APPENDICES

1. GLOSSARY

Absorptance	The ratio of radiation absorbed by a surface and the total energy falling on that surface expressed as a percentage.
Active solar energy system	A system which requires the importation of energy from outside its system immediate environment, for example, energy to operate fans and pumps.
Air change	The replacement of a quantity of air in a volume within a given period of time. This is expressed in number of changes per hour. If a house has one air change per hour, it means that all air in the house will be replaced in a one-hour period.
Albedo	The degree to which a surface reflects cosmic rays or sunlight.
Ambient temperature	The outdoor temperature surrounding an object.
Angle of incidence	The angle of the sun's rays to a line perpendicular to a surface.
Berm	A man-made mound or small hill of earth.
Black body	A theoretically perfect absorber.
Btu	British thermal unit - the quantity of heat required to raise the temperature of one pound of water 1^0F. 1 Btu = 252 calories
Calorie	The quantity of heat required to raise the temperature of one gram of water 1^0C. One calorie is about 4 Btu's.
Chimney effect	The tendency of air or gas to rise when heated, owing toits lower density compared with that of the surrounding air or gas. Thisprinciple is used to help cool a building by allowing hot or warm aior to rise out through upper level windows. This causes a negative pressure which draws in cooler air in through windows at a lower level.
Conductance	Thermal conductance refers to the ability of a material or system to conduct heat, measured in watts per degree kelvin (W/K). It indicates how easily heat can pass through a material, which is crucial in applications like building insulation.
Conduction	The transfer of thermal energy through a material without any movement of the material as a whole. This process occurs when molecules in a hotter area collide with those in a cooler area, transferring energy until thermal equilibrium is reached.
Conductivity	The quantity of heat (Btu's) that will flow through one square foot of material, in inch thick, in one hour when there is a temperature difference of 1^0F between its surfaces. Materials with high thermal conductivity transfer heat more efficiently than those with low thermal conductivity, and are used in heat sink applications. Materials with low thermal conductivity, such as mineral wool or Styrofoam, are used for thermal insulation.
Convection	The transfer of heat between a moving fluid medium (liquid or gas) and a surface, or the transfer of heat within a fluid by movements within the fluid.
Deciduous	Species of trees and shrubs which shed their leaves in autumn.

Delta-T (ΔT)	Denotes a difference in temperature, such between indoor and outdoor (ambient) temperatures.
Density	The mass of a substance which is expressed in pounds per cubic feet (kilograms per cubic meter).
Diffuse radiation	Light that travels an indirect path from the sun as it has been scattered by clouds, dust and air molecules in the air, is reflected of surface (buildings, snow) or filtered bny tree crowns.
Direct gain	Solar energy collected (as heat) in a building without special solar collection devices.
Direct radiation	Light that travels in a straight path from the sun.
Emissivity	The emissivity of the surface of a material is its effectiveness in emitting energy as thermal radiation. Thermal radiation is electromagnetic radiation that most commonly includes both visible radiation (light) and infrared radiation, which is not visible to human eyes. A portion of the thermal radiation from very hot objects is easily visible to the eye.
Energy	The capacity for doing work, taking a number of forms which may be transformed from one into another, such a thermal (heat), mechanical (work), electrical and chemical.
Equinox	The two times of the years when the sun crosses the equator and the length of the day and night are approximately equal (roughly March 22 and September 22).
Solstice	The times of the year when the sun is at it highest of lowest point in the sky. In the northern hemisphere, June 22 and December 22.
Glare	Difficulty seeing in the presence of very bright light due to the angle of the light or its reflection from bright surfaces (ex., glazing, water, white objects, ...).
Glazing	A covering of transparent or translucent material used for admitting light. Glazing retards heat losses from re-radiation and convection.
Greenhouse effect	Refers to the characteristic tendency of some transparent materials such as glass to transmit radiation shorter than about 2.5 microns and block radiation of longer wavelengths.
Heat capacity	The amount of heat that must be supplied to an object to produce a unit change in its temperature. It quantifies the ability of a material or system to store thermal energy.
Heat gain	An increase in the amount of heat contained in a space, resulting from direct solar radiation and the heat given off by people, animals, lights, equipment. Machinery and other sources.
Heat loss	A decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, doors, roof and other building envelope components.
Heat sink	A material capable of accepting and storing heat, and therefore can also act as a heat source.
Hybrid solar energy system	Hybrid systems use passive design components in combination with active components (fans, pumps, auxiliary heat, ...).
Incidence	The falling of radiation (light) on a surface.

Indirect gain system	A solar heating system in which sunlight first strikes a thermal mass located between the sun and a space. The sunlight absorbed by the mass is converted to heat and then transferred into the living or growing space.
Insolation	The total amount of solar radiation (direct, diffuse, and reflected) striking a surface exposed to the sky.
Latent heat	A change in heat content that occurs without a corresponding change in temperature, usually accompanied by a change of state.
Insulation	Materials or systems used to prevent heat gain or loss.
Nocturnal cooling	The cooling of a building or heat storage device by the radiation of excess heat into the nigh sky. With clear night skies, nocturnal cooling will be greater than on cloudy nights.
Opaque	Impenetrable by light.
Passive solar energy system	Systems relying upon parts of building design and construction for direct sun heating. In a strict sense, such systems would use no energy other than the natural sources of the sun and wind.
Phototropism	The growth or movements of plants toward a source of light.
Radiation	The direct transport of energy through space by means of electromagnetic waves.
Reflectance	Reflectance is the fraction of incident sunlight that is reflected by a surface. The light not reflected is either absorbed by the material or transmitted through it.
Refraction	The change of direction of light waves as they enter a transparent medium such as water, air or glass. Example: rainbows, prisms.
Relative humidity	The actual amount of water vapor in the atmosphere at a given temperature as a percentage of the total amount of water that could be held at that temperature.
R-factor	A unit of thermal resistance used for comparing insulating values of different materials. The higher the R-value of a material, the greater tits insulating properties.
Retrofitting	Installing solar water heating and/or cooling systems in existing buildings not originally designed for the purpose.
Solar altitude	The angle of the sun above the horizon measured in a vertical plane.
Solar energy	The photon energy originating from the sun's radiation in the wavelength region of 0.3 to 2.4 micrometers.
Solar time	The hours of the day as reckoned by the apparent position of the sun. Solar noon is that instant on any day at which the sun reaches its highest point in the sky for that day.
Specific heat	The number of Btu's required to raise the temperature of one pound of a substance 1^0F in temperature (or Joules per kilogram for a 1^0C)
Stratification	Air stratification, or thermal stratification, occurs when warm air rises and cool air sinks, creating layers of different temperatures within a space. In passive solar greenhouses, this phenomenon is used for ventilation (chimney effect).
Thermal break	An element of low heat conductivity placed in such a way as to

	reduce or prevent heat flow.
Thermal inertia	The tendency of a building with large quantities of heavy material to remain at the same temperature or to fluctuate only very slowly.
Thermal mass	Thermal mass refers to materials that can absorb, store, and release heat, helping to regulate indoor temperatures in buildings. Common materials with high thermal mass include concrete, brick, stone and water, which can enhance energy efficiency by reducing heating and cooling demands.
Time lag	The period of time between the absorption of solar radiation by a material and its release into a space. Time lag is an important consideration in sizing a thermal storage wall or Trombe wall.
Translucent	Translucent refers to a material that allows light to pass through but scatters it, making objects on the other side appear blurred or unclear.
Transparent	Capable of transmitting light so that objects or images can be seen as if there were no intervening material.
Transmittance	Transmittance is the measure of how much radiant energy passes through a material, expressed as the fraction of the incident light that successfully reaches the other side. It is often represented as a percentage, ranging from 0% (no light transmitted) to 100% (all light transmitted).
Trombe wall	A south-facing masonry exterior wall that collects and releases solar energy into a building by both radiant and convective means. This wall is insulated from the exterior by glass or other transparent material.
U-value	The number of Btu's that flow through one square foot of roof, wall or floor, in one hour, when there is a 1^0F difference in temperature between the inside and outside air, under steady state conditions. The U-value is the reciprocal of the R-factor.
Vapor barrier	A component of construction which is impervious to the flow of moisture and air, and is used to prevent condensation in walls and other locations of insulation .
VPC	Vapor Pressure Deficit is the difference between the maximum amount of moisture the air can hold when fully saturated and the amount of moisture it is currently holding. In controlled environment agriculture, such as greenhouses, VPD is actively managed to sustain optimal rates of transpiration by simultaneously manipulating of both air temperature and humidity, as these two variables determine the deficit. This allows growers to fine-tune the plant's physiological processes to match developmental stages.
Water wall	A interior wall of water-filed containers constituting a one-step heating system which combines collection and storage.

Sources:

PSI Energy Systems, Inc, Denver, CO.

Edward Mazria. 1979. The passive solar energy book: A complete guide to passive solar home, greenhouse, and building design, pp655-667. Emmaus, PA: Rodale Press.

Appendix 2

Temperature conversion table

^{0}C	^{0}F	^{0}C	^{0}F	^{0}C	^{0}F	^{0}C	^{0}F	^{0}C	^{0}F
-25	-13	-12	10.4	3	37.4	17	62.6	32	89.6
-24	-11.2	-11	12.2	4	39.2	18	64.4	33	91.4
-23	-9.4	-10	14	5	41	19	66.2	34	93.2
-22	-7.6	-9	15.8	6	42.8	20	68	35	95
-21	-5.8	-8	17.6	7	44.6	21	69.8	36	96.8
-20	-4	-7	19.4	8	46.4	22	71.6	37	98.6
-19	-2.2	-6	21.2	9	48.2	23	73.4	38	100.4
-18	-0.40	-5	23	10	50	24	75.2	39	102.2
-17	1.4	-4	24.8	11	51.8	25	77	40	104
-16	3.2	-3	26.6	12	53.6	26	78.8	41	105.8
-15	5	-2	28.4	13	55.4	27	80.6	42	107.6
-14	6.8	-1	30.2	14	57.2	28	82.4	43	109.4
-13	8.6	0	32	15	59	29	84.2	44	111.2
-12	10.4	1	33.8	15	59	30	86	45	113
-11	12.2	2	35.6	16	60.8	31	87.8	46	114.8

Appendix 3

Climate data for Boone, NC

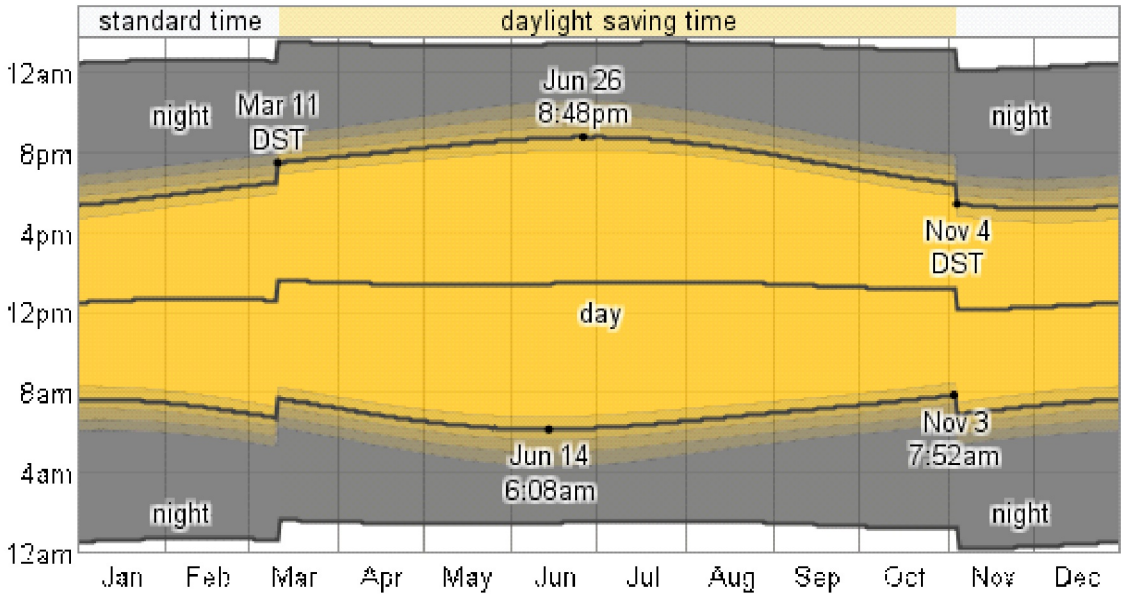
Lat: 36.2°N Long: 81.65°W Elev: 3146 ft (953.3 m) asl

NOTE: Climate data are based on 30-year moving averages, smoothing out annual variations in temperatures and precipitation.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1961-1990	Avg T-max	41	43.7	53	61.7	69.1	74.6	77.1	76.3	70.7	62.4	53.4	44.7	60.6
	Avg T-min	22.3	24.7	32.4	40.1	48.5	55.4	59.3	58.4	52.4	41.6	34.1	26.3	41.3
	Avg T	31.7	34.2	42.7	50.9	58.8	65	68.2	67.3	61.6	52	43.7	35.5	51
	Precip in	3.75	4.24	5.14	4.32	4.84	4.49	4.64	4.4	4.51	4.52	4.26	3.6	52.7
1971-2000	Avg T-max	40.6	44.4	51.7	59.9	68	74	77.7	76.3	71.1	62.6	52.7	44.1	60.5
	Avg T-min	22.9	26.3	31.9	39.6	47.5	55.6	59.9	58.1	51.8	41.5	33.7	25.6	41.5
	Avg T	31.8	35.4	41.8	49.8	57.7	64.8	68.9	67.1	61.5	52	43.2	34.8	51
	Precip in	4.04	4.41	4.71	4.64	4.46	4.65	4.79	4.83	3.5	3.22	4.32	3.04	49.55
1981-2010	Avg T-max	41.1	44.1	51.8	61	68.7	75.1	78.1	77.3	71.4	62.6	53.5	43.9	60.7
	Avg T-min	22.6	25.3	31.2	39.1	47.1	55.2	59.1	58	51.3	41.1	32.7	25.3	40.7
	Avg T	31.8	34.7	41.5	50.1	57.9	65.2	68.7	67.6	61.4	51.8	43.1	34.6	50.7
	Precip in	3.78	3.91	4.74	4.47	4.43	5.1	5	5.11	4.47	3.59	4.47	3.69	52.74
1991-2020	Avg T-max	41.2	44.5	51.5	61.6	69.2	75.6	78.9	77.5	72.1	62.8	52.8	44.8	61
	Avg T-min	22.6	24.7	30.2	38	46.6	54.5	58.7	57.2	51.2	40.3	30.4	25.7	40
	Avg T	31.9	34.6	40.9	49.8	57.9	65	68.8	67.3	61.6	51.5	41.6	35.2	50.5
	Precip in	4.38	3.65	4.72	5.42	5.36	5.66	5.27	5.59	5.68	4.69	4.4	4.32	59.14

APPENDIX 4

The solar day over the course of a year at approximately 36^0 N or S of the equator



From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights, and night (solar, civil, nautical, and astronomical) are indicated by the color bands from yellow to gray. The transitions to and from daylight saving time are indicated by the "DST" labels.

APPENDIX 5

Books on Passive Solar Greenhouse Design

We have found the following books to be very useful. While this is a good start, there are more books on the topic.

Carter, J. 1981. Solarizing Your Present Home: Practical Solar Heating Systems You Can Build. Emmaus, PA: Rodale Press.

Clegg, P. And Watkins, D. 1978. The Complete Greenhouse Book. Charlotte, vermont: Garden Way Publishing.

Hewitt, Paul. 2001. Conceptual Physics, 9th Edition. Addison-Wesley.

Mazria, Edward. 1979. The Passive Solar Energy Book: A Complete Guide to Passive Solar Home, Greenhouse, and Building Design, pp655-667. Emmaus, PA: Rodale Press.

McCullagh, J.C., ed. 1978. The Solar Greenhouse Book. Emmaus, PA: Rodale Press.

Oehler, M. 20007. The Earth-sheltered Solar Greenhouse Book. Mole Publishing Company.

Schiller, I and Plinke, M. The Year-round Solar Greenhouse. How to design and Build a Net-zero Greenhouse. Gabriola Island, BC, Canada: New Society Publishers.

Yanda, B. and Fisher R. 1076. The Food and Heat Producing Solar Greenhouse. Santa Fe, NM: John Muir Publications, Inc.

Wright, David. 2008. The Passive Solar Primer: Sustainable Architecture. Atglen, PA: Schiffer Publications.

APPENDIX 6

Books about Greenhouse Growing

Richard Bray. 2022. The Complete Beginner's Guide to Greenhouse Gardening: A Month-by -Month Planting Book to Grow 365 Days a Year. Monkey Publishuing.

Eliot Coleman and Barbara Damrosch. 1999. Four-Season Harvest: Organic Vegetables from Your Home Garden All Year Long, 2nd Edition. Chelsea Green.

Eliot Coleman and Barbara Damrosch. 2009. The Winter Harvest Handbook: Year Round Vegetable Production Using Deep-Organic Techniques and Unheated Greenhouses. Chelsea Green.

Lia Leendertz. 2014. Conservatory and Greenhouse Gardening (Collins Practical Gardener). Collins. Kindle Edition

Roger Marshall. 2014. The Greenhouse Gardener's Manual. Timber Press.

Shane Smith (Author) and Majorie Leggitt (Illustrator). 2000. Greenhouse Gardener's Companion, Revised and Expanded Edition: Growing Food & Flowers in Your Greenhouse or Sunspace. Chicago Review Press.

Cooperative Extension publications about greenhouse production (in general, or crop specific).

APPENDIX 7

Satisfactory and optimal growing temperature ranges for vegetables

Crop	Temperature range		Optimal temperature range	
Asparagus, Rhubarb	> 50^{0}F	>10^{0}C	60-75^{0}F	16-24^{0}C
Beet, Fava [broad] bean, Broccoli, Brussels sprouts, Cabbage, Chard, Collards, Horseradish, Kale, Kohlrabi, Parsnip, Radish, Rutabaga, Sorrel, Spinach, Turnip	40-75^{0}F	4-24^{0}C	60-65^{0}F	16-18^{0}C
Artichoke, Carrot, Cauliflower, Celeriac, Celery, Chicory, Chinese cabbage, Endive, Belgium endive, Florence fennel, Lettuce, Mustard, Parsely, Peas, Potato	45-75^{0}F	7-24^{0}C	60-65^{0}F	16-18^{0}C
Chive, Garlic, Leek, Onion, Salsify, Shallot	45-85^{0}F	7-29^{0}C	55-75^{0}F	13-24^{0}C
Beans (bush/pole), Lima bean	50-80^{0}F	10-27^{0}C	60-70^{0}F	16-21^{0}C
Corn, Cowpea, New Zealand Spinach	50-95^{0}F	10-35^{0}C	60-75^{0}F	16-24^{0}C
Malabar spinach, Pumpkin, Squash	50-95^{0}F	10-35^{0}C	65-75^{0}F	18-24^{0}C
Cucumber, musk melon	60-90^{0}F	16-32^{0}C	65-75^{0}F	18-24^{0}C
Sweet pepper, Tomato	65-80^{0}F	18-27^{0}C	70-75^{0}F	21-24^{0}C
Eggplant, Hot peppers, Okra, Sweet potato, Watermelon	65-95^{0}F	18-35^{0}C	70-85^{0}F	21-29^{0}C

Note: Degrees C have been rounded to whole numbers.

Source: James Edward Knott. 1957. Satisfactory (and optimal) plant growing temperature ranges. In: Handbook for Vegetable Growers, pp. 6-7. New York: John Wiley & Sons, Inc.

Knott observed that cold season crops can be grown in shady areas in the summer. All crops need at least four hours of direct sunlight per day for good growth. Seven hours are preferable, and eleven hours are even better.