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Mixed-integer linear programming models for Autonomous Home Energy Management Systems

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The integrated optimization of all energy resources (exchanges with the grid, loads, storage, microgeneration) requires Autonomous Home Energy Management Systems (AHEMS) located behind the meter, which are equipped with optimization models and algorithms capable of making decisions according to the consumer' s preferences concerning the economic and comfort dimensions. For this purpose, it is necessary to develop optimization models respecting the physical operation and control principles of the appliances as well as their habitual utilization patterns and control modes. A balance should be sought between the model detail level and the computational requirements to obtain practical solutions, having in mind their implementation in AHEMS running on low-cost processors. According to the type of control, residential loads can be categorized as: shiftable (the operation cycle cannot be interrupted), interruptible (the operation can be interrupted and resume operation at a later stage), and thermostatic (the operation is controlled by a state variable such as indoor temperature).
A comprehensive set of mixed-inetger linear programming (MILP) models of appliance operation is presented, which are aimed at being seamlessly incorporated in AHEMS allowing for the integrated optimization of all energy resources. These models take into account several parameters as operation cycles requiring different power at different stages, the behavior of a thermostat with hysteresis, main principles of heat transfer in buildings. Different cost objective function components (energy and power costs, and monetized discomfort) are presented, as well as ways of dealing with the possible user's discomfort derived from operating appliances out of the habitual periods/settings and/or temperature ranges. The computational efficiency in real settings considering a fine-grain time discretization is discusserd. These modular models are developed in a building block manner enhancing the flexibility of their utilization in overall models with different objectives encompassing the economic and comfort dimensions.

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