

REVIEW ARTICLE

Efficient Energy Management: Practical Tips for Household Electricity Conservation

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Abstract

This article outlines strategies for conserving electricity in residential settings. The focus is on simple yet impactful actions that homeowners can take to reduce energy consumption and lower utility bills. Suggestions include transitioning to LED (Light Emitting Diode) lighting, unplugging electronics when not in use, and investing in energy-efficient appliances bearing the Energy Star label. Optimizing HVAC (heating, ventilation, and air conditioning) systems through regular maintenance and utilizing programmable thermostats also proves beneficial. By implementing these measures, households can contribute to both financial savings and environmental sustainability.

Keywords: Electricity Conservation, LED Lighting, Energy Efficiency, HVAC Optimization.

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1. Introduction

In an era marked by burgeoning energy demands and environmental concerns, the imperative for energy conservation has become more pronounced than ever before. Within this context, the focus on energy-saving measures at the household level emerges as a critical avenue for mitigating environmental degradation, reducing carbon emissions, and fostering sustainable living practices. This paper delves into the significance of energy conservation in domestic settings, highlighting the pivotal role it plays in mitigating climate change and promoting resource efficiency.

1.1. The significance of conserving energy within residential settings:

Energy consumption within households constitutes a substantial portion of overall energy usage in many regions worldwide [1], [2]. From lighting and heating to powering electronic devices, the array of energy-intensive activities in homes underscores the significance of adopting energy-saving practices. The repercussions of excessive energy consumption extend beyond mere economic burdens, encompassing environmental degradation and societal ramifications. Addressing this issue necessitates a multifaceted approach that incorporates awareness-raising, policy interventions, and individual behavioral changes.

At a fundamental level, energy conservation in homes translates into reduced carbon emissions and environmental impact. The electricity generated through conventional means such as coal-fired power plants contribute significantly to

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greenhouse gas emissions, exacerbating climate change. As mentioned in [3], [4], by curbing energy consumption through efficiency measures, households can mitigate their carbon footprint and contribute to global efforts aimed at combating climate change.

Moreover, energy-saving initiatives in homes offer tangible economic benefits for individuals and communities alike. By reducing energy consumption, households can lower their utility bills, freeing up financial resources for other purposes. This economic relief is particularly significant for low-income households, for whom energy costs may constitute a substantial portion of their expenses. Additionally, energy efficiency improvements can enhance the overall value of residential properties, offering long-term financial returns for homeowners.

1.2. *Harnessing renewable energy sources:*

Central to the discourse on energy conservation is the exploration and utilization of renewable energy sources. Unlike finite fossil fuels, renewable energy derives from naturally replenishing sources such as sunlight, wind, and water, offering a sustainable alternative to conventional energy sources. Within the realm of household energy consumption, the harnessing of renewable energy presents promising opportunities for reducing reliance on non-renewable resources and mitigating environmental impact.

One of the most readily available renewable energy sources for households is sunlight [5]- [7]. Solar energy technologies, such as photovoltaic panels and solar water heaters, enable homeowners to harness the abundant energy radiated by the sun for electricity generation and water heating [8]. By investing in solar power systems, households can not only reduce their dependence on grid-supplied electricity but also benefit from long-term cost savings and energy independence.

Furthermore, solar energy holds immense potential for addressing energy poverty in underserved communities, particularly in remote or off-grid areas. Off-grid solar systems provide a reliable source of electricity to households without access to centralized power grids, empowering communities with clean and sustainable energy solutions. The proliferation of solar energy technologies also fosters job creation and economic development opportunities, driving innovation and growth in the renewable energy sector.

In addition to solar energy, other renewable sources such as wind and hydropower offer viable alternatives for household energy generation. Small-scale wind turbines can harness the kinetic energy of the wind to generate electricity, particularly in areas with consistent wind patterns [9]. Similarly, micro-hydropower systems utilize flowing water to generate electricity, making them suitable for properties located near streams or rivers. By diversifying the sources of energy production and embracing renewable technologies, households can reduce their environmental footprint and contribute to the transition towards a sustainable energy future.

- The research highlights the effectiveness of simple actions such as transitioning to LED lighting [10], unplugging electronics, and investing in Energy Star appliances in reducing energy consumption and lowering utility bills in residential settings.
- Furthermore, it underscores the importance of optimizing HVAC systems through regular maintenance and utilizing programmable thermostats to achieve both financial savings and environmental sustainability [11].

2. Methodology

2.1. *Switch to LED light bulbs:*

Switching to LED (light-emitting diode) light bulbs presents a straightforward and impactful opportunity to enhance energy efficiency within homes, businesses, and various other settings. Unlike traditional incandescent bulbs, LED bulbs consume substantially less electricity while offering significantly longer lifespans. This combination of reduced energy consumption and extended longevity not only yields immediate cost savings but also contributes to environmental sustainability by mitigating energy waste and reducing carbon emissions.

LED technology operates by producing light through the movement of electrons within a semiconductor material, resulting in minimal heat generation compared to incandescent bulbs. This inherent efficiency allows LED bulbs to convert a higher percentage of electricity into light, while wasting less energy in the form of heat. Consequently, LED bulbs can produce the same level of brightness as incandescent bulbs while consuming only a fraction of the electricity.

Moreover, the lifespan of LED bulbs far exceeds that of traditional incandescent bulbs. While incandescent bulbs typically last around 1,000 hours, LED bulbs can endure for tens of thousands of hours before requiring replacement. This longevity not only reduces the frequency of bulb replacements but also minimizes the associated maintenance costs and waste generation.

Beyond the direct benefits to consumers, the widespread adoption of LED lighting holds profound implications for energy conservation and environmental stewardship. By transitioning to LED bulbs on a large scale, communities can collectively reduce electricity demand, alleviate strain on power grids, and diminish reliance on fossil fuels for electricity generation. Additionally, the decreased energy consumption associated with LED lighting contributes to lower greenhouse gas emissions, thereby aiding global efforts to combat climate change.

In essence, the switch to LED light bulbs represents a fundamental step towards achieving a more sustainable and energy-efficient future. Through their remarkable energy savings, extended lifespan, and environmental advantages, LED bulbs offer a compelling solution to enhance illumination while simultaneously reducing environmental impact and operating costs.

As shown in Figure 1, LED lights offer energy savings of up to 90% when compared to traditional light bulbs. For instance, a 100-watt incandescent bulb can be substituted with a 9-watt LED bulb while providing equivalent light output. Typically, an LED light bulb consumes approximately 10 watts, significantly less than the approximately 60 watts used by most incandescent bulbs.

During this timeframe, there has been a significant surge in the adoption of LEDs across India. Illustrated in the accompanying Figure 2, the market share of LEDs (depicted by the yellow line) experienced a substantial increase, soaring from a mere 0.3% to a noteworthy 46%. This growth has outpaced that of incandescent (depicted in blue), CFL (orange), and Tubelight (green) lamps, with LED sales surpassing them all by 2018. This remarkable expansion in LED usage can be attributed to its proven energy-saving benefits and heightened efficiency.

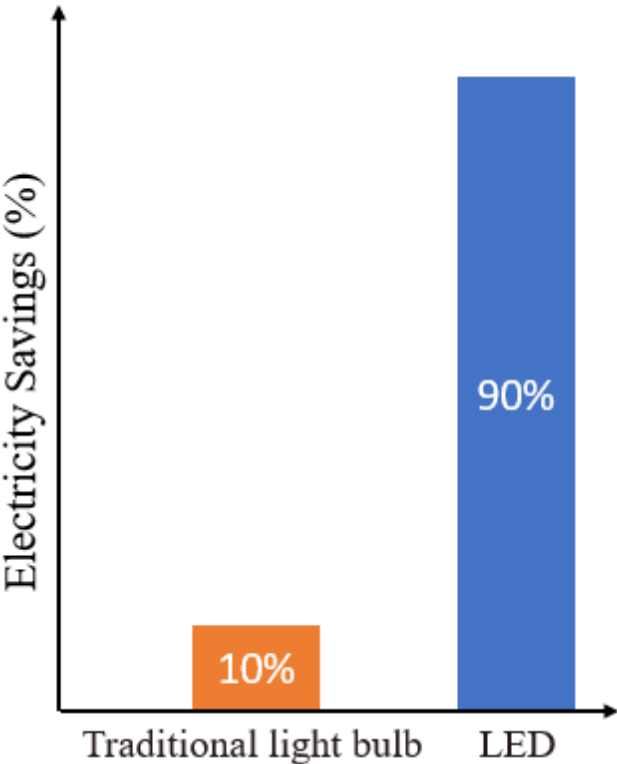


Figure 1: Savings of LED light compared to traditional light bulbs.

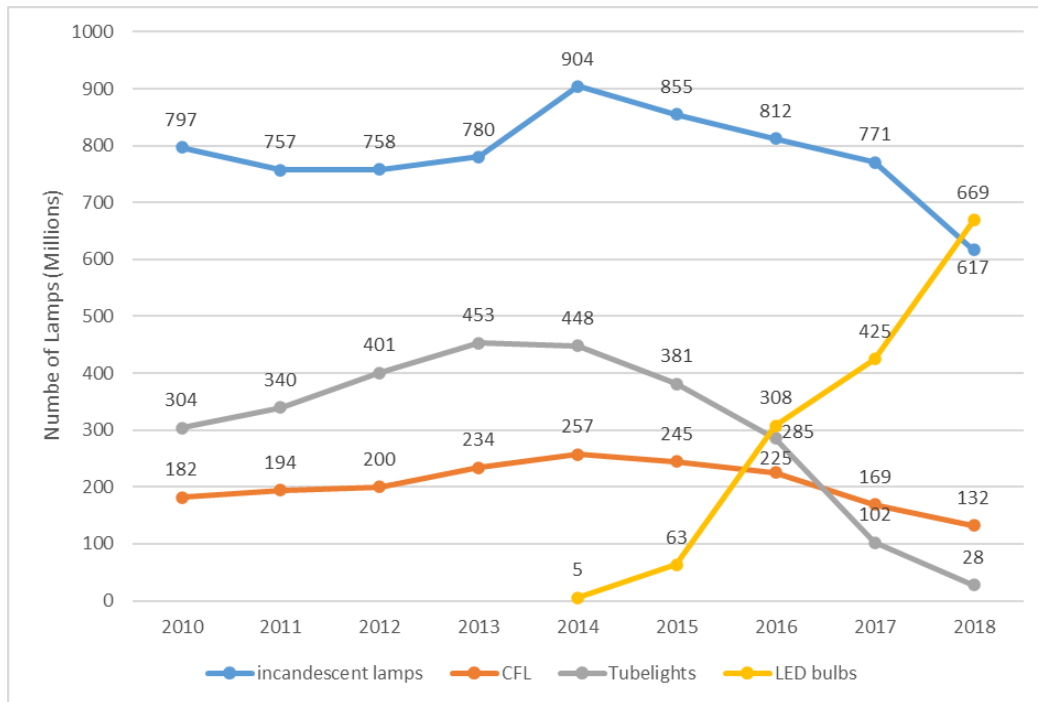


Figure 2: Current trends in the lighting industry in India.

2.2. Unplug electronics when not in use:

Unplugging electronics when they're not in use is a simple yet powerful strategy for conserving energy and reducing electricity bills. Many electronic devices continue to draw power even when switched off or in standby mode, a phenomenon commonly referred to as standby power or vampire power. While each individual device may only consume a small amount of energy in standby mode, the cumulative impact across multiple devices can be significant. By unplugging electronics or utilizing power strips to easily disconnect several devices at once, consumers can effectively eliminate standby power consumption and maximize energy efficiency.

The proliferation of electronic devices in modern households has led to a steady increase in standby power consumption. Common culprits include televisions, computers, printers, gaming consoles, chargers, and kitchen appliances. Even seemingly innocuous devices like phone chargers and coffee makers can contribute to standby power consumption if left plugged in when not in use.

Unplugging electronics is a straightforward solution to this issue, requiring nothing more than the conscious effort to disconnect devices when they're not actively being used. Alternatively, power strips equipped with on/off switches offer a convenient way to control multiple devices simultaneously, allowing users to cut off power to entire clusters of electronics with ease. This approach is particularly effective for home entertainment systems, office workstations, and other areas where multiple devices are clustered together. Beyond the immediate benefits of reducing energy consumption and lowering electricity bills, unplugging electronics also contributes to environmental sustainability. By minimizing standby power usage, consumers decrease their carbon footprint and lessen the demand for electricity generated from fossil fuels. This, in turn, helps mitigate climate change and reduces reliance on finite energy resources.

Additionally, unplugging electronics can prolong the lifespan of devices by preventing wear and tear associated with continuous power supply. Over time, this can translate into cost savings by reducing the frequency of repairs and the need for premature replacements.

In summary, Figure 3 unplugging electronics when not in use is a simple yet impactful practice that promotes energy conservation, saves money, and supports environmental sustainability. By adopting this habit in households, businesses, and other settings, individuals can play a meaningful role in reducing energy waste and building a more efficient and sustainable future.

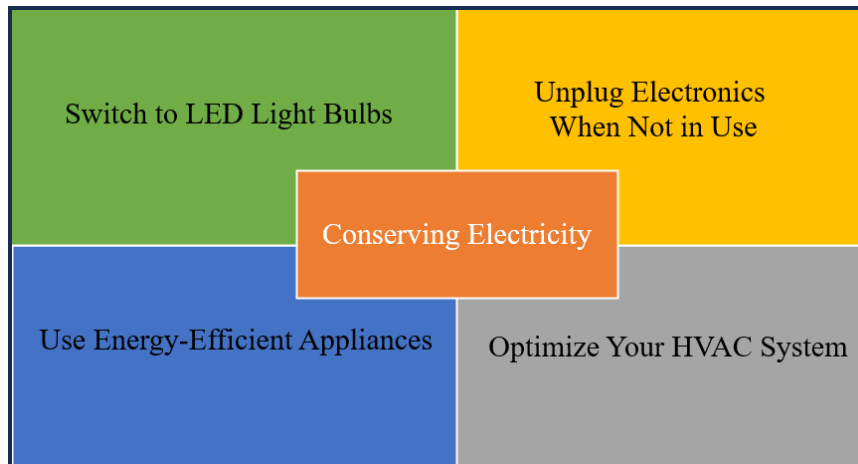


Figure 3: Overview of tips for conserving electricity.

2.3. Energy savings: BLDC motors vs. induction motors in fans:

BLDC (Brushless DC) motor fans save energy over IM (Induction Motor) fans primarily due to their higher efficiency and precise control. Here's how BLDC motor fans achieve energy savings compared to IM fans:

BLDC motor fans save energy over IM fans primarily due to their higher efficiency and precise control. Here's how BLDC motor fans achieve energy savings compared to IM based fans.

- (a). *Higher efficiency*: BLDC motors are inherently more efficient than induction motors. They have lower losses, which means that a greater percentage of the electrical energy consumed is converted into mechanical energy to drive the fan blades. This higher efficiency results in less wasted energy and lower electricity consumption during operation.
- (b). *Precise speed control*: BLDC motors offer precise speed control and can operate efficiently at various speeds. This allows BLDC motor fans to adjust their speed based on the cooling requirements of the space. For example, during times of lower cooling demand, such as when the room is already at the desired temperature, BLDC fans can operate at lower speeds, consuming less energy compared to running at full speed continuously like some induction motor fans.
- (c). *Reduced heat generation*: BLDC motors generate less heat during operation compared to induction motors due to their higher efficiency. This not only improves the lifespan of the motor but also reduces the need for additional cooling mechanisms, saving energy that would otherwise be used for cooling.
- (d). *Lower maintenance costs*: BLDC motors typically have fewer mechanical parts and require less maintenance compared to induction motors. This results in lower maintenance costs over the lifespan of the fan, contributing to overall energy savings.
- (e). *Longer lifespan*: BLDC motors generally have a longer lifespan than induction motors. This means that BLDC motor fans may not need to be replaced as frequently, reducing the energy and resources required for manufacturing and disposal, as well as the associated costs.
- (f). *Regenerative braking*: BLDC motors can be used in regenerative braking systems, where energy is recovered during braking and fed back into the system. While this feature may not be directly applicable to fans, it illustrates another potential avenue for energy efficiency in BLDC motor applications.

As mentioned in Table 1 and from above, BLDC motor fans offer significant energy savings compared to IM fans due to their higher efficiency, precise speed control, reduced heat generation, lower maintenance costs, longer lifespan, and potential for additional energy-saving features. While the initial cost of BLDC motor fans may be higher, the long-term energy savings and other benefits make them a cost-effective choice for many applications.

2.4. Use energy-efficient appliances:

Utilizing Energy Star-labeled appliances, akin to India's BEE (Bureau of Energy Efficiency) labeling system, is pivotal for curbing energy consumption and costs while fostering eco-conscious living. Sponsored by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE), Energy Star certification highlights products meeting

stringent energy efficiency benchmarks. Prioritizing Energy Star models when acquiring appliances—refrigerators, washers, dishwashers, AC units, and water heaters—promotes sustainable practices. These appliances, meticulously scrutinized for adherence to energy efficiency standards, substantially trim utility bills while guaranteeing or surpassing performance benchmarks.

Table 1: Comparison of losses and other important factors between BLDC motors and IM.

Factor	BLDC Motors	Induction Motors
Efficiency	Higher efficiency due to lower losses	Typically, lower efficiency due to losses
Speed Control	Precise speed control at various speeds	Limited speed control options
Heat Generation	Lower heat generation due to higher efficiency	Higher heat generation due to lower efficiency
Lifespan	Longer lifespan due to fewer mechanical parts	Shorter lifespan due to more mechanical parts
Maintenance	Lower maintenance requirements	Higher maintenance requirements
Power Factor	Higher power factor	Lower power factor
Starting Torque	Can provide high starting torque if needed	Typically, lower starting torque
Size	Generally smaller and lighter	Bulkier and heavier
Cost	Higher initial cost, but lower operational costs	Lower initial cost, but higher operational costs
Regenerative Braking	Possible in some configurations	Not typically applicable

The advantages are manifold. Energy Star appliances boast reduced energy consumption, leading to tangible savings over their lifecycle, offsetting initial investment. Furthermore, they substantially curb greenhouse gas emissions, aligning with eco-goals and resource conservation endeavors. Advanced technologies embedded in Energy Star appliances augment performance and longevity, exemplified by energy-efficient refrigerators sporting enhanced insulation and smart controls to optimize energy usage and food preservation.

In essence, embracing Energy Star-certified appliances champions energy efficiency, cost savings, and environmental stewardship. Informed choices in appliance procurement foster sustainability, ushering in a future marked by enhanced performance and diminished environmental footprint.

Table 2: comparison between 3-star AC (Air Conditioner) and 5-star AC.

white Aspect	3-Star AC	5-Star AC
Energy Efficiency Rating	Lower	Higher
Cooling Capacity	Similar	Similar
Power Consumption	Higher	Lower
Annual Electricity Cost	Moderate	Reduced
Initial Cost	Lower	Higher
Lifespan	Similar	Similar
Environmental Impact	Moderate	Lower
Potential Savings	Moderate	Substantial
Performance	Effective, but less energy-efficient	Highly efficient, optimal performance

The Table 2 outlines the differences and potential savings between 3-star and 5-star AC units in terms of energy efficiency, cooling capacity, power consumption, annual electricity cost, initial cost, lifespan, environmental impact, potential savings, and performance.

2.5. Optimize your HVAC system:

Optimizing your HVAC (heating, ventilation, and air conditioning) system through regular maintenance is essential for ensuring optimal performance, energy efficiency, and indoor comfort. HVAC systems play a crucial role in regulating temperature, humidity, and air quality within residential, commercial, and industrial spaces. However, without proper upkeep, these systems can experience reduced efficiency, increased energy consumption, and higher operational costs.

Regular maintenance of HVAC systems involves several key tasks aimed at maximizing performance and longevity. These tasks typically include:

- (a). *Filter replacement:* Regularly replacing air filters is essential for maintaining good indoor air quality and promoting efficient airflow. Clogged or dirty filters restrict airflow, forcing the HVAC system to work harder and consume more energy. By replacing filters according to manufacturer recommendations, typically every 1–3 months, you can ensure optimal performance and reduce strain on the system.
- (b). *Cleaning and inspection:* Periodically cleaning HVAC components such as coils, fans, and ductwork helps prevent dirt, dust, and debris buildup, which can impede airflow and reduce efficiency. Additionally, scheduling routine inspections by HVAC professionals allows for the early detection of potential issues such as leaks, worn parts, or refrigerant deficiencies, preventing costly repairs and downtime.
- (c). *Calibration and adjustment:* Ensuring that HVAC systems are properly calibrated and adjusted can improve efficiency and comfort. This may involve adjusting thermostat settings, balancing airflow in ductwork, or optimizing equipment settings for seasonal changes in temperature and humidity.
- (d). *Sealing and insulation:* Proper insulation and sealing of ductwork, windows, doors, and other openings prevent air leaks and maintain consistent indoor temperatures. By minimizing heat loss or gain, HVAC systems can operate more efficiently and require less energy to maintain desired comfort levels.
- (e). *Upgrade and retrofit:* Consider upgrading older HVAC equipment to more energy-efficient models or retrofitting existing systems with advanced technologies such as programmable thermostats, variable-speed drives, or zoned heating and cooling. These upgrades can significantly reduce energy consumption and improve overall system performance.

By prioritizing regular maintenance and optimization of HVAC systems, property owners can enhance energy efficiency, extend equipment lifespan, minimize operating costs, and ensure a comfortable and healthy indoor environment for occupants. Investing in professional maintenance services and adopting proactive maintenance practices can yield long-term benefits in terms of energy savings, comfort, and system reliability.

3. Conclusion

This research highlights the pivotal role of LED lighting adoption and HVAC optimization in electricity conservation within residential settings. By emphasizing the significance of energy-efficient lighting solutions like LED bulbs and the implementation of HVAC optimization strategies such as routine maintenance and programmable thermostats, homeowners can effectively reduce electricity consumption and lower utility bills. These findings underscore the importance of implementing practical measures for sustainable energy usage, contributing to environmental preservation and cost savings. Further research could explore additional innovative solutions to bolster energy efficiency in residential environments.

Declarations and ethical statements

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CRediT authorship contribution statement

G. V. Mrudu: Conceptualization, Data curation, Methodology, Investigation, Visualization, Writing–Original draft, Review & Editing. **Rohit. G:** Conceptualization, Methodology, Writing–Review & Editing. **Harshavardhan. G:** Data curation, Formal analysis & Visualization. **Dhanush. K:** Validation & Formal analysis. **Anudeep. B:** Conceptualization, Methodology, Validation, Writing–Original draft, Review & Editing.

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References

- [1] Hoshino Y, Yuasa T, Fujino I, Furumura T, Yamada K. Suggestion for simple home network. In *The 1st IEEE Global Conference on Consumer Electronics 2012* 2012 Oct 2 (pp. 741-745). IEEE. Available from: <https://doi.org/10.1109/GCCE.2012.6379971>
- [2] Anudeep B, Nayak PK. Transient energy-based combined fault detector and faulted phase selector for distribution networks with distributed generators. *International Transactions on Electrical Energy Systems*. 2020 Apr;30(4):e12288. Available from: <https://publons.com/publon/10.1002/2050-7038.12288>
- [3] Yang M, Yu X. Energy-efficient technologies. In *Energy Efficiency: Benefits for Environment and Society*. 2015 Feb 22 (pp. 113-126). London: Springer London. Available from: https://doi.org/10.1007/978-1-4471-6666-5_10
- [4] Ahvenniemi H, Häkkinen T. Households' potential to decrease their environmental impacts: A cost-efficiency analysis of carbon saving measures. *International Journal of Energy Sector Management*. 2020 Jan 9;14(1):193-212. Available from: <https://doi.org/10.1108/IJESM-02-2019-0009>
- [5] Anudeep B, Nayak PK. Differential power based selective phase tripping for fault-resilient microgrid. *Journal of Modern Power Systems and Clean Energy*. 2021 Mar 9;10(2):459-70. Available from: <https://doi.org/10.35833/MPCE.2020.000194>
- [6] Anudeep B, Nayak PK, Biswas S. An Improved Protection Scheme for DFIG-Based Wind Farm Collector Lines. *Electric Power Systems Research*. 2022;211:108224. Available from: <https://doi.org/10.1016/j.epsr.2022.108224>
- [7] Anudeep B, Salomons E, Housh M. An optimization model for simultaneous design and operation of renewable energy microgrids integrated with water supply systems. *Applied Energy*. 2024;361:122879. Available from: <https://doi.org/10.1016/j.apenergy.2024.122879>
- [8] Irfan M, Deilami S, Huang S, Veettil BP. Rooftop solar and electric vehicle integration for smart, sustainable homes: A comprehensive review. *Energies*. 2023 Oct 25;16(21):7248. Available from: <https://doi.org/10.3390/en16217248>
- [9] Adnan WM, Aziz AB, Raya LB. Feasibility study of wind power generation system using small scale wind turbines. In: *2022 IEEE 10th Conference on Systems, Process & Control (ICSPC)*. 2022 Dec 17 (pp. 166-169). IEEE. Available from: <https://doi.org/10.1109/ICSPC55597.2022.10001785>
- [10] Cowan K, Daim T. Adoption of energy efficiency technologies: A review of behavioral theories for the case of LED lighting. Research and technology management in the electricity industry: Methods, tools and case studies. 2013 Jun 26:229-48. Available from: https://doi.org/10.1007/978-1-4471-5097-8_10
- [11] Kim D, Lee J, Do S, Mago PJ, Lee KH, Cho H. Energy modeling and model predictive control for HVAC in buildings: A review of current research trends. *Energies*. 2022 Oct 1;15(19):7231. Available from: <https://doi.org/10.3390/en15197231>