International Current Journal of Engineering and Science (ICJES)
Volume 5, Issue 3, pp 1-4, March-2026
ISSN (Online): 2583-7257
Article DOI: https://doi.org/10.47001/ICJES/2026.503001

Intelligent Load Demand Management in a Smart Grid Environment

[1]C. Deepa Venkat, [2]D. Karpagam

[1,2]Cyber Security Department of Cyber Security, SRM Institute of Science and Technology, Trichy, Tamilnadu, India

Abstract **- Now a days, energy saving is one of the most important issue for development of smart grid. The utility companies have higher electric charge during peak periods, so smart grid emphasizes off-peak energy consumption. The Intelligent Load Management system (ILMS) shall play a very important role in realizing residential demand response in smart grid environment. Therefore, the ILMS system with Demand Response (DR) is proposed, in which different loads are used and corresponding priority is adjusted based on priority of user. The controller board is used, which makes a decision to switch ON/OFF action of the selected end use appliances based on utility signal as well as home owners load priority and preference setting. It also demonstrates that how each appliance will perform when it will be controlled by Intelligent Load Management System ILMS. The proposed system is also responsible for collecting electrical consumption data from all loads and provides an interface for homeowner to retrieve appliances status. It provides user to know the status of appliances though LCD display.**

Keywords: Smart Grid, Load Demand Management, Intelligent Energy Management, Demand Response, Smart Energy Systems, Power Load Optimization.

I. INTRODUCTION

Nowadays, Utility companies across the world have taken various steps for efficient consumption of electricity. The process of observing, controlling and conserving electricity usage in an organization/ building is known as energy management or home energy management. It has been reported that 40% of the global power consumption takes place inside residential buildings. Home Energy Management systems are usually called smart grid systems. This allows for direct communication between the utility company and the consumer. The energy management system optimizes the energy usage by informing the customer on a live basis of their corresponding consumption rates. Utility companies have higher electric charges during peak periods, so the smart grid emphasizes off peak energy consumption. The employment of ILMS systems in a residential area reduces energy bills for consumers and peak demands. A ILMS system in smart grid enables Demand Response (DR) and Demand Side Management (DSM) programs. Demand response (DR) is defined as “changes in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use are at times of high wholesale market prices` or when system reliability is jeopardized”. The DR action can be either incentive-based (e.g., direct load control) or time- based (e.g., dynamic pricing, critical peak pricing) program. The concept of proposed ILMS system is based on this topic while taking into account homeowner’s load priority and comfort preference. DR programs help in managing and varying electricity consumption on electricity supply basis.

The maximum consumption of energy is caused by inefficient use on consumer side. In recent years many ILMS systems are proposed to reduce energy wastage, Also in existing ILMS systems the load controllers are incapable to gather electrical consumption data from selected appliances and perform local control based on demand response signal sent by controller board. The Home Energy Management system shall play a very important role in realizing residential demand response in smart grid environment.

This dissertation is motivated by several rising applications of smart grid. Traditionally, over the past several decades, electric power systems have encountered more frequent stress condition due to ever increasing electricity demand, inefficient use of electric power generation and transmission resources. Transmission line outages have been a common cause of system stress conditions, which are possible to occur during critical peak hours. Such events will cause a supply limit situation where cascading failures and large area blackouts are possible. These problems have partially tackled by demand side management. Demand Response (DR) has been envisioned to deal with such unexpected supply limit events by selectively reducing system loads. DR also plays an important role in load shifting from peak hours to off peak hours that can help to increase reliability and efficiency in operation.

International Current Journal of Engineering and Science (ICJES)
Volume 5, Issue 3, pp 1-4, March-2026
ISSN (Online): 2583-7257
Article DOI: https://doi.org/10.47001/ICJES/2026.503001

II. PROPOSED SYSTEM

The concept of the proposed system is to design and developed the intelligent home energy management system with user friendly interface including monitoring and control functionalities for the home owner and load controllers that gather electrical consumption data from the appliances and perform local control based on Demand Response (DR) by using controller board.

A distribution board and meter can be used to provide an interface between utility and home owner in a real life environment. ILMS receives external signal, which includes demand curtailment request and duration, its algorithm is designed to guarantee the total power consumption below the specified demand limit level during the specified duration. The proposed ILMS algorithm allows the home owner to operate their appliances when needed as long as the total household consumption remains below the specified limit during a DR event In proposed system, current sensors are used to monitor power levels of each loads and the LCD display is used to monitor and relay to control appliances status and power consumption.

III. BLOCK DIAGRAM & CIRCUIT DIAGRAM

Block Diagram

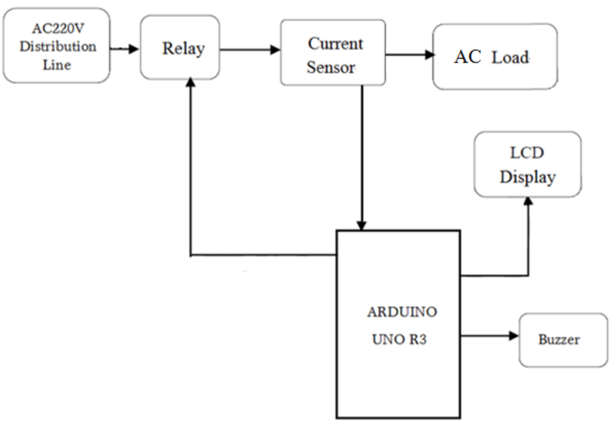

Figure 1: Block diagram

Block Diagram Description

An ILMS system plays a crucial role in achieving automated DR within a house, as most residential customers do not have time, nor proactive enough to perform DR manually. A DR event is defined as a period during which the customer demand needs to be curtailed to alleviate a system stress condition. Customers who participate in a DR program can be informed of a DR event by an external signal from a utility via their smart meters. Different loads are used in this project and the corresponding priority is adjusted based on the priority of the loads.

The controller board makes a decision to switch ON/OFF selected end-use appliances based on the utility signal received, as well as homeowners load priority and preference settings. Arduino uses current sensors and relay to control and monitor the appliances status and power consumption

A load controller provides an interface between the HEM unit and a selected appliance. A control module(gateway), which is simply an electronic relay circuit that provides the capability to switch a selected appliance ON/OFF, depending on the command sent by the HEM unit or user. A communication module, which is responsible for providing communication paths between a load.

Circuit Diagram

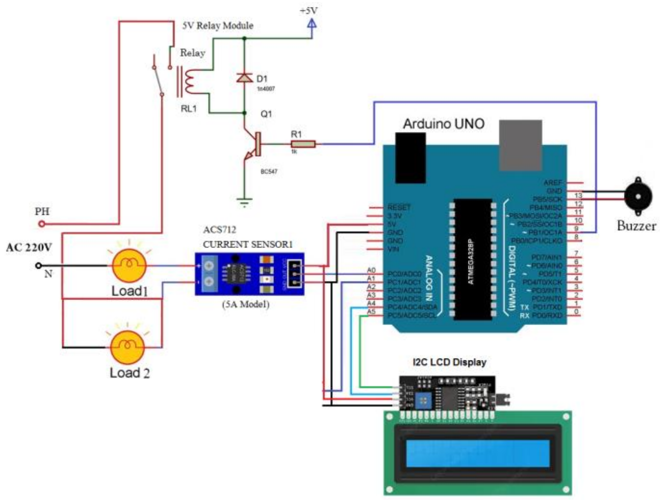

Figure 2: Circuit diagram

Circuit Diagram Description

Here Arduino UNO R3 microcontroller is the main controlling unit of the hardware system. Power flow through the different load sections are measured by using ACS712 current sensors. It converts AC current value into a equivalent analog dc voltage output. ATMega328 microcontroller in the Arduino board has the necessary program loaded into its flash memory which functions and performs input and output operations. The current values are calculated by the microcontroller by reading analog voltages from each sensor through ADC pins. Read analog voltage is converted into digital values from 0-255 from the input analog voltage ranging from 0 to 5v. For each milliamp a 0.1 v is produced and incremented or decremented according the current flow through the ac load. Finally the current value is calculated and

Volume 5, Issue 3, pp 1-4, March-2026
ISSN (Online): 2583-7257
Article DOI: https://doi.org/10.47001/ICJES/2026.503001

the measured load current though each section is displayed in the 16 x 2 LCD module. The power limit is set for each load sections in the Arduino program. Each time the read load current value is compared to the set value in program. If the value of set limit is exceeded an alarm is produced and then the power is cut off to that section automatically. If the excess load is switched off manually then the power is reconnected. Thus the power to load is always maintained below the maximum allowed limit, therefore demand is maintained below maximum value and over loading of the power line is prevented.

IV. RESULTS AND DISCUSSION

The results obtained from the proposed Intelligent Load Demand Management system in a Smart Grid Environment demonstrate significant improvements in energy utilization and load balancing across the grid. The system was tested under different load conditions using simulated household and industrial energy consumption data. The intelligent control algorithm continuously monitored the load demand through smart meters and analyzed the consumption patterns in real time. Based on the predicted demand, the system efficiently redistributed electrical loads during peak hours by prioritizing essential loads and delaying non-critical appliances. The experimental results show that peak load demand was reduced considerably, leading to improved grid stability and reduced stress on power generation units.

Further analysis indicates that the integration of intelligent algorithms enhances the responsiveness of the smart grid system. During peak demand periods, the system automatically triggered demand response actions, which resulted in a noticeable reduction in overall power consumption. Load forecasting accuracy improved due to the use of historical consumption data and real-time monitoring. The system also demonstrated faster decision-making capability in managing distributed energy resources such as renewable energy sources and storage systems. As a result, energy wastage was minimized and the efficiency of the grid was significantly improved.

In addition, the proposed system contributes to better energy management and sustainability. The intelligent load management approach ensures that electricity is supplied more efficiently while maintaining user comfort and operational reliability. The results indicate that implementing such intelligent control mechanisms can reduce operational costs for utility providers and improve energy availability for consumers. Overall, the study confirms that intelligent demand management techniques play a crucial role in the development of modern smart grids by improving reliability, optimizing load distribution, and supporting the integration of renewable energy resources.

V. CONCLUSION

The Intelligent Load Management system with demand response plays a most important role in effectively managing the wastage of energy on consumer side. This project presents a new design to control power consumption of appliances at home. The proposed Home Energy Management system for demand response applications which can proactively and effectively control and manage the appliance operation to keep the total household consumption below a specified demand limit by managing selected power-intensive loads according to their priority. The proposed energy management system takes into account both load priority and user preferences.

REFERENCES

[1] Fang Xing, Misra Satyajayant, Xue Guoliang, and Yang Dejun, “Smart Grid – The New and Improved Power Grid: A Survey,” IEEE Communications Surveys & Tutorials, vol. 14, no. 4, pp. 944–980, 2012.

[2] Amin Massoud and Wollenberg Bruce, “Toward a Smart Grid: Power Delivery for the 21st Century,” IEEE Power and Energy Magazine, vol. 3, no. 5, pp. 34–41, 2005.

[3] Palensky Peter and Dietrich Dietmar, “Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads,” IEEE Transactions on Industrial Informatics, vol. 7, no. 3, pp. 381–388, 2011.

[4] Gungor Vehbi C., Sahin Dilan, Kocak Taskin, Ergüt S., Buccella Cosimo, Cecati Carlo, and Hancke Gerhard, “Smart Grid Technologies: Communication Technologies and Standards,” IEEE Transactions on Industrial Informatics, vol. 7, no. 4, pp. 529–539, 2011.

[5] Vishwa Chetanbhai Lakhnakiya. (2025). Cognitive CloudOps: Integrating Generative AI for Predictive Infrastructure Management and Self-Optimizing DevOps Pipelines. International Current Journal of Engineering and Science (ICJES), 4(9), 30-38. Article DOI: https://doi.org/10.47001/ICJES/2025.409006

[6] Ali Khaled Alshurmani, Taha Mahmoud Radman, & Mohammed Fadhl Abdullah. (2026). IoT-Based Overcurrent Protection in Substations: A Case Study of New Enma Substation, Aden. International Research Journal of Innovations in Engineering and Technology - IRJIET, 10(1), 103-112. Article DOI https://doi.org/10.47001/IRJIET/2026.101012

[7] Mohsenian-Rad Amir-Hamed, Wong Vincent, Jatskevich Juri, Schober Robert, and Leon-Garcia Alberto, “Autonomous Demand-Side Management

Volume 5, Issue 3, pp 1-4, March-2026
ISSN (Online): 2583-7257
Article DOI: https://doi.org/10.47001/ICJES/2026.503001

Based on Game-Theoretic Energy Consumption Scheduling for the Future Smart Grid," IEEE Transactions on Smart Grid, vol. 1, no. 3, pp. 320–331, 2010.

[8] Gellings Clark W., "The Concept of Demand-Side Management for Electric Utilities," Proceedings of the IEEE, vol. 73, no. 10, pp. 1468–1470, 1985.

[9] Strbac Goran, "Demand Side Management: Benefits and Challenges," Energy Policy, vol. 36, no. 12, pp. 4419–4426, 2008.

[10] Conejo Antonio J., Morales Juan M., and Baringo Luis, "Real-Time Demand Response Model," IEEE Transactions on Smart Grid, vol. 1, no. 3, pp. 236–242, 2010.

[11] Kailas, V. Cecchi, and A. Mukherjee, Kailas, Aravind, Valentina Cecchi, and Arindam Mukherjee. "A survey of communications and networking technologies for energy management in buildings and home automation." Journal of Computer Networks and Communications 2012 (2012).

[12] Ullah, M. N., et al. "A Survey of Different Residential Energy Consumption Controlling Techniques for Autonomous DSM in Future Smart Grid Communications." arXiv preprint arXiv:1306.1134 (2013).

[13] M. A. Piette, D.Watson, N.Motegi, S. Kiliccote, and E. Linkugel, "Automated demand response strategies and commissioning commercial building controls," in Proc. 14th Natl. Conf. Building Commissioning, San Francisco, CA, Apr. 2006.

[14] D. Han and J. Lim, "Design and implementation of smart home energy management systems based on ZigBee," IEEE Trans. Consum. Electron., vol. 56, no. 3, pp. 1417–1425, 2010.

[15] Khaled Hassan Balhaf, Manal Abdul Aziz Al-Nahari, Alwiyah Ahmed Balhaf, Manal Omar Bawazir, Adnan Swailem Ba'adil, & Mohammed Fadhl Abdullah. (2026). A Hybrid Framework for Medical X-ray Image Enhancement and Segmentation Using K-Means, Fuzzy C-Means, and Fuzzy Connectivity. International Research Journal of Innovations in Engineering and Technology - IRJIET, 10(2), 1-8. Article DOI https://doi.org/10.47001/IRJIET/2026.102001

[16] Y. S. Son, T. Pulkkinen, K. Y. Moon, and C. Kim, "Home energy management system based on power line communication," IEEE Trans. Consum. Electron., vol. 56, pp. 1380–1386, 2010.

[17] J. Li, J. Y. Chung, J. Xiao, J.W. Hong, and R. Boutaba, "On the design and implementation of a home energy management system," in Proc. 6th Int. Symp.Wireless Pervasive Comput. (ISWPC), Feb. 23–25, 2011, pp. 1–6.

Citation of this Article:

C. Deepa Venkat, & D. Karpagam. (2026). Intelligent Load Demand Management in a Smart Grid Environment. *International Current Journal of Engineering and Science (ICJES)*, 5(3), 1-4. Article DOI: https://doi.org/10.47001/ICJES/2026.503001

****