World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

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Improving energy efficiency

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World Journal of Advanced Research and Reviews, 2024, 24(03), 2254-2257

Publication history: Received on 10 November 2024; revised on 21 December 2024; accepted on 23 December 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.24.3.3899

Abstract

This paper discusses strategies for improving energy efficiency, focusing on the adoption of high-efficiency electrical devices and minimizing unnecessary electricity consumption across residential, public, and industrial areas. The study highlights the importance of selecting energy-efficient devices, utilizing modern technologies in lighting systems, and optimizing the use of industrial motors and transformers. Additionally, it explores demand-side management (DSM) techniques such as load curve modification, energy storage, and the potential of new energy sources like wind, solar, and tidal power. The paper concludes by emphasizing the need for effective energy management through DSM to reduce energy consumption, enhance power quality, and achieve sustainable economic and environmental benefits.

Keywords: Energy efficiency; Electricity consumption; Demand-side management; Load curve modification; Energy storage; Sustainable energy management

1. Introduction

The growing demand for energy, coupled with the increasing need to reduce energy consumption and its environmental impact, has made energy efficiency a central focus for both developed and developing nations [1]. As the global economy continues to expand, energy use, particularly electricity consumption, is expected to rise sharply. This presents significant challenges in balancing the supply and demand of electricity, reducing operational costs, and mitigating environmental concerns such as carbon emissions [2,3].

Energy efficiency is widely recognized as a key solution to addressing these challenges. By improving the performance of electrical devices and systems, it is possible to achieve substantial energy savings and lower operational costs. This includes adopting high-efficiency devices, optimizing industrial processes, and minimizing unnecessary electricity consumption. Additionally, advancements in energy management technologies such as smart lighting, energy storage, and demand-side management (DSM) have shown promising results in reducing energy waste and enhancing system reliability [4].

In this context, this paper explores various strategies to improve energy efficiency, emphasizing the importance of selecting and utilizing high-performance electrical devices in residential, public, and industrial settings. It also investigates DSM techniques designed to manage electricity demand, such as modifying load curves, implementing energy storage systems, and integrating renewable energy sources. These approaches, when effectively applied, can significantly contribute to energy conservation, economic growth, and environmental sustainability.

By focusing on the adoption of energy-efficient practices and technologies, this study aims to provide a comprehensive understanding of how to optimize energy consumption across different sectors, with the goal of achieving long-term energy savings and a greener future for society.

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2. Solutions to improve energy efficiency

2.1. Using high-efficiency devices

With the rapid development of science, high-efficiency devices that consume less electricity, have longer lifespans, and are not too expensive have been developed. Our country's economy has undergone significant changes and improvements, with the increasing use of electrical devices, so choosing high-efficiency devices will result in great economic benefits [5].

Electrical devices come in two forms: household electrical devices and industrial electrical devices [6]. *Household electrical devices* are used in residential areas, offices, and administrative areas. These include lights, fans, televisions, refrigerators, air conditioners, water heaters, induction cookers, microwaves, washing machines, rice cookers, and irons. Among them, devices that use a lot of electricity and consume energy frequently should be the focus of improving energy efficiency, such as lights, TVs, refrigerators, rice cookers, irons, and washing machines.

In developing countries, lighting accounts for a significant portion of electricity usage. Therefore, energy-saving lighting devices are being manufactured using new technologies, offering quick return on investment and economic benefits.

Industrial electrical devices: Electric motors are major consumers of electricity in industry. In many developing countries, the use of squirrel-cage induction motors is still widespread. These motors are simple, inexpensive, and easy to maintain, but they have low efficiency and low power factor, which results in lower energy efficiency.

New generation motors have been improved by increasing the core cross-section, using low-loss core materials, and using low-resistance winding wire with large diameter. As a result, the payback time and the power output of the motors are optimized, resulting in high efficiency. To implement the use of high-efficiency electrical devices, we need to focus on:

- Tracking updates on electrical device manufacturing technology.
- Establishing a system for assessing and testing quality.
- Providing information and communication to help customers select and use high-efficiency devices, including assisting customers.

2.2. Minimizing the use of unnecessary electricity

Reducing unnecessary electricity consumption can be divided into three main areas:

- Residential areas: This includes private homes and apartment buildings.
- Public areas: Offices, shopping centers, government agencies, schools, hospitals, hotels, etc.
- Industrial areas.

In residential areas, electricity is mainly used for lighting and household devices. By selecting high-efficiency electrical devices that meet electricity usage needs and limiting the unnecessary use of devices, a significant amount of energy can be saved.

To achieve this goal, auxiliary devices like automatic power cut-off systems, automatic light dimming, and automatic disconnection of water heaters when not in use can be installed. Additionally, designing homes to maximize natural light helps reduce lighting and fan usage. In apartment buildings, adjusting the load when electricity is not needed can also reduce consumption. In public areas, attention should be given to the design of buildings to minimize energy consumption in lighting systems. Cooling and heating may not significantly contribute. The use of large-power lights for advertising should also be minimized.

In industrial areas, energy-saving measures are diverse and effective with low cost [7].

- Design and construct workshops.
- Arrange production plans reasonably to minimize the operation of high-power devices like grinders, water pumps, air compressors during peak hours. Devices should not run idle.
- Turn off unnecessary lights and electrical devices during production breaks.
- Reactive power compensation to improve power factor.

- Transformers
    - Select transformers with appropriate capacity.
    - Distribute transformer loads efficiently.
    - Disconnect transformers when not in use to prevent losses in coils.
    - Improve the power factor of the grid.
- Electric motors
    - Maintain a regular maintenance and servicing plan.
    - Avoid or limit operations at low or no load.
    - Use motors with suitable capacity.
    - Install capacitors to adjust the power factor.
    - Use energy-efficient motors.
    - Use speed control devices (inverters).
- Lighting systems
    - Use devices to set times and control light intensity.
    - Use efficient light shades.
    - Improve room parameters.
    - Use uneven lighting methods.
    - Maximize natural light.
    - Regularly maintain lighting systems.

2.3. Demand-side Management (DSM)

2.3.1. Changing the load curve

The goal is to flatten the load curve of the power system to reduce losses and create the most economical operating method.

- Peak shaving reduces the system load during peak hours to reduce the need for increased power generation, minimizing energy loss and improving power quality.
- Filling the valley increases load during off-peak hours using low-cost fuel-generated power. This increases total energy consumption without increasing peak power.
- Load shifting moves the peak load to off-peak hours. This reduces peak power but does not change total energy consumption. Common applications include shifting energy-storing devices to off-peak hours.
- Conservation involves reducing energy consumption by improving device efficiency.
- Strategic load increase involves adding new customers, increasing both peak capacity and total energy consumption.
- Flexible load curve means considering the reliability of electricity supply as a variable in planning, allowing for load shedding when necessary.

2.3.2. Energy storage methods

Pumped storage hydropower helps address both surplus and shortage by utilizing "wasted" electricity during off-peak hours to generate power during peak hours.

2.3.3. Potential for new energy sources

Vietnam has significant potential for new energy sources, such as wind (in Bach Long Vi, Ninh Thuan), geothermal, solar, industrial waste gas, and tidal energy. These new energy sources offer many benefits by utilizing forms of energy that are otherwise wasted.

2.3.4. Electricity pricing

Electricity use varies throughout the day, as demand for electricity is not uniform, especially in different industries. Thus, peak and off-peak hours appear on the system's load curve. During peak hours, the system needs to generate additional power, which may still result in power cuts. In developed countries, electricity pricing is an effective tool to manage and balance electricity demand. This helps improve energy efficiency (e.g., using multi-rate meters), benefiting both suppliers and consumers [8,9].

3. Conclusion

DSM is a collection of diverse solutions impacting technology, economics, and society. DSM helps electricity providers manage and control energy demand within their capacity and encourages consumers to use electricity more efficiently.

Due to rapidly increasing demand for electricity, DSM is considered the best solution for energy supply, offering high efficiency. Therefore, applying DSM is urgent and timely. In this chapter, we explored the DSM strategy aimed at improving energy efficiency, benefiting society as a whole.

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