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Scheduling of Smart Home Appliances for Energy Management through various Optimization Algorithms

Abdul Muneeb[1], Amjad Ullah Khattak[2], Muhammad Israr[3], Ahmad Jamal[4]
[1,2,3,4]Department of Electrical Engineering and Technology Peshawar, Pakistan
abdulmuneeb.eec@uetpeshawar.edu.pk[1], amjad67@gmail.com[2], muhammad.israr@uetpeshawar.edu.pk[3], engrahmadjamal@gmail.com[4]

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***Abstract*—** Consumers regulate power use through two-way transmission between the source and the customer via Smart Meters, according to Advanced Metering Infrastructure (AMI) (SM). Smart Grid helps to reduce power consumption expenses by utilising DSM. User latency, on the other hand, increases as a result of home appliance planning. This problem with scheduling is characterised as an optimization problem. Meta-heuristic algorithms have garnered a lot of attention in recent years as a technique to solve optimization problems. As a result, using the Cuckoo Search Algorithm and the Multi-universe Algorithm, we provide an effective technique in HEMS to address the appliances optimization problem (MVO). One smart home and a smart building are part of the proposed concept, which includes thirty smart homes. Suggested solutions are exceptionally efficient in terms of power usage and Peak to Average Ratio reduction (PAR). Aside from that, the suggested solution strikes the right balance between power expenses and user comfort. The Real-Time Pricing (RTP) signal is used to compute the power cost of a single smart dwelling or a smart building.

***Keywords*—** Smart Meter, Advance Metering Infrastructure, Real-Time Pricing, Cuckoo Search and MVO.

I. Introduction

The Electricity Distribution System in Pakistan is plagued by technical, financial, and management issues. As the infrastructure ages and utilities are unable to satisfy demand, consumers are becoming increasingly irritated. The most up-to-date information technology can help to alleviate these problems. The Smart Grid is set up with an energy management system to assist in solving the problem of peak demand. The smart grid for power systems outlines the electrical networks, as well as the requirements and activities for consumers, in order to offer dependable, affordable, and safe electricity. Utilities throughout the world are working hard to satisfy smart grid demands. The combination of traditional grid systems with the most up-to-date information, communication, control, and digital technology is referred to as smart grid. [1]

Pakistan gets electricity from both renewable and non-renewable sources. Hydro, wind, tides, and solar are examples of renewable resources, whereas thermal and nuclear are examples of non-renewable sources. Due to construction, transmission, and long-distance electricity distribution, current-strength networks are experiencing electricity losses, according to ongoing study. Traditional transmission and distribution strains are responsible for about 90% of outages. However, the traditional energy infrastructure is incapable of meeting the energy customers' long-term needs. In addition, because of the heavy reliance on fossil fuels, current electrical systems emit excessive amounts of carbon dioxide. Globally, the electricity sector is responsible for 42 percent of greenhouse gas emissions. In contrast, fossil fuels are used in the transportation system. Thereby the transportation sector is responsible for 24 percent of worldwide greenhouse gas emissions [2-4].

II. Methodology

The energy sector is entering a new phase, dubbed "smart energy," in which it will efficiently use/store/produce/transmit/ energy, making it more sustainable, reliable, continuous, safe, ecological, and autonomous through the application of new information and communication technologies (ICT). The "smartest" method to tackle any future issue is to use modern technologies to change the energy components and the responsibilities of the participants.

A. Smart Energy

When it comes to smart energy systems, they're cost-effective and they make use of green renewable energy resources. Energy generation, storage, delivery, and consumption are all intelligently linked into a single system. An increasing trend in energy the world faces environmental, economic and sustainability issues. Finite resources are becoming more expensive, and the pollution created by fossil fuels is becoming unsustainable for the environment. Energy efficiency and sustainability can only be enhanced by supporting and growing the use of distributed and renewable energy generation (e.g., solar, wind, geothermal, biomass) close or at consumption sites, according to the World Energy Agency's (WEA) latest Global Energy Report.

B. Smart Grid

The Smart Grid is the combination of different renewable and non-renewable sources that has some salient trademarks for the market competitor. The decentralization of power generation (DPG) supports participation at the end of the node, not only for the consumer side but also for the generation. Smart Grid supremacy incorporates more efficient performance to reduce administrative expenses and cut energy bills for consumers. It also allows consumers to play a dynamic part in the operational system, ensuring efficiency and transparency while transferring or distributing electricity, as well as repairing itself and ensuring energy quality and harmony.

C. Micro Grid

Intelligent microgrids are miniature versions of future power systems that handle all of the functions of an energy system, including production, transmission, and control the flow of power to clients. Two modes of microgrid: grid and island mode connected. Consumers in a microgrid have control over consumption, timing, and amount. The electricity system changes from an external network to ESS-stored electricity when power generation is low in comparison to electricity. Power can be exported to neighbouring microgrids if there is excess power generation.

D. Smart Home

Contrary to previous eras, humanity has made technological advances in the last few decades. In the near future, units will be more intelligent, able to recognise our mental condition and our requirements, and even communicate with us directly. A new era will be ushered in by the Internet of Things and Artificial Intelligence (AI). On the other hand, smart lighting immediately responds to voice commands, or the TV automatically opens when your voice is heard, changing colours to match what's being shown on screen, etc. The home controller and automation system can access remote control devices from anywhere there is an internet connection. You can use it to organise and manage your activities if you want to start or stop your washing machine at a predetermined period dependent on the price of power. A device or event that, in a similar manner, triggers another device by specifying the activity according on the customer's choices. In an emergency, for example, the lighting system is turned on immediately, the power is placed in a critical position, all doors are opened/unlocked, and the emergency phone is activated.[8]

E. Home Energy Management System (HEMS)

The Home Energy Management System (HEMS) makes all of the choices in smart homes. In practise, the terms "smart home" and "household energy management system" are equivalent. The HEMS Interfacing allows the user to monitor, regulate, and manage the household's coherent power generation and consumption. From the perspective of public institutions, it reduces peak load and prevents the demand response system from collapsing. On the other hand, when combined with a decrease in energy consumption, the use of clean renewable energy supplies, and electric vehicles, lowering gas emissions per person is a tremendous success. It saves energy, lowers expenses, and improves user comfort. The displays and estimates power consumption based on the price of net-purchased energy, the amount the user sells to the net in real-time, the amount of energy generation from renewable energy sources, switched on / off devices, and the quantity of energy used by each device, among other factors. Furthermore, it visualises and tracks its energy "from generation through consumption, to the expenses and revenues of household energy" and offers energy-saving tips to users.

III. Results And Discussion

These results are simulated in Matlab and discussed in this chapter (2015). On the basis of performance, we determine which algorithm is the best. To demonstrate the correctness and efficiency of our suggested work. For single and numerous smart homes, we ran simulations to optimise the planning. It was therefore decided that in the heuristic techniques, it was necessary to include the average of 20 runs as a crucial variable. 12 smart gadgets with the same life, including 30 intelligent homes, are part of our design for separate households and structures (i.e., length of time, power rating). All units (appliances) used in our simulations are listed in the table below, along with their parametric parameters. Because they are unscheduled and operate at a specific time, non-deferrable devices are not included in the load management process. The operating schedule consists of 24 time slots per day, from 8 a.m. until 8 a.m. the next morning. On the basis of electricity costs, hourly consumption costs, PARs, and waiting times (described below), the suggested approach is compared to earlier meta-heuristic algorithms. [5-7]

A. Electricity Cost Simulation

A utility's peak demand can be maintained and controlled by implementing TOUs and other demand-side pricing strategies. Compare the cost of energy for scheduled and unscheduled (GA, Cuckoo, MVO) loads in figures 1 and 2, respectively. Using the meta-heuristic approach based on scheduled load, the simulation shows that the cost of the unscheduled load is substantially lower. While unscheduled and unscheduled algorithms have similar results, the MVO-based scheduling has better results in both circumstances.

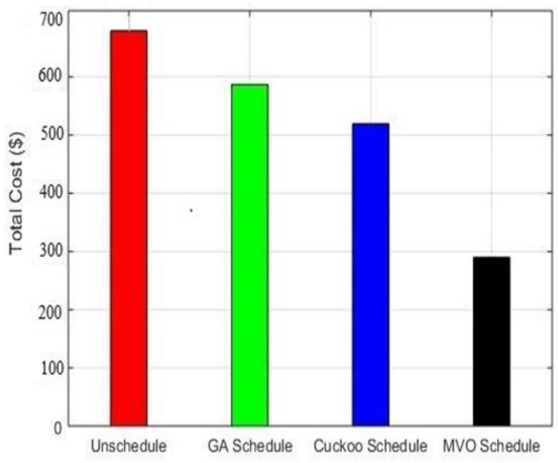

Figure 1: Cost for Single Home

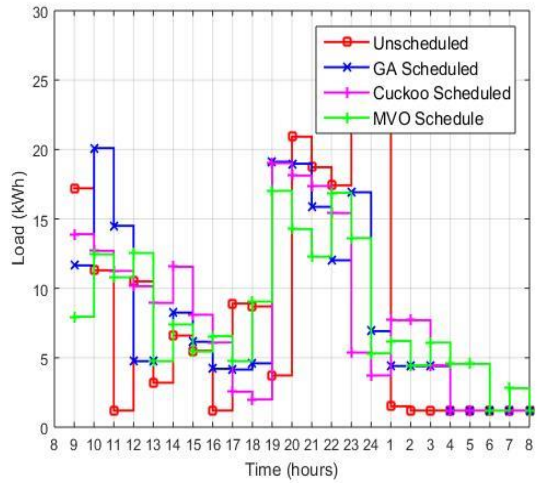

Figure 3:Hourly Consumption of Single Home

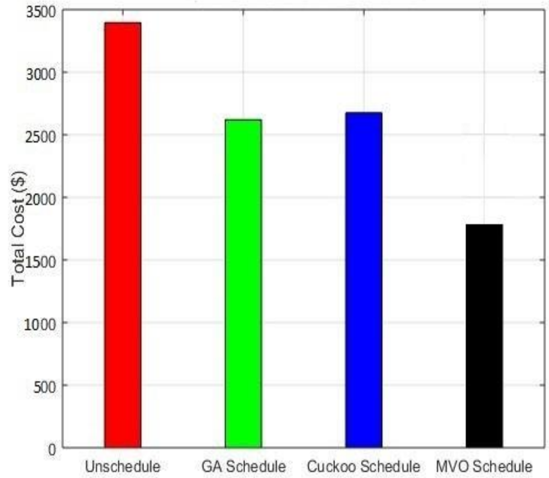

Figure 2: Cost for thirty homes

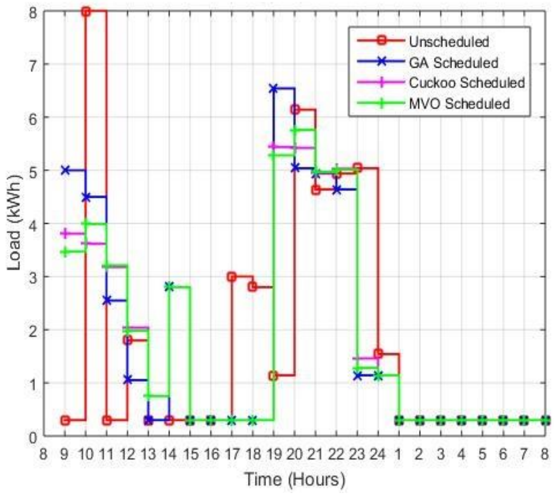

Figure 4: Hourly Consumption for 30 Smart Home

B. HourlyElectricity Consumption

Explain the graph of the consumer's hourly usage of different appliances in Figures 3 and 4. An unscheduled circumstance results in a spike in consumption due to the increasing demand for power. In order to switch the energy usage from Peak-Hour (PH) to OPH, the scheduling algorithms must be calculated first. This means that MVO's scheduled load patterns are reasonably stable and low during high-priced hours. In contrast, the scheduled load pattern for Cuckoo shows a more consistent response.

C. Peak to Average Ratio (PAR)

As the PAR increases or decreases, the grid's stability is impacted. The fall in prices has no effect on the PAR. PAR results employing RTP signals for a single smart home and 30 smart homes are shown in figures 5 and 6. Compared to other scheduling strategies, MVO-scheduled load PAR is less for single smart houses, and Cuckoo is somewhat less for 30 smart homes compared to other techniques. All scheduling strategies are considered in this paper, including MVO – Schedule load, which minimises the PAR. Another optimization method such as Cuckoo and GA are compared to the suggested algorithm PAR.

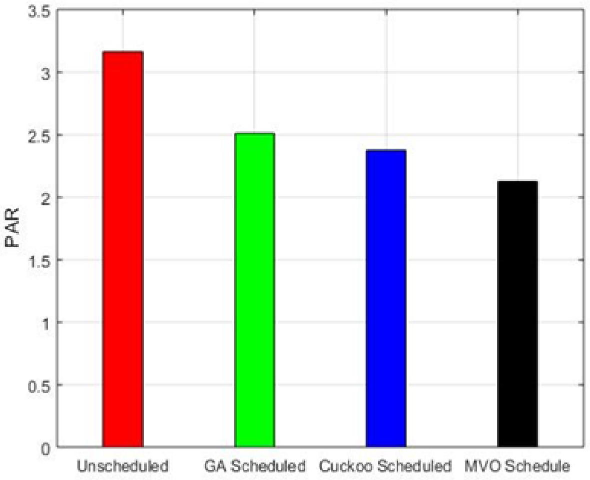

Figure 5: PAR for Single Home

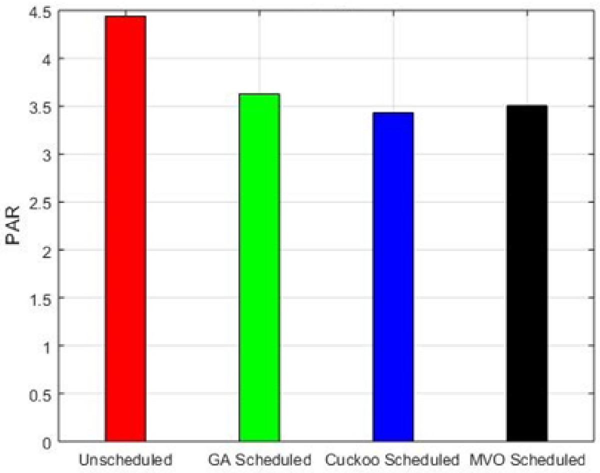

Figure 6: PAR for 30 Smart Homes

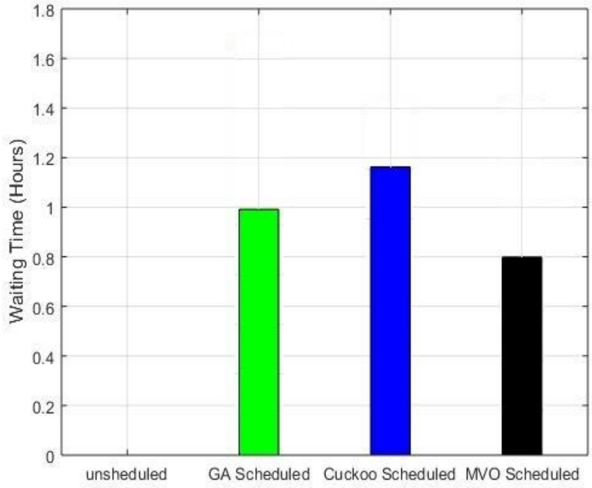

Figure 7: Waiting Time for Single Home

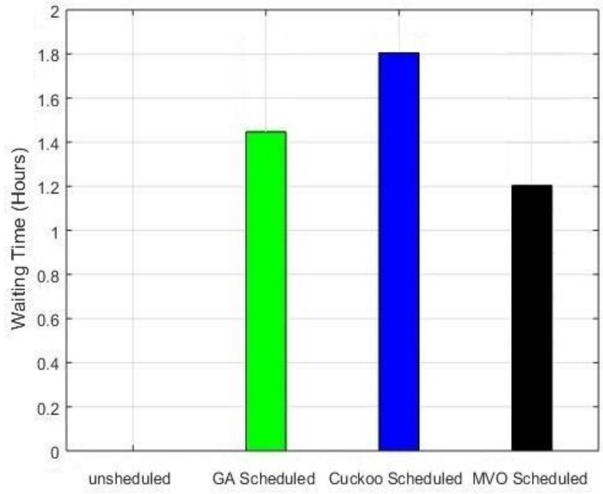

Figure 8: Waiting Time for 30 Smart Home

D. Appliances Waiting Time

Figures 7 and 8 of Single and 30 smart homes illustrate that as prices and PAR fall, the waiting time increases. Because of this, there is a trade-off between the cost of power and waiting time when energy costs are high (user comfort). In cases where a consumer turned on an appliance, but it did not work within the stated time interval, scheduling lowered electricity costs. A specific amount of time T is therefore required of the users in order for them to get their work done. As you can see, MVO's results are far superior to those of alternative scheduling algorithms in both circumstances.

CONCLUSION

These plans have been superimposed on the Demand Side Management Plan for Energy Expansion (DSMEP). MVO and CSA bio-metaheuristic algorithms are used in a real-world scenario to partition a household's power load into multiple units of load and determine the best way to use it. As soon as the cue is received from the providers, they are put in charge of arranging the portable contraptions in relation to their charges, which are escalating day-by-day. As a result, the proposed scheme's execution was compared to the unexpected load based on PAR, total energy consumption and billing data as well as a measure of the user's comfort in terms of time-savings gained. It was determined that the performance of our idea was superior to other well-known algorithms such as GA and Cuckoo Search since it reduced the cost of electricity and had nothing to do with operations by shifting some load to low-demand hours. Retaliation, it reduces utility loads by decreasing PAR and enhancing consumer comfort.

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