Energy Efficient Refrigeration and Flexible Power Consumption in a Smart Grid

Refrigeration and heating systems consume substantial amounts of energy worldwide. However, due to the thermal capacity there is a potential for storing "coldness" or heat in the system. This feature allows for implementation of different load shifting and shedding strategies in order to optimize the operation energywise, but without compromising the original cooling and indoor climate quality. In this work we investigate the potential of such a strategy and its ability to significantly lower the cost related to operating systems such as supermarket refrigeration and heat pumps for residential houses. With modern Economic Model Predictive Control (MPC) methods we make use of weather forecasts and predictions of varying electricity prices to apply more load to the system when the thermodynamic cycle is most efficient, and to consume larger shares of the electricity when the demand and thereby the prices are low. The ability to adjust power consumption according to the demands on the power grid is a highly wanted feature in a future Smart Grid. Efficient utilization of greater amounts of renewable energy calls for solutions to control the power consumption such that it increases when an energy surplus is available and decreases when there is a shortage. This should happen almost instantly to accommodate intermittent energy sources as e.g. wind turbines. We expect our power management solution to render systems with thermal storage capabilities suitable for flexible power consumption. The aggregation of several units will contribute significantly to the shedding of total electricity demand. Using small case studies we demonstrate the potential for utilizing daily variations to deliver a power efficient cooling or heating and for the implementation of Virtual Power Plants in Smart Grid scenarios.

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