Minimizing Electricity Bills for Smart Buildings in a Dynamic Power Market: Framework, Algorithms, and Impact on Energy Conservation (PI: Dr. Wang Dan; 2013/14)

Energy is a global concern and the electricity bills nowadays are leading to unprecedented costs in many domains. Electricity price is dynamically changing, especially in future smart grid context. In this project, we investigate how to cut the electricity bills of commercial buildings in such dynamic power market. In buildings, the thermal systems (i.e., the heating and air-conditioning systems) dominate electricity bills. As a result, we have seen research and development from automatic device turning-off schemes to prudent policies on appliance/room usage.

We observe that the thermal system has a special property of *thermal inertia*, i.e., the energy will not immediately dissipate from thermal air/water. *Intuitively,* with inertia, the energy can be "held up" in the thermal system for a certain time, making it possible to purchase electricity in low price facing a dynamic power market, "inertia" it in the thermal system or rooms, and use it at appropriate time. Thermal inertia opens opportunities for buildings to develop advanced schedules to substantially cut electricity bills. With thermal inertia, dynamic power market, as well as the progress of advanced sensing systems to collect fine-grained data, there is a call for a comprehensive computing study on advanced schedules for building, meetings, and people, to maximize electricity bill reduction.

We propose a smart building framework to minimize electricity bills. This framework pervasively collects data in building thermal systems, rooms, and participatory human feedbacks on their thermal comfort through smart phones; these data are used for computing and physical modeling. We study deterministic optimization problems that minimize electricity bills and conduct stochastic analysis given probabilistic electricity prices and human activities. The work is cross-discipline and we face physical modeling, where there may be inevitable inaccuracy. We investigate how computing algorithms should be designed such that physical modeling inaccuracies will not overturn optimization results. Finally, our project focuses on electricity bill reduction; this matches the incentive of buildings. Yet we show this is not proportional to energy conservation. Such mismatch can be important for smart grid design in energy conservation. We thus study the impact of self-centric smart buildings on overall energy conservation. Our research will 1) develop smart building framework and algorithms that can be conveniently adopted by industry; 2) enrich understanding of cross-discipline sensing and computing system designs; and 3) contribute one concrete demand side whose characteristics could be taken into consideration for smart grid demand side abstractions.