ABSTRACT

Hang, Yin. Ph.D., Purdue University, May 2012. Integrated Energy, Economic, and Environmental Assessment for the Optimal Solar Absorption Cooling and Heating System. Major Professor: Ming Qu.

Buildings in the United States are responsible for 41% of the primary energy use and 30% of carbon dioxide emissions. Due to mounting concerns about climate change and resource depletion, meeting building heating and cooling demand with renewable energy has attracted increasing attention in the energy system design of green buildings. One of these approaches, the solar absorption cooling and heating (SACH) technology can be a key solution to addressing the energy and environmental challenges. SACH system is an integration of solar thermal heating system and solar thermal driven absorption cooling system. So far, SACH systems still remain at the demonstration and testing stage due to not only its high cost but also complicated system characteristics.

This research aims to develop a methodology to evaluate the life cycle energy, economic and environmental performance of SACH systems by high-fidelity simulations validated by experimental data. The developed methodology can be used to assist the system design. In order to achieve this goal, the study includes four objectives as follows:

- **Objective 1:** Develop the evaluation model for the SACH system. The model includes three aspects: energy, economy, and environment from a life cycle point of view.
- **Objective2:** Validate the energy system model by solar experimental data.
- **Objective 3:** Develop a fast and effective multi-objective optimization methodology to find the optimal system configuration which achieves the maximum system benefits on energy, economy and environment. Statistic techniques are explored to reveal the

relations between the system key parameters and the three evaluation targets. The Pareto front is generated by solving this multi-objective optimization problem.

- **Objective 4:** Apply the developed assessment methodology to different building types and locations.

Furthermore, this study considered the influence of the input uncertainties on the overall system performance. The sensitivity analysis was performed firstly to identify the most sensitive inputs to the model outputs, and then the Monte Carlo simulation method was applied to perform the uncertainty analysis of these sensitive inputs according to the effect of range and shape of their probability density function. The optimization method developed before was extended to incorporate inputs uncertainties.

The research would have great significance for the development of sustainable buildings. The assessment method could be used directly to identify the opportunities for reducing the negative environmental impacts related to buildings. The optimization methodology developed is fast, efficient and easy for implementation. The trends discovered from various building types and climate patterns will become useful guidelines for designers and other professionals.