Performance Evaluation of the Heat Storage System in the Solar Greenhouse at the Urban Environmental Laboratory

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I. Introduction

Background:

In 1980 - 82 I was involved in the design of the Urban Environmental Laboratory (UEL), home of the Center for Environmental Studies at Brown. Specifically, I worked on the energy conservation, solar space heating and ventilation systems. The building is "super-insulated," and uses passive solar heating admitted directly into some rooms, and indirectly into other areas through the large attached greenhouse on the south side of the building. It is the intention of this project to investigate certain aspects of the energy flows between the greenhouse and the rest of the building, specifically between the greenhouse and the basement of the building, which serves as the heat storage for the greenhouse.

The greenhouse:

The greenhouse, with about 500 sq. ft. of south-facing glass, admits much solar energy, routing some to the rest of the building, by various means. During the heating season, some of the captured radiant solar energy passes directly through the greenhouse, through windows into the adjoining office area; some heats air which is blown by a fan through the basement of the building where the brick and concrete structure absorbs some energy; and some heats interior greenhouse surfaces which then transmit heat to adjoining spaces, as well as to the outdoors. Some is also lost as reflected visible and shorter wave infrared radiation directly back out through the glazing, and some is stored in the materials in the greenhouse. Some solar energy is used in the evaporation of water from the many plants and exposed soil surfaces in the greenhouse, adding a latent component to the convective heat transfers.

At night, many of the energy flows reverse, with free and fan-forced convective air flow from the basement, as well as conductive heating from adjoining spaces and passive heat release from the materials within the greenhouse providing warmth. There is fin-tube hot water heating in the greenhouse, but the greenhouse went through the entire previous winter without requiring its use, and it was turned off for the present monitoring period.

It is generally assumed, with such greenhouses, that there is a net contribution of solar heat; that is, more heat is delivered to the adjoining structure than is taken from it for heating the greenhouse. Since this greenhouse is attached to a super-insulated building, the solar heated air is not directed into the normally occupied rooms, as it would be in a less insulated building. In the UEL, whenever the sun is shining, the direct sun into the occupied rooms plus the heat of occupancy keeps these rooms at a comfortable temperature, so the excess solar heat from the greenhouse is stored in the basement. Passive heat storage within the greenhouse is minimal for two reasons. First, the space that would be occupied by passive heat storage, such as water containers, is used for growing plants, and second, the dark color required for best passive heat storage would rob daylight from the plants, which would result in less-than-optimum plant growth. The white-glazed brick north wall