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Review

The management of sustainable energy sources in the mechanical sector

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Abstract: In order to increase energy security in the face of rising energy demand and declining funding for fossil fuels, energy supply must be diversified and a shift to renewable energy must occur. Sustainable energy supply management aims to achieve a low-carbon intensity of production, particularly in energy-intensive industries such as mechanical engineering. The article investigates the possibility of transitioning the current mechanical-engineering enterprise system, as well as the technical, environmental and economic indicators of production, to the new concept of the "green economy", which will serve as an alternative to the industry's continued sustainable development. This article examines key energy-saving strategies. An observational 40-point model for calculating the energy risk of the mechanical-engineering enterprise has been developed, as has a sequence diagram of production and technology that takes into account the impact on the environment and the possibility of energy industrialization. This allows the setting of strategic objectives to ensure the sustainable development of energy production in the mechanical-engineering industry and developing the main principles of efficient enterprise activity. It has been demonstrated that one of the criteria for increasing the profitability indicator is the adaptability of enterprises to external conditions and the expansion of alternative energy sources from our own various information sources.

Keywords: control of the energy supply; materials for energy (resources); mechanical engineering industry; sustainable development

1. Introduction

The mechanical engineering sector, one of the most resource-intensive manufacturing sectors, is presently seen as a promising area of development in many nations due to its access to a variety of resources and products as well as its potential for ongoing improvement [1]. Modernization and ongoing improvement are essential for the mechanical engineering sector's strategic development in developing nations, but these processes demand sizable financial investments that are scarce and hard to come by and must be made in the face of rising risks, global innovation trends and intensifying competition. More mechanical engineering businesses are focusing on eco-friendly and resource-saving production systems as a result of the greening of the manufacturing sector and digitization, which should support the growth of an economically viable economy. The national economy's technical upgrading is physically supported by the mechanical engineering sector's infrastructure. Significant mechanical engineering facilities were either destroyed or shut down when a war conflict in Ukraine broke out, which complicated future development without reconstruction and restructuring. Numerous active Ukrainian businesses must contend with constrained resources and output, as well as a challenging marketing environment. Due to the greening of the manufacturing sector and the fact that obsolete technologies were used and had a high resource intensity that had a detrimental impact on the environment, making them unprofitable, environmental and economic indicators were poor [2]. In recent years, finding alternative reserves and innovations to protect natural resources and embrace "green technology" to meet international standards has been one of the strategic aims of every business. Energy costs accounted for 20% of enterprise spending in Europe on average, compared to 10% in industrialized nations, suggesting that energy costs may be reduced. Europe is experiencing an energy crisis that, as a result of poor inter-state relations and a reliance on external suppliers for resources, grew significantly in 2022 and spread to the entire continent. The need to discover new solutions, embrace "green technology", alter supply chains and value systems and decrease energy use was sparked by the rise in energy prices on a global scale.

The issue of energy use, as well as the issue of armed conflict and the ongoing instability of the energy supply at nuclear thermal power plants and other energy facilities, emerged in the Ukraine, and the majority of Western countries, while mechanical-engineering enterprises of strategic importance to the nation were unable to replace outmoded equipment and adopt new technology. In order to improve the current situation and prepare for reconstruction in the postwar era, this essay explores the sustainability of the management of the energy supply in the mechanical engineering sector as a vital area of Ukraine, and the majority of Western countries development. For Ukraine in the post-war period, systematic approaches to the development of mechanical engineering may no longer be applicable, necessitating further research and development in the field of environmentally friendly engineering in the framework of the efficient management of the energy supply.

2. Literature review

Energy's transition into a crucial market has had political and economic repercussions, resulting in interdependencies between nations, state subsidies, ongoing research and the development of new technologies. There have been numerous forms of financial support for alternative energy sources in Poland, one of the European nations bordering Ukraine, including favorable fees, grants and loans, which were heavily utilized by firms to quickly enhance and update existing technology [3,4]. In

addition, they slowed the dynamics of the energy crisis in 2022 compared to nations that relied solely on fossil fuels and antiquated mechanical engineering.

The state has actively supported the growth of photovoltaic systems in Poland in recent years as a result of special development programs and business promotion to enhance the technical and environmental indicators of enterprises. Photovoltaic systems are one of the strategies for promoting low-carbon energy production [5]. By reducing the amount of fossil fuels used to generate energy, photovoltaic systems can enhance a building's overall energy efficiency. They can also help both small and large businesses become less reliant on conventional energy sources [6].

However, it is challenging to introduce alternative energy-efficient technologies and energy sources that would boost profitability over the long term; this is true even for developing nations with shaky political and economic systems. However, future carbon reductions may be larger if energy-efficient technology and energy sources are used [5].

The use of pricey decision support systems in small systems can be unprofitable when examining small mechanical engineering enterprises, and NPV for lithium-ion technology is significantly higher than for hydrogen technology; for instance, the NPV output of the 1 MWh and 1 MW storage system is −4.85 million EUR for hydrogen, whereas NPV for lithium-ion is −0.23 million EUR, indicating the prospects for lithium-ion technology to improve current energy systems [7].

When using contemporary automatic control systems and the organic cycle, waste hot fluid and steam generation, which can be employed in mechanical engineering businesses, can also be used as a source of additional energy [8,9].

The development of renewable energy sources in Poland and support from the government for the implementation of low-carbon development ideas have positive long-term effects, draw investment to Ukraine's promising development areas, enhance the state of the energy market and produce more energy reserves [10].

This technology is promising for further development in Ukraine, where one will develop a new concept of environmental and economic security during reconstruction, and it is anticipated that this will lead to the rapid growth and large flow of foreign investment. Photovoltaic energy producers are increasing in number in Poland.

3. Methodology

Public energy security has become a real problem due to the world's growing reliance on energy carriers, necessitating an immediate response in many nations. Adoption of new technology has been prompted by Russia's military and energy aggression, not only in the manufacturing but also in the defense industries.

Because of this, businesses that specialize in mechanical engineering have been one of the targets for the introduction of green technologies that have lately gained popularity in industrialized nations where the issue of funding was put on the back burner in favor of environmental issues [11,12].

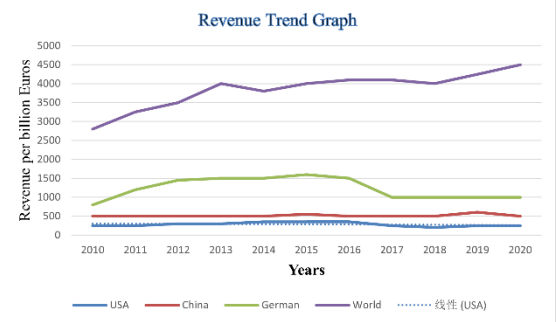

Figure 1. Revenues of the mechanical-engineering industry [5].

In Figure 1, it is shown that China, the USA and Germany hold the greatest market shares for mechanical engineering, and displays their respective revenues in the sector. The environment in which mechanical-engineering businesses operate in Ukraine is marked by systematic legal changes, an unbalanced government economic strategy, a fragile financial system, a decline in high-tech production, as well as escalating international competition and pressure on the domestic market. This environment creates a significant level of uncertainty for the businesses' economic activities. These issues pose serious risks to mechanical engineering businesses, necessitating the development of an effective economic security management system. The current economic-security system of the majority of mechanical-engineering businesses is insufficient to actively oppose the implementation of external and internal hazards, which leads to the development of crisis processes.

A process of planning, organizing, motivating and controlling necessary to meet the objectives of the efficient operation of any corporate entity can be characterized as the economic-security management system used by mechanical engineering firms.

Analyzing the fundamental components of their operations and functional security goals while taking into account the social, economic and environmental aspects is necessary for the development of a system for ensuring, organizing and managing the economic security of mechanical engineering enterprises. A new green economic system built around the idea of enhancing public wellbeing is now being established in European nations as they go through a time of transformation.

As a result, every aspect of industrial activity is constantly changing and in a dynamic condition [13,14]. Thus, there is a broad concept of developments in industrialized nations. Global trends in resource and environmental preservation are having an impact on most facets of society as a result of everyone being more accountable for their own economic activities [15]. According to [16], the idea of public consciousness is founded on general education, cultural development, environmental awareness and the ongoing adoption of innovations that attempt to improve current material flows. A resource preservation plan, which is a part of the general strategy for sensible nature management and incorporates energy conservation concepts, is one of the elements of the circular economy idea.

Mechanical-engineering companies have production areas with high energy-intensive sources. The energy conservation approach is founded on the idea of increasing the use of renewable energy sources as a replacement for traditional mineral resources, which are unequally distributed throughout the world and have limited reserves, making them the target of specific countries' economic policies and products, whose markets are influenced by different countries' foreign policies. This is only achievable with the availability of funding and government assistance for green economy projects. Based on the analysis of energy production and consumption from renewable energy sources, we can

point out the favorable trend in 2022 as well as the rising share of usage of renewable energy sources in both Ukraine and Europe, which proves favorable trends (the trend line is growing) and the efficacy of technologies reducing the energy dependence on conventional energy sources.

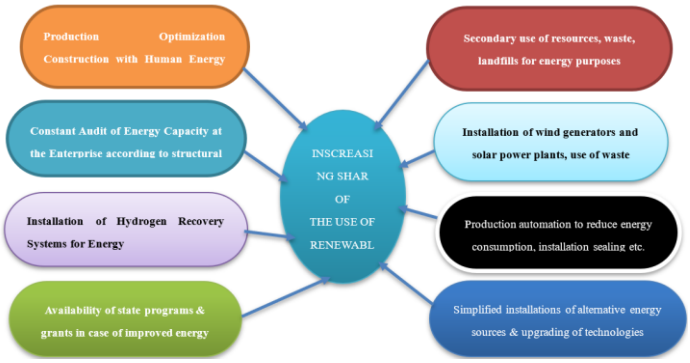

Figure 2. Important methods for reducing energy use in mechanical engineering businesses given the notion of the "green economy".

Moreover, the start of hostilities has led to a perilous situation near nuclear power facilities in Ukraine, demonstrating the ineffectiveness of the current market mechanisms and safety procedures [17].

When mechanical engineering businesses rely solely on external energy channels and do not have access to alternate energy sources of their own, more risk considerations are introduced. This risk element, because of the unevenness, applies not just to Ukraine but to the entire world.

Thus, resource allocation, oligopoly on the energy market and the manipulation of some nations to achieve their own objectives are practiced. Ukraine is currently dealing with a decline in real GDP, the closure of mechanical engineering businesses, increasing costs for the defense industry and a decrease in real salaries (by 83% compared to January 2022 and December 2021, meaning this percentage has increased during the hostilities).

Only in the event of orders for the defense sector are mechanical engineering businesses able to upgrade their equipment. Modernizing businesses should be done without consideration for the environment preservation, but rather on modifying manufacturing of commodities that are still useful for consumption today.

To put it another way, the system should be stable at a specific time interval and be able to reset to zero without causing harm to output, the environment or the economy. The usage of one's own renewable energy sources serves as the variable indication in this situation should be higher when there are significant swings in the energy market and there are more risks of unfavorable effects on mechanical engineering business operations [18].

A set of procedures that can adapt the system to changes is the modeling of the many parts of the mechanical Engineering enterprise's economic-security management system and offering suitable defense against any dangers to the manufacturing system's operations. The approval of processes for grouping and processing collected data in order to make effective managerial decisions is included in the information support for the economic-security management of mechanical engineering enterprises, which goes beyond a simple list of information sources and economic parameters. Therefore, one can achieve the stabilization of the situation in the face of external market fluctuations and the shift in risks for this enterprise based on the establishment of its own photovoltaic center and the possibility of

supplementing with other sources of alternative energy generation. Information assistance for mechanical engineering's economic-security management can also be implemented.

Enterprises encompass the approval of methods for grouping and processing acquired data in order to make effective managerial decisions. Enterprises are not just a set of information sources and economic characteristics. Therefore, one can achieve the stabilization of the situation based on the development of their own photovoltaic center and the potential addition of other sources of alternative energy generation in the face of changes in this enterprise's risks and external market swings. The application of cutting-edge technologies in manufacturing includes the integrity of business data and all resources, and the quick avoidance of crisis circumstances and the eradication of harmful elements that have an impact on the operations of the mechanical engineering firm. As a result, the management system for the mechanical engineering company is a collection of different actions designed to safeguard its interests from adverse external influences.

As a result, the formation of the mechanical engineering enterprise's economic-security management system is a complicated and multifaceted process that affects its sustainable development and defense against dangers and threats. The technical re-equipment and reconstruction of fundamental facilities, adjustments to the strategic set of business areas, adjustments to the business philosophy and the selection of an organizational management structure that will satisfy the demands of the aforementioned factors are all frequent requirements for mechanical-engineering businesses. Consequently, the deciding element in the economic adaptability, which comprises organizational support of the enterprise's behavior under conditions defined by changes in internal and external environments, is the key to security management in mechanical engineering firms.

4. Conclusion

The energy problem is brought on by both natural and political factors, one of which is the strategic foreign policy pursued by nations with abundant energy reserves, which also affects the market. This causes energy risk and has an impact on all macroeconomic indicators in nations that rely heavily on energy imports. Because mechanical engineering businesses consume a lot of energy, it is important to establish a variety of strategies to lessen reliance on outside energy sources. These strategies should primarily focus on production optimization, maximizing internal resources and implementing new technologies. However, when creating a plan for the reconstruction of Ukraine, it is important to use cutting-edge technologies, optimize production, upgrade or completely replace existing facilities in accordance with EU economic and environmental standards, and this will help to save resources and boost enterprise productivity. Developing autonomous energy generation systems at the mechanical engineering company based on the use of its own facilities (waste production, steam production, etc.) and the construction of a photovoltaic system designed on the principles of implementing the concept of the green economy are two ways to lessen the risk of an energy crisis.

In order to promote a work-friendly environment, each company should strive for maximum independence and avoid using centralized energy resources or use them as little as possible. In addition to fostering an atmosphere for additional labor, this will increase enterprises' independence from military operations. Along with limited energy sources, solar energy will also be stored. This energy will be converted using photovoltaic cells and benefit the environment.

The most economical solar cell producers, albeit there are currently many of them, are found in China. Positively for Ukraine, the production of solar cells has the potential to create new revenue

streams. According to the study's results, installing autonomous energy generators that utilize renewable energy sources increases an organization's profitability by 8.6%.

As a result, enterprises' risks are reduced by 22%, which is critical for stable operation. This results in an 8% decrease in production costs and an increase in market competitiveness, which is also due to the product's environmental friendliness since this is currently popular in many developed countries. Dependencies on external influences (risks) should be considered and minimized when assessing the sustainability of energy supply management in mechanical engineering.

Due to the optimization of production processes and the adoption of innovative energy conservation and generation technologies, they can be achieved by implementing the concepts of social consciousness and the green economy at the enterprise.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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