

POST OCCUPANCY CALIBRATION AND REASSESSMENT OF DESIGN PHASE ENERGY MODELING

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ABSTRACT

Extensive energy modeling was used during the design process of the Aldo Leopold Foundation Legacy Center in Baraboo, Wisconsin (USA) both to minimize the building's overall projected energy use and in a number of instances to determine whether proposed subsystems were viable for maintaining comfort. This paper focuses on three such simulations: a comparison of the thermal performance of earth ducts versus energy recovery ventilators as outdoor-air pre-treatment devices, the design of a heat pump / radiator system to provide minimal heating in an infrequently used wing of the building, and the use of a heat pipe between the photovoltaic array inverter room and the air handler to provide ventilation air stream reheat in the cooling season. The paper presents a critique of the three design decisions based on experiential performance in the case of the heat pipe and heat pump/radiator systems, and based on data monitoring and model calibration in the case of the earth ducts.

INTRODUCTION

Aldo Leopold (1887-1948) was a forester, ecologist and later a professor at the University of Wisconsin – Madison. He spent much of his life restoring natural habitat on a farm in central Wisconsin and was somewhat central in the development of the concept of land ethics. At the time of his work he and others were learning as they went. That same mentality was given as something of a challenge to the Legacy Centre design team. It was made clear that the Centre building was to leave as small an ecological footprint as possible, achieve net-zero energy, use simulation extensively to inform design, and that it was permissible for the design team to try out innovative ideas and have them fail (within reason) so long as the final decisions were strongly justified within the context of the basis of design. From an energy modeling perspective, this meant that the design team needed a simulation tool that was as close as possible to a library of first-principals components without any managerial structure to them and it meant that whatever simulations were carried out in support of the design work were going to need to be verified once the building was occupied. In this case, a “first principals” model is one that relies only on

fundamental energy transfer algorithms and not on empirical relations, curve fits, or artificial simplifications. For example, instead of using a building model that predefines a zone temperature, then calculates a load, then imposes that load on a system, the required “first principals” building model in this case would perform an energy balance on the zone given the current environmental conditions and the current state of the mechanical systems and would simply calculate the resulting temperature and humidity of the zone. Control decisions would be made by models watching the zone conditions and a time step appropriate for making control decisions would be used.

SIMULATION TOOL

The simulations described in this paper were carried out using the TRNSYS v16.0 energy modeling environment (Klein, et. al., 2005) with TESS Libraries v2.0 (Thornton, et. al., 2005), an earth duct/hypocaust model that was developed at the Centre Universitaire d'Études des Problèmes de l'Énergie (Hollmuller, et.al.,1998) and with a number of additional components that developed during the course of the building's design process.

To some extent, energy simulation software can be placed on a sliding scale where on the one end are tools that are fast and efficient to use in part because they have more built-in assumptions and by consequence, less flexibility in what they can model. On the other end of the scale are tools that require a greater investment in time both to learn and to use but which allow the simulation of much more diverse systems through their modularity and flexibility. They also tend to force the simulator to develop a significant understanding of the building's dynamics and energy transfer. In the case of the Legacy Centre and its design objectives, a tool from the second category (ie one that forces the simulator to understand the physics of the building and its systems) is wholly appropriate.

By no means does TRNSYS stand alone in this second category of software tools al be it with the late addition of a buffer tank to the heat pump system. However there is always a push for simpler “easier to use” tools. It is worth noting that these more complex tools are appropriate and necessary in high performance (especially “net-zero energy”)

