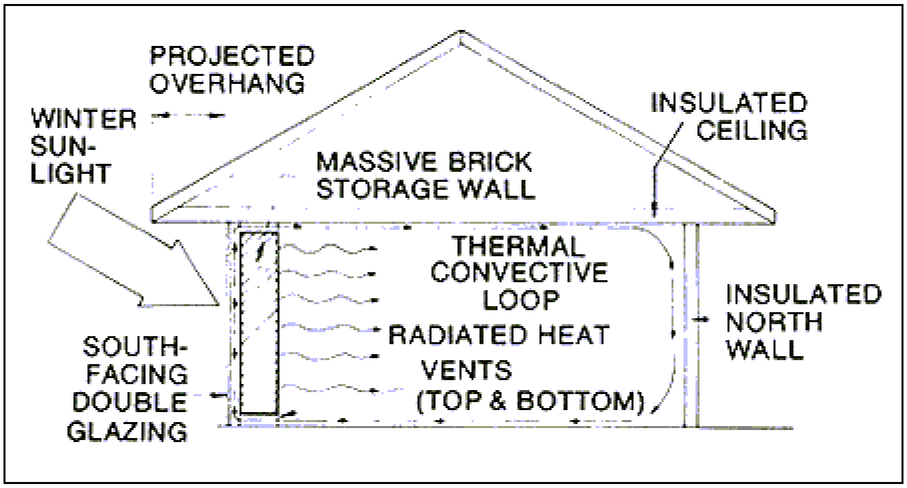
Increased Building Depth Using Direct Gain System with Clerestory

FIG. 4

Ultraviolet degradation is of the greatest concern when direct gain systems are utilized. Materials subject to ultraviolet degradation should not be exposed to direct sunlight. This may become an inconvenience in the living areas heated by direct gain. The walls and floors exposed to the sunlight and used for thermal storage should not be covered. Wall hangings and carpet greatly decrease the performance of the system.

THERMAL STORAGE WALL SYSTEMS

The thermal storage wall system, often referred to as a Trombe Wall System, is schematically represented in Fig. 5. The thermal storage wall may be vented, as shown in Fig. 5, and provide heat by radiation and convection, or it may be unvented and supply heat by radiation alone. A thermal storage wall system is shown on the left of Fig. 2. It consists of glazing, usually spaced 2 to 4 in. on the exterior of a South-facing wall, constructed of brick masonry. The massive brick wall, usually 10 to 18 in. thick, may be loadbearing, or non-loadbearing.



Vented Thermal Storage Wall System

FIG. 5

The winter sunlight penetrating the South glazing heats the brick, the heat slowly penetrates the brick wall and warms the interior. Thermal storage walls may have sufficient heat storage to maintain comfortable temperatures in buildings for periods up to three completely overcast days. The thermal storage wall systems have considerably less temperature fluctuation than do direct gain systems, but usually do not achieve the same high initial interior temperatures.

The massive brick thermal storage wall prevents ultraviolet degradation of materials contained in the living space because solar radiation does not directly enter the habitable space. The performance may be substantially increased by providing vents at the top and bottom of the brick wall to provide convection in addition to the heat radiated from the interior face of the wall. Vented walls may be used to decrease the temperature fluctuations and increase the maximum temperature achieved in the living space. Fig. 1 shows a vented thermal storage wall under construction. When venting the storage wall system, vents with automatic or manual closures should be used so that the system does not reverse at night, creating a heat loss.

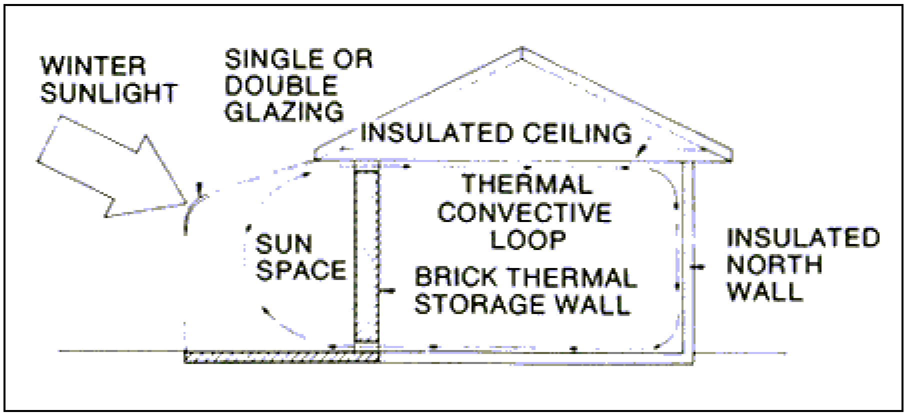
If controlled vents are not installed on the vented thermal storage wall systems, night insulation is essential to prevent heat losses at night. Night insulation may be required on unvented thermal storage walls and those with controlled vents to increase the efficiency of the system.

COMBINED SYSTEMS

The best thermal performance and living conditions result by combining the thermal storage wall system and the direct gain system. This combination permits some direct sunlight into the living spaces, achieves higher interior temperatures than the thermal wall system alone, provides less temperature fluctuation than the direct gain system alone and provides natural lighting. The combination essentially utilizes the best of the two systems.

ATTACHED SUNSPACES

Attached sunspaces are a combination of the components of the direct gain system and the thermal storage wall system, as shown in Fig. 2 on the right, and in Fig. 6. The sunspace is a room, or space, which typically has both a glass roof and a glass South-facing wall. The East and West walls may also be glass. The floor is similar to that of the direct gain system. It consists of 4 to 8-in. thick brick masonry. The North wall is a 10 to 18-in. thick brick thermal storage wall. The room is vented or ducted to other areas of the structure. With the assistance of fans and blowers, the structure is heated by the extreme temperatures achieved in the sunspace. The sunspace usually has severe temperature fluctuations and is often unbearably hot during daylight hours. They do require removable shading devices to prevent solar gains in the summer. They will also require night insulation if they are to become useable living space in the evening hours.

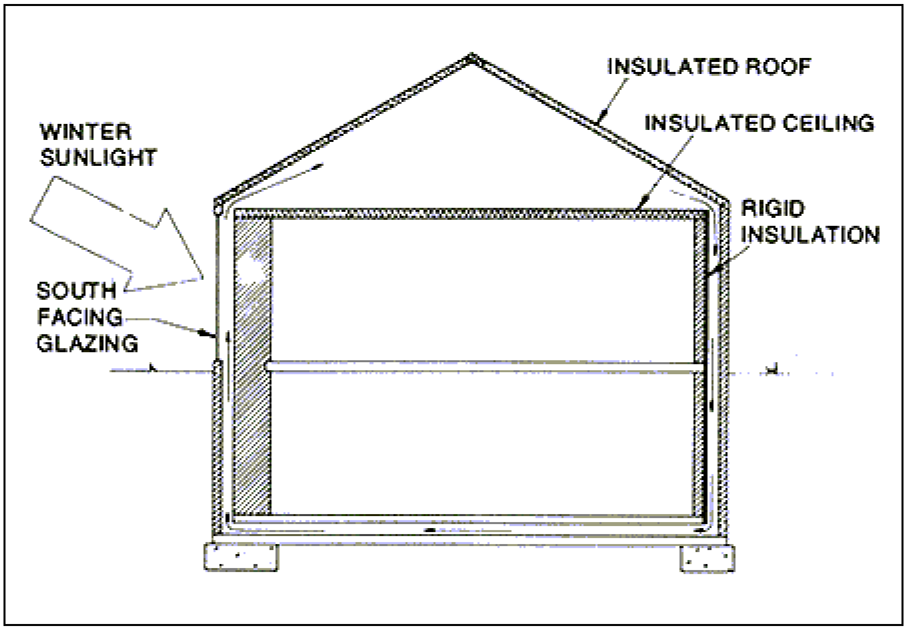


Attached Sunspace

FIG. 6

CAVITY WALL SYSTEM

The cavity wall system, shown in Fig. 7, is a modification of the double envelope system. The concept of the cavity wall system is that the South-facing thermal storage wall heats up and creates a convective loop around the entire building envelope. The warmed air space minimizes the temperature differential from the interior of the building through the inner wythe of the cavity wall. There are no generally accepted design procedures for this type of system presently available. Some experts in the passive solar design field feel that the increased thermal performance may be accounted for by the insulation in the interior and exterior shells of the double envelope system. Others feel that there is no convective loop occurring, i.e., the air between the double envelope shells is stagnant.



Cavity Wall System

FIG.7

The use of a properly constructed, insulated brick cavity wall on the North side of the building could be used to provide a moderate heat loss to drive the convective loop through the air space in the building envelope. This would reduce the temperature of the air being circulated through the cavity, but the air should still reach high enough temperatures as it passes through the air space of the thermal storage wall system to provide a net heat gain.

Since there is still considerable controversy regarding this type of system, and since accurate performance analysis is not easily accomplished, these systems should only be designed and constructed with the appropriate awareness of the expected and achievable performance level of the system.

METRIC CONVERSION

Because of the possible confusion inherent in showing dual unit systems in the calculations, the metric (SI) units are not given in this *Technical Notes.* Table 13 in *Technical Notes* 4 provides metric (SI) conversion factors for the more commonly used units.

SUMMARY

This *Technical Notes* has provided general information concerning passive solar heating systems. It has described several passive solar heating systems, the basic principles of their operation and general design consideration. This introduction to passive solar heating systems hopefully provides sufficient familiarization with concepts so that the design of such systems will be understood. Passive solar cooling is discussed in *Technical Notes* 43C. The material properties of brick masonry, as related to passive solar energy systems, is provided in *Technical Notes* 43D.. Details and construction information are provided in *Technical Notes* 43G.

This *Technical Notes* does *not* and is *not* intended to provide information for specific designs and applications, but rather offers general information to assist in the consideration and use of brick masonry in passive solar heating systems. The decision to use these concepts in the design specific applications is *not* within the purview of the Brick Institute of America, and must rest with the owner or designer of any specific project.

Environmental Data for Passive Solar Systems
TABLE 2[a,b]

ALABAMA

Birmingham Latitude 33° 34'N Elevation 630'

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	54.3	34.1	44.2	654	706.6
FEB	57.7	36.1	46.9	517	967.1
MAR	64.8	41.8	53.3	389	1296.1
APR	75.3	51.0	63.2	116	1673.5
MAY	82.5	58.4	70.5	20	1856.9
SEP	84.7	63.0	73.9	6	1454.6
OCT	75.8	50.8	63.3	137	1210.8
NOV	64.0	40.1	52.1	391	857.9
DEC	55.5	34.9	45.2	614	661.4
ANN	73.6	51.2	62.4	2844	1344.7

ALABAMA (continued)

Mobile Latitude 30° 41'N Elevation 220'

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	61.1	41.3	51.2	451	828.2
FEB	64.1	43.9	54.0	337	1099.6
MAR	69.5	49.2	59.4	221	1407.5
APR	78.0	57.7	67.9	40	1721.7
MAY	85.0	64.5	74.8	0	1872.1
SEP	86.5	68.4	77.5	0	1449.4
OCT	79.7	58.0	68.9	39	1298.7
NOV	69.5	47.5	58.5	211	955.1
DEC	63.0	42.8	52.9	385	759.2
ANN	77.3	57.4	67.4	1684	1384.7

ALASKA

Fairbanks Latitude 64° 49'N Elevation 453'

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	−2.2	−21.6	−11.9	2384	30.1
FEB	9.3	−14.3	−2.5	1890	221.4
MAR	23.3	−4.3	9.5	1720	674.2
APR	40.4	17.3	28.9	1083	1193.9
MAY	58.8	35.7	47.3	549	1603.6
SEP	54.4	34.4	44.4	618	709.4
OCT	33.5	16.9	25.2	1234	292.6
NOV	11.7	−6.2	2.8	1866	74.1
DEC	−1.5	−19.3	−10.4	2337	2.5
ANN	36.3	15.0	25.7	14344	767.8

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft^2
ARIZONA					
Phoenix Latitude 33° 26'N Elevation 1112'					
JAN	64.8	37.6	51.2	428	1021.3
FEB	69.3	40.8	55.1	292	1374.1
MAR	74.5	44.8	59.7	185	1814.1
APR	83.6	51.8	67.7	60	2354.8
MAY	92.9	59.6	76.3	0	2676.5
SEP	98.4	69.1	83.8	0	2015.4
OCT	87.6	56.8	72.2	17	1576.5
NOV	74.7	44.8	59.8	182	1150.5
DEC	66.4	38.5	52.5	388	932.0
ANN	85.1	55.4	70.3	1552	1869.4
Tucson Latitude 32° 07'N Elevation 2556'					
JAN	63.5	38.2	50.9	442	1099.0
FEB	67.0	39.9	53.5	333	1432.0
MAR	71.5	43.6	57.6	243	1864.3
APR	80.7	50.3	65.5	81	2363.0
MAY	89.6	57.5	73.6	0	2671.4
SEP	93.1	67.1	80.1	0	1978.8
OCT	83.8	56.4	70.1	29	1601.9
NOV	72.2	44.8	58.5	221	1208.4
DEC	64.8	39.1	52.0	403	995.8
ANN	81.5	54.1	67.8	1752	1872.3
ARKANSAS					
Little Rock Latitude 34° 44'N Elevation 266'					
JAN	50.1	28.9	39.5	791	731.3
FEB	53.8	31.9	42.9	619	1002.8
MAR	61.8	38.7	50.3	470	1312.7
APR	73.5	49.9	61.7	139	1610.7
MAY	81.4	58.1	69.8	21	1929.3
SEP	85.8	60.8	73.3	5	1518.0
OCT	76.0	48.7	62.4	143	1228.3
NOV	62.4	38.1	50.3	441	847.2
DEC	51.2	31.1	41.6	725	673.7
ANN	72.6	49.3	61.0	3354	1404.4
CALIFORNIA					
Los Angeles Latitude 33° 56'N Elevation 105'					
JAN	63.5	45.4	54.5	331	926.1
FEB	64.1	47.0	55.6	270	1214.0
MAR	64.3	48.6	56.5	267	1618.7
APR	65.9	51.7	58.8	195	1950.9
MAY	68.4	55.3	61.9	114	2059.6
SEP	75.7	61.6	68.7	23	1681.4
OCT	72.9	57.5	65.2	77	1317.0
NOV	69.6	51.3	60.5	158	1003.9
DEC	66.5	47.3	56.9	279	848.5
ANN	69.2	54.1	61.7	1819	1593.8
Sacramento Latitude 38° 31'N Elevation 26'					
JAN	53.0	37.1	45.1	617	596.9
FEB	59.1	40.4	49.8	426	939.4
MAR	64.1	41.9	53.0	372	1458.4
APR	71.3	45.3	58.3	227	2003.6
MAY	78.8	49.8	64.3	120	2434.8
SEP	87.7	55.3	71.5	5	1906.7
OCT	77.1	49.5	63.3	101	1314.9
NOV	63.6	42.4	53.0	360	781.9
DEC	53.3	38.3	45.8	595	538.4
ANN	73.2	47.4	60.3	2843	1642.9
CALIFORNIA (continued)					
San Francisco Latitude 37° 37'N Elevation 16'					
JAN	55.3	41.2	48.3	518	707.6
FEB	58.6	43.8	51.2	386	1009.3
MAR	61.0	44.9	53.0	372	1455.1
APR	63.5	47.0	55.3	291	1920.0
MAY	66.6	49.9	58.3	210	2225.6
SEP	73.6	54.5	64.1	66	1742.0
OCT	70.3	51.6	61.0	137	1226.1
NOV	63.3	47.2	55.3	291	821.4
DEC	56.3	42.9	49.7	474	642.2
ANN	65.1	48.7	56.9	3042	1552.8
COLORADO					
Denver Latitude 39° 45'N Elevation 5332'					
JAN	43.5	16.2	29.9	1088	840.1
FEB	46.2	19.4	32.8	902	1127.0
MAR	50.1	23.8	37.0	868	1530.4
APR	61.0	33.9	47.5	525	1879.3
MAY	70.3	43.6	57.0	253	2134.9
SEP	77.7	47.8	62.8	120	1726.8
OCT	66.8	37.2	52.0	408	1300.5
NOV	53.3	25.4	39.4	768	883.5
DEC	46.2	18.9	32.6	1004	731.8
ANN	64.0	36.2	50.1	6016	1568.4
Pueblo Latitude 38° 17'N Elevation 4721'					
JAN	45.5	14.7	30.1	1082	894.3
FEB	49.8	19.6	34.7	848	1171.6
MAR	54.9	25.0	40.0	775	1563.8
APR	66.4	36.9	51.7	405	1956.0
MAY	75.5	46.6	61.1	148	2162.5
SEP	81.5	50.8	66.2	55	1779.5
OCT	70.7	38.2	54.5	335	1360.9
NOV	56.5	25.1	40.8	726	953.8
DEC	48.2	17.7	33.0	992	782.2
ANN	67.9	37.7	52.8	5394	1622.7
CONNECTICUT					
Hartford Latitude 41° 56'N Elevation 180'					
JAN	33.4	16.1	24.8	1246	477.5
FEB	35.7	17.9	26.8	1070	714.7
MAR	44.6	26.6	35.6	911	978.5
APR	58.9	36.5	47.7	519	1315.0
MAY	70.3	46.2	58.3	226	1568.5
SEP	74.5	51.0	62.8	106	1154.5
OCT	64.3	40.8	52.6	384	852.9
NOV	50.6	31.9	41.3	711	497.3
DEC	36.8	19.6	28.2	1141	385.1
ANN	59.6	38.6	49.1	6350	1058.3
DELAWARE					
Wilmington Latitude 39° 40'N Elevation 79'					
JAN	40.2	23.8	32.0	1023	571.4
FEB	42.2	24.9	33.6	879	827.0
MAR	51.1	32.0	41.6	725	1149.2
APR	63.0	41.5	52.3	381	1480.1
MAY	73.1	51.6	62.4	128	1710.2
SEP	78.2	57.6	67.9	32	1317.7
OCT	67.8	46.5	57.2	254	983.9
NOV	55.2	36.2	45.7	579	644.6
DEC	43.0	26.3	34.7	939	488.6
ANN	63.7	44.3	54.0	4940	1207.7
WASHINGTON, D.C.					
Latitude 38° 57'N Elevation 289'					
JAN	41.2	23.0	32.1	1020	572.0
FEB	43.4	24.1	33.8	874	815.3
MAR	52.7	30.9	41.8	719	1125.0
APR	65.0	41.1	53.1	357	1458.9
MAY	74.5	50.6	62.6	131	1718.1
SEP	78.7	55.0	66.9	43	1340.0
OCT	68.2	43.5	55.9	291	1003.8
NOV	55.6	33.7	44.7	609	650.9
DEC	43.3	24.7	34.0	961	481.1
ANN	64.7	42.7	53.7	5010	1208.4
FLORIDA					
Jacksonville Latitude 30° 30'N Elevation 29'					
JAN	64.6	44.5	54.6	348	899.9
FEB	66.9	45.7	56.3	282	1164.3
MAR	72.2	50.1	61.2	176	1521.7
APR	79.0	57.1	68.1	24	1855.7
MAY	84.6	63.9	74.3	0	1956.3
SEP	86.0	70.4	78.2	0	1442.3
OCT	79.2	61.7	70.5	19	1223.1
NOV	71.4	51.0	61.2	161	996.0
DEC	65.6	45.1	55.4	317	817.6
ANN	78.1	58.7	68.4	1327	1438.2
GEORGIA					
Atlanta Latitude 33° 39'N Elevation 1033'					
JAN	51.4	33.4	42.4	701	717.6
FEB	54.5	35.5	45.0	560	968.9
MAR	61.1	41.1	51.1	443	1303.6
APR	71.4	50.7	61.1	144	1686.2
MAY	79.0	59.2	69.1	27	1853.8
SEP	81.2	63.4	72.3	8	1422.0
OCT	72.5	52.3	62.4	137	1199.9
NOV	61.9	40.8	51.4	408	882.9
DEC	52.7	34.3	43.5	667	674.2
ANN	70.3	51.3	60.8	3095	1345.3
Savannah Latitude 32° 08'N Elevation 52'					
JAN	61.1	38.7	49.9	483	794.7
FEB	63.6	40.5	52.1	379	1043.8
MAR	69.5	46.4	58.0	256	1398.5
APR	77.8	54.3	66.1	63	1761.4
MAY	84.8	61.8	73.3	0	1852.3
SEP	85.4	66.9	76.2	0	1363.7
OCT	78.2	55.9	67.1	60	1216.7
NOV	69.3	44.9	57.1	253	941.1
DEC	62.1	38.7	50.4	458	753.7
ANN	76.8	54.9	65.9	1952	1364.5
IDAHO					
Boise Latitude 43° 34'N Elevation 2868'					
JAN	36.5	21.4	29.0	1116	485.3
FEB	43.8	27.2	35.5	826	839.7
MAR	51.6	30.5	41.1	741	1304.1
APR	61.4	36.5	49.0	480	1826.9
MAY	70.6	44.1	57.4	252	2276.7
SEP	77.6	48.5	63.1	127	1737.2
OCT	64.7	39.4	52.1	406	1137.8
NOV	48.9	30.7	39.8	756	628.3
DEC	39.1	25.0	32.1	1020	437.2
ANN	62.6	39.1	50.9	5833	1495.5

*Based on 1941-1970 Period. Zeros appearing for all values appearing in these columns signify that 1941-1970 period normals were not available.

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft^2
ILLINOIS					
Chicago Latitude 41° 47′N Elevation 623′					
JAN	31.5	17.0	24.3	1262	507.0
FEB	34.6	20.2	27.4	1053	759.5
MAR	44.6	29.0	36.8	874	1106.9
APR	59.3	40.4	49.9	453	1459.0
MAY	70.3	49.7	60.0	208	1788.9
SEP	75.8	56.0	65.9	57	1353.9
OCT	65.0	45.6	55.4	316	968.9
NOV	48.1	32.6	40.4	738	565.6
DEC	35.3	21.6	28.5	1132	401.5
ANN	59.4	41.8	50.6	6127	1215.1
INDIANA					
Indianapolis Latitude 39° 44′N Elevation 807′					
JAN	36.0	19.7	27.9	1150	495.6
FEB	39.3	22.1	30.7	960	746.9
MAR	49.0	30.3	39.7	784	1037.4
APR	62.8	41.8	52.3	387	1398.4
MAY	72.9	51.5	62.2	159	1688.0
SEP	77.7	54.9	66.3	63	1324.0
OCT	67.0	44.3	55.7	302	977.0
NOV	50.5	32.8	41.7	699	579.1
DEC	38.7	23.1	30.9	1057	416.6
ANN	62.2	42.4	52.3	5577	1165.0
South Bend Latitude 41° 42′N Elevation 774′					
JAN	31.5	16.5	24.0	1271	415.7
FEB	34.1	18.5	26.3	1084	659.6
MAR	43.9	26.6	35.3	921	992.5
APR	58.4	37.8	48.1	507	1387.4
MAY	69.4	47.3	58.4	245	1722.5
SEP	74.7	52.8	63.8	98	1291.3
OCT	63.7	43.0	53.4	368	909.2
NOV	47.2	31.9	39.6	762	497.1
DEC	35.1	21.2	28.2	1141	340.3
ANN	58.5	39.6	49.1	6462	1138.0
IOWA					
Des Moines Latitude 41° 32′N Elevation 965′					
JAN	27.5	11.3	19.4	1414	580.7
FEB	32.5	15.8	24.2	1142	860.7
MAR	42.5	25.2	33.9	964	1180.5
APR	59.7	39.2	49.5	465	1556.6
MAY	70.9	50.9	60.9	186	1867.5
SEP	74.6	54.0	64.3	94	1433.9
OCT	64.9	43.6	54.3	350	1067.8
NOV	46.4	29.2	37.8	816	658.3
DEC	32.8	17.2	25.0	1240	486.9
ANN	58.3	39.7	49.0	6710	1311.8
KANSAS					
Topeka Latitude 39° 04′N Elevation 886′					
JAN	38.3	17.7	28.0	1147	680.9
FEB	44.1	22.7	33.4	885	941.0
MAR	52.6	29.7	41.2	745	1256.9
APR	66.3	42.6	54.5	329	1641.6
MAY	75.8	53.2	64.5	118	1915.4
SEP	80.4	56.0	68.2	55	1516.4
OCT	70.3	44.8	57.6	259	1146.6
NOV	54.3	31.5	42.9	663	771.6
DEC	41.8	21.8	31.8	1029	583.5
ANN	65.5	43.0	54.3	5243	1384.8

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft^2
KANSAS (continued)					
Wichita Latitude 37° 39′N Elevation 1339′					
JAN	41.4	21.2	31.3	1045	783.9
FEB	47.1	25.4	36.3	804	1058.2
MAR	55.0	32.1	43.6	671	1405.5
APR	68.1	45.1	56.6	275	1782.5
MAY	77.1	55.0	66.1	90	2035.8
SEP	81.9	59.2	70.6	32	1616.1
OCT	71.3	47.9	59.6	211	1249.8
NOV	55.8	33.8	44.8	606	870.8
DEC	44.3	24.6	34.5	946	689.9
ANN	67.6	45.6	56.6	4687	1502.3
KENTUCKY					
Louisville Latitude 38° 11′N Elevation 489′					
JAN	42.0	24.5	33.3	983	545.5
FEB	45.0	26.5	35.8	818	789.3
MAR	54.0	34.0	44.0	661	1102.0
APR	66.9	44.8	55.9	286	1466.7
MAY	75.6	53.9	64.8	105	1719.8
SEP	80.5	57.7	69.1	35	1361.2
OCT	70.3	45.9	58.1	241	1042.2
NOV	54.9	35.1	45.0	600	652.8
DEC	44.1	27.1	35.6	911	487.9
ANN	65.9	45.3	55.6	4645	1215.7
LOUISIANA					
Baton Rouge Latitude 30° 32′N Elevation 75′					
JAN	61.5	40.5	51.0	451	785.1
FEB	64.5	43.2	53.9	335	1054.1
MAR	70.6	48.7	59.7	208	1379.4
APR	79.0	57.7	68.4	33	1681.2
MAY	85.2	64.3	74.8	0	1871.2
SEP	87.2	67.7	77.5	0	1464.4
OCT	80.4	56.6	68.5	54	1301.1
NOV	70.3	46.9	58.6	208	920.4
DEC	63.7	42.0	52.9	381	736.8
ANN	77.9	56.9	67.4	1670	1378.5
MAINE					
Portland Latitude 43° 39′N Elevation 62′					
JAN	31.2	11.7	21.5	1349	450.3
FEB	33.3	12.5	22.9	1179	681.9
MAR	40.8	22.8	31.8	1029	969.6
APR	52.8	32.5	42.7	669	1303.9
MAY	63.6	41.7	52.7	381	1567.4
SEP	69.9	47.4	58.7	200	1157.8
OCT	60.2	38.0	49.1	493	822.4
NOV	47.5	29.7	38.6	792	459.3
DEC	34.9	16.4	25.7	1218	362.9
ANN	55.3	34.7	45.0	7498	1050.6
MASSACHUSETTS					
Boston Latitude 42° 22′N Elevation 16′					
JAN	35.9	22.5	29.2	1110	475.5
FEB	37.5	23.3	30.4	969	709.6
MAR	44.6	31.5	38.1	834	1016.4
APR	56.3	40.8	48.6	492	1325.8
MAY	67.1	50.1	58.6	218	1620.5
SEP	72.2	56.7	64.5	76	1259.9
OCT	63.2	47.5	55.4	301	889.6
NOV	51.7	38.7	45.2	594	502.9
DEC	39.3	26.6	33.0	992	403.0
ANN	58.7	43.8	51.3	5621	1104.7

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft^2
MARYLAND					
Baltimore Latitude 39° 11′N Elevation 154′					
JAN	41.9	24.9	33.4	980	586.9
FEB	43.9	25.7	34.8	846	840.0
MAR	53.0	32.5	42.8	688	1162.2
APR	65.2	42.4	53.8	340	1487.9
MAY	74.8	52.5	63.7	110	1713.9
SEP	79.0	57.9	68.5	27	1330.3
OCT	68.3	46.4	57.4	250	997.6
NOV	56.1	36.0	46.1	567	660.3
DEC	43.9	26.6	35.3	921	499.3
ANN	65.1	44.8	55.0	4729	1215.0
MICHIGAN					
Detroit Latitude 42° 25′N Elevation 627′					
JAN	31.7	19.2	25.5	1225	417.4
FEB	33.7	20.1	26.9	1067	680.4
MAR	43.1	27.6	35.4	918	1000.2
APR	57.6	38.6	48.1	507	1399.0
MAY	68.5	48.3	58.4	238	1715.9
SEP	74.2	54.8	64.5	80	1253.2
OCT	63.4	45.2	54.3	342	876.1
NOV	47.7	34.4	41.1	717	477.8
DEC	35.4	23.8	29.6	1097	343.5
ANN	58.3	41.4	49.9	6228	1120.0
MINNESOTA					
Duluth Latitude 46° 50′N Elevation 1417′					
JAN	17.6	−0.6	8.5	1751	388.6
FEB	22.1	2.0	12.1	1481	672.8
MAR	32.6	14.4	23.5	1287	1034.5
APR	47.8	29.3	38.6	792	1372.8
MAY	60.0	38.8	49.4	484	1642.6
SEP	64.0	44.8	54.4	318	1095.0
OCT	54.3	36.2	45.3	611	724.8
NOV	35.3	21.4	28.4	1098	380.7
DEC	22.5	6.3	14.4	1569	291.7
ANN	48.1	29.1	38.6	9756	1064.3
Minneapolis St. Paul Latitude 44° 53′N Elevation 837′					
JAN	21.2	3.2	12.2	1637	464.0
FEB	25.9	7.1	16.5	1358	763.9
MAR	36.9	19.6	28.3	1138	1103.5
APR	55.5	34.7	45.1	597	1441.9
MAY	67.9	46.3	57.1	271	1737.3
SEP	70.7	49.3	60.0	173	1254.7
OCT	60.7	39.2	50.0	472	850.6
NOV	40.6	24.2	32.4	978	480.4
DEC	26.6	10.6	18.6	1438	353.3
ANN	53.8	34.3	44.1	8159	1170.2
MISSISSIPPI					
Jackson Latitude 31° 29′N Elevation 331′					
JAN	58.4	35.8	47.1	569	753.5
FEB	61.7	37.8	49.8	442	1026.4
MAR	68.7	43.4	56.1	313	1369.1
APR	78.2	53.1	65.7	74	1708.4
MAY	85.0	60.4	72.7	6	1940.8
SEP	88.0	64.0	76.0	0	1509.2
OCT	80.1	51.5	65.8	91	1271.4
NOV	68.5	42.0	55.3	301	901.6
DEC	60.5	37.3	48.9	504	708.8
ANN	77.1	52.8	65.0	2300	1408.6

MISSOURI

Kansas City Latitude 39° 18′N Elevation 1033′

Month	Normal Temperature (Deg F)*			Normal Degree Days*	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	35.7	18.4	27.1	1175	647.9
FEB	41.4	23.1	32.3	916	894.7
MAR	50.7	30.6	40.7	753	1202.9
APR	64.7	43.7	54.2	336	1575.0
MAY	74.2	54.0	64.1	127	1872.6
SEP	78.8	57.1	68.0	50	1452.4
OCT	68.2	46.9	57.6	259	1092.3
NOV	51.4	33.1	42.3	681	737.3
DEC	39.3	23.3	31.3	1045	561.5
ANN	63.5	43.8	53.7	5357	1340.0

St. Louis Latitude 38° 45′N Elevation 564′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	39.9	22.6	31.3	1045	627.4
FEB	44.2	26.0	35.1	837	885.6
MAR	53.0	33.5	43.3	682	1204.7
APR	67.0	46.0	56.5	272	1564.2
MAY	76.0	55.5	65.8	103	1871.3
SEP	80.1	59.1	69.6	35	1459.2
OCT	69.8	48.4	59.1	224	1099.8
NOV	54.1	35.9	45.0	600	718.3
DEC	42.7	26.5	34.6	942	530.6
ANN	65.6	46.2	55.9	4750	1326.6

MONTANA

llings Latitude 45° 48′N Elevation 3570′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	31.2	12.5	21.9	1336	486.0
FEB	37.1	17.7	27.4	1054	763.0
MAR	42.1	23.1	32.6	1004	1189.5
APR	55.8	33.4	44.6	612	1526.3
MAY	65.7	43.3	54.5	333	1912.8
SEP	71.3	46.5	58.9	221	1470.0
OCT	61.0	37.5	49.3	487	986.8
NOV	45.0	26.4	35.7	879	561.4
DEC	35.8	17.7	26.8	1184	421.2
ANN	57.3	35.3	46.3	7265	1324.7

Great Falls Latitude 47° 29′N Elevation 3661′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	29.3	11.6	20.5	1380	420.5
FEB	35.9	17.2	26.6	1075	720.2
MAR	40.4	20.6	30.5	1070	1170.4
APR	54.5	32.3	43.4	648	1488.7
MAY	65.0	41.5	53.3	367	1847.6
SEP	70.0	44.6	57.3	260	1378.5
OCT	59.4	37.1	48.3	524	924.6
NOV	43.4	25.7	34.6	912	497.6
DEC	34.7	18.2	26.5	1194	336.2
ANN	55.9	33.8	44.9	7652	1262.3

NEBRASKA

North Omaha Latitude 41° 22′N Elevation 1325

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	29.1	11.2	20.2	1389	634.0
FEB	34.8	16.1	25.5	1106	892.1
MAR	44.1	25.1	34.6	942	1222.5
APR	61.0	38.9	50.0	456	1558.4
MAY	71.4	50.4	60.9	186	1872.6
SEP	75.2	53.6	64.4	99	1373.2
OCT	65.9	42.8	54.4	342	1049.8
NOV	47.4	28.3	37.9	813	644.1
DEC	34.3	17.0	25.7	1218	511.2
ANN	59.4	39.3	49.4	6601	1320.5

NEVADA

Las Vegas Latitude 36° 05′N Elevation 2178′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	55.7	32.6	44.2	645	978.0
FEB	61.3	36.9	49.1	451	1339.5
MAR	67.8	41.7	54.8	324	1823.5
APR	77.5	50.0	63.8	126	2319.0
MAY	87.5	59.0	73.3	10	2646.3
SEP	94.8	65.4	80.1	0	2037.3
OCT	81.0	53.1	67.1	74	1539.8
NOV	65.7	40.8	53.3	357	1085.5
DEC	56.7	33.7	45.2	614	880.5
ANN	79.2	52.4	65.8	2601	1864.2

Reno Latitude 39° 30′N Elevation 4400′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	45.4	18.3	31.9	1026	800.4
FEB	51.1	23.0	37.1	781	1149.9
MAR	56.0	24.6	40.3	766	1649.4
APR	64.0	29.6	46.8	546	2159.3
MAY	72.2	37.0	54.6	328	2523.1
SEP	81.8	38.6	60.2	168	1997.7
OCT	70.0	30.5	50.3	456	1431.0
NOV	56.3	23.9	40.1	747	912.3
DEC	46.4	19.6	33.0	992	705.5
ANN	67.0	31.7	49.4	6022	1760.7

NEW HAMPSHIRE

Concord Latitude 43° 12′N Elevation 344′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	31.3	9.9	20.6	1376	459.5
FEB	33.8	11.3	22.6	1187	686.1
MAR	42.4	22.1	32.3	1014	973.6
APR	56.7	31.7	44.2	624	1317.1
MAY	68.6	41.5	55.1	315	1582.2
SEP	72.4	46.5	59.5	182	1140.2
OCT	62.3	36.3	49.3	487	817.1
NOV	47.9	28.1	38.0	810	462.7
DEC	34.6	14.9	24.8	1246	362.1
ANN	57.5	33.7	45.6	7360	1053.0

NEW JERSEY

Newark Latitude 40° 42′N Elevation 29′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	38.5	24.3	31.4	1042	551.7
FEB	40.2	24.9	32.6	907	793.0
MAR	48.8	32.4	40.6	756	1108.7
APR	61.2	42.2	51.7	399	1448.6
MAY	71.6	52.1	61.9	143	1687.1
SEP	77.0	58.6	67.8	34	1272.9
OCT	66.9	48.1	57.5	243	950.9
NOV	54.2	38.2	46.2	564	596.2
DEC	41.5	27.4	34.5	946	454.4
ANN	62.5	45.2	53.9	5034	1165.3

NEW MEXICO

Albuquerque Latitude 35° 03′N Elevation 5312′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	46.9	23.5	35.2	924	1016.5
FEB	52.6	27.4	40.0	700	1342.0
MAR	59.2	32.3	45.8	595	1767.6
APR	70.1	41.4	55.8	282	2228.4
MAY	79.9	50.7	65.3	58	2538.1
SEP	83.4	56.7	70.1	7	1971.7
OCT	71.7	44.7	58.2	218	1546.7
NOV	57.1	31.8	44.5	615	1133.7
DEC	47.5	24.9	36.2	893	927.7
ANN	70.0	43.5	56.8	4292	1827.5

NEW YORK

Albany Latitude 42° 45′N Elevation 292′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	30.4	12.5	21.5	1349	456.5
FEB	32.7	14.3	23.5	1162	688.4
MAR	42.6	24.2	33.4	980	985.9
APR	58.0	35.7	46.9	543	1335.2
MAY	69.7	45.7	57.7	253	1569.9
SEP	73.7	50.1	61.9	135	1170.3
OCT	62.8	40.0	51.4	422	817.3
NOV	48.1	31.1	39.6	762	457.1
DEC	34.1	17.7	25.9	1212	355.9
ANN	58.1	37.1	47.6	6888	1065.8

Buffalo Latitude 42° 56′N Elevation 705′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	29.8	17.6	23.7	1280	348.9
FEB	31.0	17.7	24.4	1137	546.4
MAR	39.0	25.2	32.1	1020	888.5
APR	53.3	36.4	44.9	603	1314.9
MAY	64.3	45.9	55.1	321	1596.5
SEP	70.8	52.3	61.6	138	1151.8
OCT	60.2	42.7	51.5	419	784.4
NOV	46.1	33.5	39.8	756	403.3
DEC	33.6	22.2	27.9	1150	283.3
ANN	55.0	39.1	47.1	6927	1034.3

New York City Latitude 40° 47′N Elevation 187′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	38.5	25.9	32.2	1017	500.4
FEB	40.2	26.5	33.4	885	721.0
MAR	48.4	33.7	41.1	741	1037.1
APR	60.7	43.5	52.1	387	1363.9
MAY	71.4	53.1	62.3	137	1636.2
SEP	76.8	59.9	68.4	29	1213.7
OCT	66.8	50.6	58.7	209	895.3
NOV	54.0	40.8	47.4	528	532.9
DEC	41.4	29.5	35.5	915	404.0
ANN	62.3	46.7	54.5	4848	1098.9

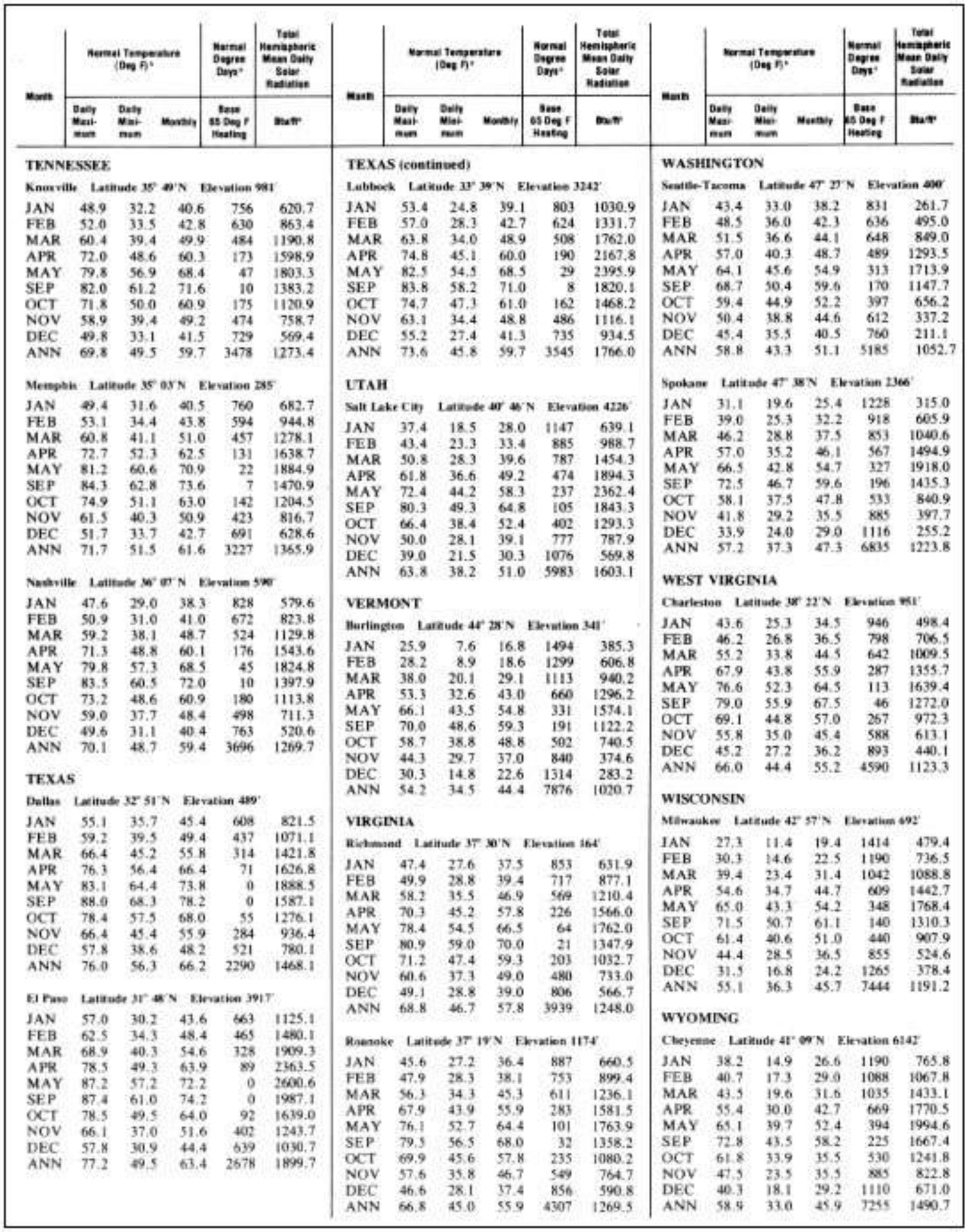
NORTH CAROLINA

Charlotte Latitude 35° 13′N Elevation 768′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	52.1	32.1	42.1	710	719.0
FEB	54.9	33.1	44.0	588	971.0
MAR	62.2	39.0	50.6	461	1317.5
APR	72.7	48.9	60.8	145	1695.0
MAY	82.0	57.4	68.8	34	1855.6
SEP	80.2	61.9	72.0	10	1415.6
OCT	73.1	50.3	61.7	152	1173.4
NOV	62.4	39.6	51.0	420	865.5
DEC	52.5	32.4	42.5	698	672.4
ANN	71.2	49.7	60.5	3218	1344.4

Raleigh-Durham Latitude 35° 52′N Elevation 440′

Month	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft²
JAN	51.0	30.0	40.5	760	693.9
FEB	53.2	31.1	42.2	638	943.1
MAR	61.0	37.4	49.2	502	1275.1
APR	72.2	46.7	59.5	180	1644.3
MAY	79.4	55.4	67.4	48	1808.3
SEP	81.5	59.7	70.6	12	1377.1
OCT	72.4	48.0	60.2	186	1105.4
NOV	62.1	37.8	50.0	450	812.1
DEC	51.9	30.5	41.2	738	635.6
ANN	70.4	47.8	59.1	3514	1295.5



Month	Normal Temperature (Deg F)[b]			Normal Degree Days[b]	Total Hemispheric Mean Daily Solar Radiation
	Daily Maximum	Daily Minimum	Monthly	Base 65 Deg F Heating	Btu/ft^2
TENNESSEE					
Knoxville Latitude 35° 49'N Elevation 981'					
JAN	48.9	32.2	40.6	756	620.7
FEB	52.0	33.5	42.8	630	863.4
MAR	60.4	39.4	49.9	484	1190.8
APR	72.0	48.6	60.3	173	1598.9
MAY	79.8	56.9	68.4	47	1803.3
SEP	82.0	61.2	71.6	10	1383.2
OCT	71.8	50.0	60.9	175	1120.9
NOV	58.9	39.4	49.2	474	758.7
DEC	49.8	33.1	41.5	729	569.4
ANN	69.8	49.5	59.7	3478	1273.4
Memphis Latitude 35° 03'N Elevation 285'					
JAN	49.4	31.6	40.5	760	682.7
FEB	53.1	34.4	43.8	594	944.8
MAR	60.8	41.1	51.0	457	1278.1
APR	72.7	52.3	62.5	131	1638.7
MAY	81.2	60.6	70.9	22	1884.9
SEP	84.3	62.8	73.6	7	1470.9
OCT	74.9	51.1	63.0	142	1204.5
NOV	61.5	40.3	50.9	423	816.7
DEC	51.7	33.7	42.7	691	628.6
ANN	71.7	51.5	61.6	3227	1365.9
Nashville Latitude 36° 07'N Elevation 590'					
JAN	47.6	29.0	38.3	828	579.6
FEB	50.9	31.0	41.0	672	823.8
MAR	59.2	38.1	48.7	524	1129.8
APR	71.3	48.8	60.1	176	1543.6
MAY	79.8	57.3	68.5	45	1824.8
SEP	83.5	60.5	72.0	10	1397.9
OCT	73.2	48.6	60.9	180	1113.8
NOV	59.0	37.7	48.4	498	711.3
DEC	49.6	31.1	40.4	763	520.6
ANN	70.1	48.7	59.4	3696	1269.7
TEXAS					
Dallas Latitude 32° 51'N Elevation 489'					
JAN	55.1	35.7	45.4	608	821.5
FEB	59.2	39.5	49.4	437	1071.1
MAR	66.4	45.2	55.8	314	1421.8
APR	76.3	56.4	66.4	71	1626.8
MAY	83.1	64.4	73.8	0	1888.5
SEP	88.0	68.3	78.2	0	1587.1
OCT	78.4	57.5	68.0	55	1276.1
NOV	66.4	45.4	55.9	284	936.4
DEC	57.8	38.6	48.2	521	780.1
ANN	76.0	56.3	66.2	2290	1468.1
El Paso Latitude 31° 48'N Elevation 3917'					
JAN	57.0	30.2	43.6	663	1125.1
FEB	62.5	34.3	48.4	465	1480.1
MAR	68.9	40.3	54.6	328	1909.3
APR	78.5	49.3	63.9	89	2363.5
MAY	87.2	57.2	72.2	0	2600.6
SEP	87.4	61.0	74.2	0	1987.1
OCT	78.5	49.5	64.0	92	1639.0
NOV	66.1	37.0	51.6	402	1243.7
DEC	57.8	30.9	44.4	639	1030.7
ANN	77.2	49.5	63.4	2678	1899.7
TEXAS (continued)					
Lubbock Latitude 33° 39'N Elevation 3242'					
JAN	53.4	24.8	39.1	803	1030.9
FEB	57.0	28.3	42.7	624	1331.7
MAR	63.8	34.0	48.9	508	1762.0
APR	74.8	45.1	60.0	190	2167.8
MAY	82.5	54.5	68.5	29	2395.9
SEP	83.8	58.2	71.0	8	1820.1
OCT	74.7	47.3	61.0	162	1468.2
NOV	63.1	34.4	48.8	486	1116.1
DEC	55.2	27.4	41.3	735	934.5
ANN	73.6	45.8	59.7	3545	1766.0
UTAH					
Salt Lake City Latitude 40° 46'N Elevation 4226'					
JAN	37.4	18.5	28.0	1147	639.1
FEB	43.4	23.3	33.4	885	988.7
MAR	50.8	28.3	39.6	787	1454.3
APR	61.8	36.6	49.2	474	1894.3
MAY	72.4	44.2	58.3	237	2362.4
SEP	80.3	49.3	64.8	105	1843.3
OCT	66.4	38.4	52.4	402	1293.3
NOV	50.0	28.1	39.1	777	787.9
DEC	39.0	21.5	30.3	1076	569.8
ANN	63.8	38.2	51.0	5983	1603.1
VERMONT					
Burlington Latitude 44° 28'N Elevation 341'					
JAN	25.9	7.6	16.8	1494	385.3
FEB	28.2	8.9	18.6	1299	606.8
MAR	38.0	20.1	29.1	1113	940.2
APR	53.3	32.6	43.0	660	1296.2
MAY	66.1	43.5	54.8	331	1574.1
SEP	70.0	48.6	59.3	191	1122.2
OCT	58.7	38.8	48.8	502	740.5
NOV	44.3	29.7	37.0	840	374.6
DEC	30.3	14.8	22.6	1314	283.2
ANN	54.2	34.5	44.4	7876	1020.7
VIRGINIA					
Richmond Latitude 37° 30'N Elevation 164'					
JAN	47.4	27.6	37.5	853	631.9
FEB	49.9	28.8	39.4	717	877.1
MAR	58.2	35.5	46.9	569	1210.4
APR	70.3	45.2	57.8	226	1566.0
MAY	78.4	54.5	66.5	64	1762.0
SEP	80.9	59.0	70.0	21	1347.9
OCT	71.2	47.4	59.3	203	1032.7
NOV	60.6	37.3	49.0	480	733.0
DEC	49.1	28.8	39.0	806	566.7
ANN	68.8	46.7	57.8	3939	1248.0
Roanoke Latitude 37° 19'N Elevation 1174'					
JAN	45.6	27.2	36.4	887	660.5
FEB	47.9	28.3	38.1	753	899.4
MAR	56.3	34.3	45.3	611	1236.1
APR	67.9	43.9	55.9	283	1581.5
MAY	76.1	52.7	64.4	101	1763.9
SEP	79.5	56.5	68.0	32	1358.2
OCT	69.9	45.6	57.8	235	1080.2
NOV	57.6	35.8	46.7	549	764.7
DEC	46.6	28.1	37.4	856	590.8
ANN	66.8	45.0	55.9	4307	1269.5
WASHINGTON					
Seattle-Tacoma Latitude 47° 27'N Elevation 400'					
JAN	43.4	33.0	38.2	831	261.7
FEB	48.5	36.0	42.3	636	495.0
MAR	51.5	36.6	44.1	648	849.0
APR	57.0	40.3	48.7	489	1293.5
MAY	64.1	45.6	54.9	313	1713.9
SEP	68.7	50.4	59.6	170	1147.7
OCT	59.4	44.9	52.2	397	656.2
NOV	50.4	38.8	44.6	612	337.2
DEC	45.4	35.5	40.5	760	211.1
ANN	58.8	43.3	51.1	5185	1052.7
Spokane Latitude 47° 38'N Elevation 2366'					
JAN	31.1	19.6	25.4	1228	315.0
FEB	39.0	25.3	32.2	918	605.9
MAR	46.2	28.8	37.5	853	1040.6
APR	57.0	35.2	46.1	567	1494.9
MAY	66.5	42.8	54.7	327	1918.0
SEP	72.5	46.7	59.6	196	1435.3
OCT	58.1	37.5	47.8	533	840.9
NOV	41.8	29.2	35.5	885	397.7
DEC	33.9	24.0	29.0	1116	255.2
ANN	57.2	37.3	47.3	6835	1223.8
WEST VIRGINIA					
Charleston Latitude 38° 22'N Elevation 951'					
JAN	43.6	25.3	34.5	946	498.4
FEB	46.2	26.8	36.5	798	706.5
MAR	55.2	33.8	44.5	642	1009.5
APR	67.9	43.8	55.9	287	1355.7
MAY	76.6	52.3	64.5	113	1639.4
SEP	79.0	55.9	67.5	46	1272.0
OCT	69.1	44.8	57.0	267	972.3
NOV	55.8	35.0	45.4	588	613.1
DEC	45.2	27.2	36.2	893	440.1
ANN	66.0	44.4	55.2	4590	1123.3
WISCONSIN					
Milwaukee Latitude 42° 57'N Elevation 692'					
JAN	27.3	11.4	19.4	1414	479.4
FEB	30.3	14.6	22.5	1190	736.5
MAR	39.4	23.4	31.4	1042	1088.8
APR	54.6	34.7	44.7	609	1442.7
MAY	65.0	43.3	54.2	348	1768.4
SEP	71.5	50.7	61.1	140	1310.3
OCT	61.4	40.6	51.0	440	907.9
NOV	44.4	28.5	36.5	855	524.6
DEC	31.5	16.8	24.2	1265	378.4
ANN	55.1	36.3	45.7	7444	1191.2
WYOMING					
Cheyenne Latitude 41° 09'N Elevation 6142'					
JAN	38.2	14.9	26.6	1190	765.8
FEB	40.7	17.3	29.0	1088	1067.8
MAR	43.5	19.6	31.6	1035	1433.1
APR	55.4	30.0	42.7	669	1770.5
MAY	65.1	39.7	52.4	394	1994.6
SEP	72.8	43.5	58.2	225	1667.4
OCT	61.8	33.9	35.5	530	1241.8
NOV	47.5	23.5	35.5	885	822.8
DEC	40.3	18.1	29.2	1110	671.0
ANN	58.9	33.0	45.9	7255	1490.7

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[a] Reprinted from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data and Information Service, National Climate Center, Asheville, North Carolina - "Input Data for Solar Systems," by V. V. Cinquemani. J. R. Owenby, Ir., and R. G. Baldwin.

[b] Based on 1941 - 1970 Period. Zeros appearing for all values appearing in these columns signify that 1941 - 1970 period normals were not available.

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