

# INDUSTRIAL ENERGY EFFICIENCY: AN INTERDISCIPLINARY APPROACH

## Abstract

Enhancing energy security, environmental sustainability, and economic success all depend on industry energy efficiency. In plans to lessen climate change, it is very crucial. Governments have implemented several policies and initiatives targeted at increasing the energy efficiency of their manufacturing industries as a result of the evidence of a significant potential for cost-effective efficiency-derived reductions in industrial energy usage and greenhouse gas (GHG) emissions.

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## I. INTRODUCTION

Industrial Energy Efficiency means the energy efficiency derived from commercial technologies and measures to improve energy efficiency or to generate or transmit electric power and heat, including electric motor efficiency improvements, demand response, direct or indirect. The phrase "industrial energy efficiency" refers to energy efficiency resulting from commercially available technologies and methods to increase energy efficiency or to produce or transfer electric power and heat, such as demand response, direct or indirect combined heat and power, and waste heat recovery. The industrial sector accounts nearly a third of all worldwide energy consumption. A significant value that, given the current state of environmental awareness and demand, offers enormous potential for development in terms of energy efficiency: encouraging an approach to change, in favor of a more environmentally friendly and sustainable world. There are a variety of infrastructures, procedures, and other components in the industrial sector that can be enhanced. Therefore, we must prioritize industrial energy efficiency [1-3]. There is a single idea that encompasses all the adjustments required for this third of the world's energy usage to be more effective and environmentally friendly: innovation. The proper implementation of all technological advancements in all phases of the process can be advantageous; it adds value, resulting in a gradual transformation from industry to industry that affects society as a whole. Since economics is the main force behind business, lowering overall operational costs is the biggest motivation for greater energy efficiency. Fortunately, there are numerous and significant chances to improve efficiency. According to independent research, U.S. industry as a whole may cut energy use by 14% to 22% in the near future by implementing cost-effective efficiency techniques, especially when it comes to current technologies that utilize the heat generated during the production of electricity. Petroleum refining, bulk chemicals, paper, and metal—primarily iron and steel and aluminum—are the industries that use the most energy. As a result, those areas are the focus of research initiatives and cooperation between the public and private sectors.

## II. NEED OF INDUSTRIAL ENERGY EFFICIENCY [4-6]

Reducing manufacturing energy consumption levels through a variety of technologies, techniques, and business practices is known as industrial energy efficiency. A business could decide to become more energy-efficient for a number of reasons, including:

- Higher energy prices
- Rising rates of inflation
- Environment-related issues
- In order to boost market competition
- To establish financial stability

Even if we can't completely avoid energy bills, we can drastically cut down on how much energy we use. Energy.gov states that buildings can "achieve practical energy reductions of about 20%, and approximately 30% of the savings can be achieved without capital investment, using only procedural and behavioral changes." We enhance productivity and revenue while establishing ourselves as lean leaders by increasing our energy efficiency.

Other advantages are:

- Improved performance and dependability of the equipment
- Lower costs for maintenance
- Spending less and generating less garbage
- Increased worker safety
- Better relations within the community
- Decreased emissions of CO<sub>2</sub>

### III. THE BENEFITS OF ENERGY CONSERVATION IN INDUSTRY [7-10]

1. **Productivity increase:** Energy efficiency is the ability to sustain productivity while consuming less energy to carry out the same industrial activities. In fact, if carried out properly, the goal is that as performance improves, productivity rises and unnecessary expenditures are reduced.
2. **Social responsibility and corporate image:** Along with introducing the energy transition and committing to the 2030 Agenda and Paris Agreement targets, the corporate image greatly boosts the business as customers place a higher value on organizations that are more environmentally friendly.
3. **Maintaining market competition:** A business that pays less for electricity is better able to make investments in production, hire more people, upgrade its technology, etc., making it more competitive. However, it is even more crucial to keep in mind that in order to remain competitive, companies must adhere to the UN's CO<sub>2</sub> emission reduction objectives in order to avoid paying fines.
4. **Save time and money:** Energy efficiency also involves energy management, which enables you to keep an eye on all processes and solutions used to ensure that they remain operational at their peak efficiency and preventing the loss of either time or money due to prolonged maintenance or decreased efficiency.

### IV. INDUSTRIAL ENERGY EFFICIENCY SOLUTIONS [11-13]

Despite the fact that energy usage differs from facility to facility, there are always chances to optimize the lighting, HVAC systems, and motors.

1. **Lighting:** It offers a lot of chances for immediate gains because it makes up approximately 7% of our electricity use. At the conclusion of the workday, turn off the lights in any locations that are vacant. If doing so causes inconvenience, think about adding automatic light sensors, which can cut monthly lighting expenditures by about 20%.
  - **Control lighting standards:** Controlling lighting intensity helps save electricity use. Toyota, for instance, developed a lumens-to-surface-area ratio that allotted the ideal amount of light for each particular region, lowering their lighting expenses by 30%.
  - **Modify the lighting:** The kind of lighting used can have a big impact. Think about moving from T-12 to T-8 tubes, which have a 60% longer lifespan and 30% less

energy consumption. Another choice is "daylighting," which involves carefully placing windows and skylights to let in more natural light without adding to the building's heat load. There is evidence to suggest that daylighting can cut lighting expenses by up to 70%.

**2. HVAC systems:** To maintain buildings at the ideal temperature, HVAC systems [14-16] need a steady flow of energy. As a result, 53% of all the energy used in a facility is used by HVAC systems. Even tiny changes can make a big difference because one system uses more than half of our energy.

- **Maintain the ducts:** Regular examinations of the air ducts are necessary for proper maintenance and will let you know when repairs are required. The earliest possible time should be taken to make any repairs. For instance, it has been demonstrated that even a minor leak can raise monthly HVAC energy consumption by 30%.
- **Install programmable thermostats:** Programmable thermostats can cut HVAC energy usage by 15% by automatically adjusting the building's temperature to ideal settings throughout the day to enhance HVAC efficiency.
- **Improve or add insulation:** Every building, regardless of age, can profit from improved or added insulation. In fact, according to the EPA, good insulation can result in a 15% decrease in heating and cooling expenses.

Before rebuilding your HVAC system entirely or in part, take into account system recommissioning. In order to determine the areas that have an impact on your energy efficiency, this approach evaluates your HVAC system and maintenance practices. With the use of this information, it is possible to decide if it is more cost-effective to repair or modify the equipment rather than replace it.

- **Think about heat recovery:** Systems that use thermal heat to circulate throughout the building, such as run-around loops and heat pipes, are examples of heat recovery systems. These systems are nearly 65% efficient in recovering heat and using less HVAC power overall.

**3. Motors:** It play a crucial role in production. More than 90% of all installed motors therefore run constantly at maximum speed. Inefficient motors can use up to 55% of the facility's total electricity consumption if they aren't properly maintained.

- **Perform motor maintenance:** By preventing failures, motor maintenance increases equipment life and lowers energy use. Preventive or predictive maintenance can regularly reduce energy use by around 30%.
- **Install adjustable-speed drives:** An ASD is an industrial electric motor whose speed is controlled by an external controller. This helps machines run more efficiently and save energy.

In order to reduce electrical stress during voltage motor starts-ups, ASDs are also used for soft starts. ASDs can save up to 60% on energy, and they can pay for themselves in just eight months of investment.

- **Think about rewinding:** The motor coil is taken out, wound again, and then installed during rewinding. Rewinding should be taken into consideration before replacement because it not only optimizes energy consumption but also brings motors back to their highest levels of energy efficiency with less than .5% efficiency loss. However, motor replacement is advised if rewinding costs 60% or more of the price to buy and install a new motor.

Choose your motors carefully because they have a big influence on how much energy you use. The motor's life-cycle expenses should be given the most thought, even though many people simply take into account the prices of purchase and installation. In actuality, the motor's energy consumption over the course of its useful life is directly related to 95% of the life-cycle costs.

## V. FUTURE PERSPECTIVES OF ENERGY EFFICIENCY

1. **Big Data:** The technical advances that are already starting to be implemented in this area will determine the future of energy efficiency. For instance, "IoT" technology is making it feasible to construct small devices that gather signals in the field at minimal cost through extremely efficient protocols, yielding massive volumes of data within what is called "Big Data". Big data technologies are the computer programs that are used to manage all kinds of datasets and turn them into commercially useful information. Big data engineers, for example, use complex analytics to evaluate and process enormous volumes of data in their work. The four basic categories of big data technologies are data storage, data mining, data analytics, and data visualization [17-19]. Each of them has a specific tool linked with it, thus based on the big data technologies needed for your organization, you should pick the appropriate tool.

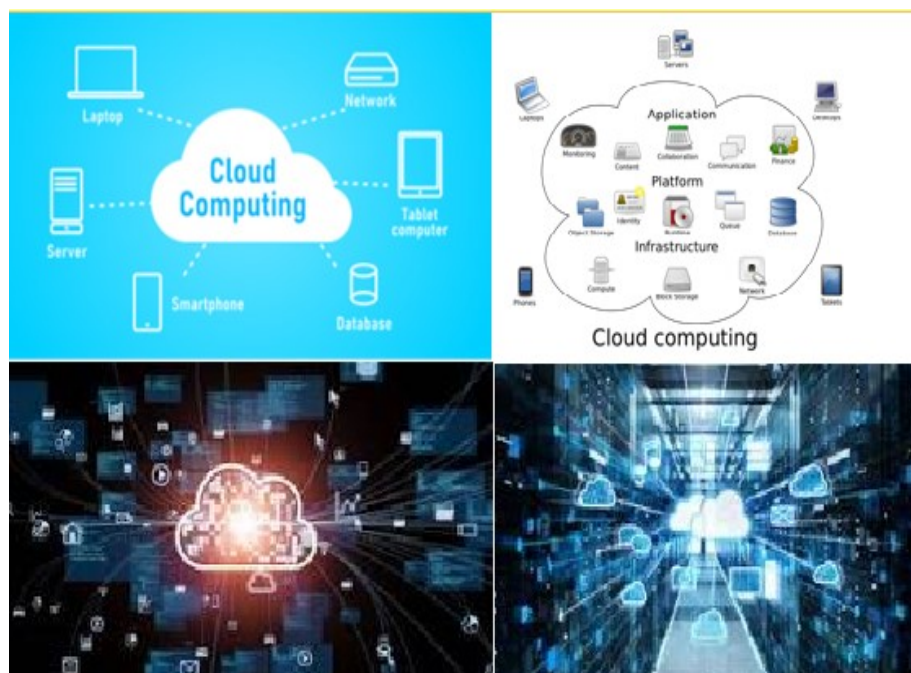


**Figure 1:** Big Data Technology

2. **Cloud Computing:** With its ability to self-grow and self-provide services, "cloud computing" clearly has a lot to offer in this regard [20-23]. The development of "Machine Learning" algorithms, as well as "Business Analytics" trends and tools, enable dynamic and continuous learning of business processes based on patterns and correlations of historical data. This enables more precise information analysis and forecasting. A technological advancement that makes advantage of the Internet is cloud computing. It allocates computer power. Software, servers, insights, databases, statistics, and other types of data are some of these resources.

Depending on the cloud services you select and in contrast to conventional on-site IT, cloud computing assist in the following:

- **Reduced IT costs:** By using the cloud, you may transfer some or all of the costs and work associated with building, installing, configuring, and administering your own infrastructure on-site.
- **Enhance flexibility and time-to-value:** Instead of waiting weeks or months for IT to reply to a request, buy and setup supplementary gear, and install software, your firm may begin using enterprise apps in the cloud in only a few minutes. Cloud also enables you to give some users—more especially, developers and data scientists—free access to software and infrastructure assistance.
- **Scale more easily and affordably:** Cloud offers elasticity, allowing you to scale capacity up and down in response to spikes and dips in demand rather than purchasing extra capacity that sits idle during slack periods. You can spread your applications closer to users all over the world by utilizing the worldwide network of your cloud provider.



**Figure 2:** Cloud Computing Technology

- 3. Digital Twin:** The "Digital Twin" is a further remarkable trend. A digital twin is a representation of a thing or system in cyberspace [24-28]. Before alterations to real things are made and put into action, these virtual duplicates are used to run simulations in order to gather data and forecast how they will perform. A digital twin is first created by specialists, frequently data scientists or applied mathematicians. These programmers investigate the physics underlying the physical system or object being copied, and then use the information they learn to create a mathematical model that replicates the original in digital space. The twin is designed to be able to take information from sensors collecting data from a physical counterpart. As a result, the twin is able to replicate the physical thing in real time and provide insights into its functionality and potential issues. The physical counterpart's prototype may have served as the basis for the twin's design, in which case the twin can offer input as the product is developed or even act as a prototype before the physical counterpart is constructed.



**Figure 3:** Digital Twin Technology

## VI. CONCLUSION

Every level of our organization's activity has waste. Even while trash cannot ever be totally eradicated, we must do everything we can to limit its negative consequences on our company. We can boost our profitability and productivity while securing our position as competitive lean leaders in the industry by recognizing the ways we are producing waste, such as our power consumption, and actively taking efforts to limit its presence and effects. Analyzing the energy-intensive wood products industry is being done in a similar manner. Researchers have highlighted next-generation mill technologies, increased fiber recycling, improved wood processing, and improved raw materials as prospects for efficiency gains. The application of modern technologies can significantly increase productivity in the chemical sector. According to studies, using high-temperature reactors, corrosion-resistant metal and ceramic-lined reactors, and advanced process controls can result in energy savings of 10% to 20% in just petroleum refining.

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