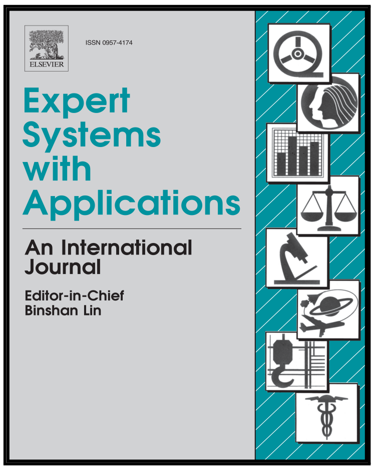

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Optimizing Residential Energy Management Using an Autonomous Scheduler System

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Highlights

- Home energy system proposed using L-BFGS-B and ToU to optimize appliance scheduling.
- Energy allocation resources coordinated by proposed SCL embedded in smart meter.
- SCL guarantees automation of the proposed SHEMS and prevents human intervention.
- Simulation using real electric load data on residential prosumers with PV systems.
- Clustered 267 customers based on their energy lifestyles.

Abstract

In this paper, a smart home energy management system (SHEMS) is developed using a limited memory algorithm for bound constrained problems known as L-BFGS-B, along with time-of-use (ToU) pricing to optimize appliance scheduling in a 24-hour period. The allocation of energy resources for each appliance is coordinated by a smart controllable load (SCL) device embedded in the household's smart meter. SCL guarantees automation of the proposed SHEMS and prevents manual participation of customers in demand response (DR) programs. The model is simulated on a population of 247 residential prosumers with solar PV systems based on 15-min interval electric load data from a residential community in Austin, TX. After clustering households based on their electricity profiles, the proposed optimization model is performed. Simulation results show that the proposed autonomous scheduling system reduces cumulative energy consumption for customers across the different clusters. In addition, when households are grouped based on their respective category according to the ToU pricing scheme, the simulation reports a notable decrease in total energy consumption, from 65.771 kWh to 44.295 kWh, as well as a reduction in the cumulative cost of energy, from \$6.550 to \$4.393 per day. Simulation results confirm that the proposed algorithm effectively improves the operational efficiency of the distribution system, reduces power congestion at key times, and decreases electricity costs for prosumers.

Keywords: Appliance scheduling; demand response; energy management; L-BFGS-B; ToU pricing

1. Introduction

In recent years, the continuous use of advanced metering infrastructure (AMI) has produced highly granular data on user consumption from smart meters. The smart grid allows bi-directional communication between consumers and electric utilities, using a network of communication, control, automation and new technologies. These smart grids work together to make the grid more efficient, reliable, secure and environmentally friendly. Energy demand constantly changes during the day; therefore, utility companies must adjust the number of active power plants based on the amount of power required at various points of the day. Electricity is more expensive at peak times, as companies must run more power plants to match the level of demand. The smart grid allows utility companies to control electricity usage based on feedback from customers. As seen in Figure 1, a smart grid utilizes new technologies and infrastructure to improve the flow of information and communication between all stakeholders—including generation entities, such as solar energy production—and the transmission system.

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