

Design and Thermal Analysis of a Passive Solar, Earth-Bermed Greenhouse for the George D. Aiken Forestry Sciences Laboratory

Abstract: Modern conventional greenhouses are designed to collect maximum incoming solar radiation. As a result, these buildings are highly energy inefficient despite their ability to gain heat for a small portion of the day. The greenhouse at the George D. Aiken Forestry Sciences Laboratory (FS lab) in S. Burlington, VT exemplifies inefficient greenhouse design, requiring large amounts of heat to maintain necessary temperatures in the winter. Passive solar greenhouses, however, are designed to minimize backup heating and cooling requirements through the maximization of passive heat gains and the minimization of heat loss. This research aims to produce a set of design parameters to inform the design and thermal analysis of a passive solar, earth-bermed greenhouse for the FS lab. Users were interviewed to determine their needs and uses related to the greenhouse. A site analysis was conducted to determine position and orientation of the earth-sheltered greenhouse on the site with respect to solar access, proximity to existing head house (building attached to the greenhouse and used for preparation and storage), prevailing wind patterns, topography and microclimate. Detailed plans of the site and the greenhouse—including materials lists—were produced using the following design parameters: a) user interviews; b) site analysis; c) passive solar and earth-sheltered design principles; d) thermal model created to project the future conditioning requirements of the building based on various building material assemblies and floor plans and; e) plant growth requirements within a controlled environment. Finally, the cost of construction was estimated as well as the total cost of conditioning the structure for one year. This research demonstrates the effectiveness of using passive solar and earth-berming techniques to design a greenhouse that has a greatly reduced heating and cooling load.