The concept, approach and benefits of energy auditing and its impact on the environment

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Abstract. The electricity industry plays an irreplaceable role in the rise of the economic potential and development of every country around the world. The international community of industry, research institutions and global businesses focuses more on green finance; it rises its interest in environmental protection, climate change and strategies for sustainable development. A worldwide sudden increase in electricity consumption could occur due to the commitment to decarbonize economies. The implementation of an energy audit and its control elements in energy management is of great benefit to the organization and leads to the rational use of energy resources and improvement of energy efficiency. In addition, it can also promote the continuous sustainable development of the economy and society. Therefore, it seems reasonable for the electric power industry to incorporate the principles of sustainable development into its strategy and operations. This study aims to evaluate the energy audit and its impact on the environment in the context of reviewing current and potential problems and prospects. It will also describe the role of renewable energy in the sustainable development of the electricity sector. Furthermore, it identifies the main factors of sustainable development for the electricity sector.

1 Introduction

Our planet is facing enormous ecological, social, economic and, last but not least, energy problems. Which led to the fact that in September 2015 all 193 member states of the United Nations adopted the 17 Sustainable Development Goals (SDGs) with the intention of solving these problems by 2030 [1]. The SDGs are designed as a program to improve the financial situation, to fight against unethical behaviour and to save our planet related to climate change. The Fig. 1 shows an overview of all 17 Sustainable Development Goals (SDGs). Sustainable development tries to eliminate or mitigate the negative manifestations of the current way of development of human society. Therefore, sustainable development does not only take into account economic growth, but also social values and natural wealth. Therefore, the main question is how to preserve the quality of life and ensure the needs of current generations without jeopardizing future generations. The social, environmental and economic pillars of society are closely linked and that one cannot be prioritized at the expense of the others.

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Historically, sustainable development stems from the need to better protect nature and the environment, but today it also applies to the area of good and efficient management and governance. In order to achieve real sustainable development, coherent public policies in all their forms (strategies, laws, audits) need to be created. This can be achieved through fact-based decision-making and improving the conditions for public participation, industrial enterprises and scientific research organizations so that meaningful social dialogue can be created.

Fig. 1. Sustainable Development Goals (SDGs) [1]

Moreover, electrical energy plays an irreplaceable role in the rise of the economic potential and development of every country in the world. If we start with recent history, the end of the 20th century and at the beginning of the 21st century usable energy from fossil fuels is running out, and renewable energies ("alternative energy sources") are still not developed enough to offer a full replacement. Today, it is important to address the dependence on renewable energy because fossil fuels are a limited resource.

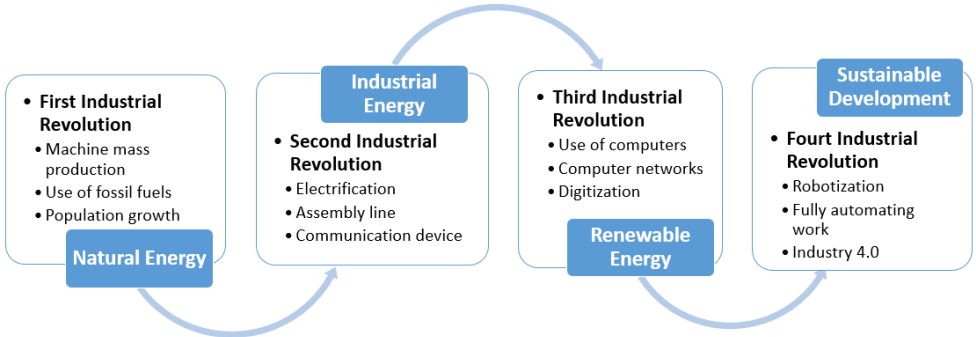

Fig. 2. Elements of production processes and electricity industry in relation to the industrial revolution.

Renewable energy sources are obtained from renewable energy sources such as wind, solar, geothermal, biomass, and hydropower [2–6]. Current analyses show that proven oil reserves

will not be enough to cover global demand [6-9]. In Fig. 2, it can be observed that the first industrial revolution laid the foundations leading to massive pollution. Concretely, the widespread use of fossil fuels has led to environmental damage and, as a result, to renewable energy, permanent sustainable development, and ultimately to the automation and digitization of the electricity industry.

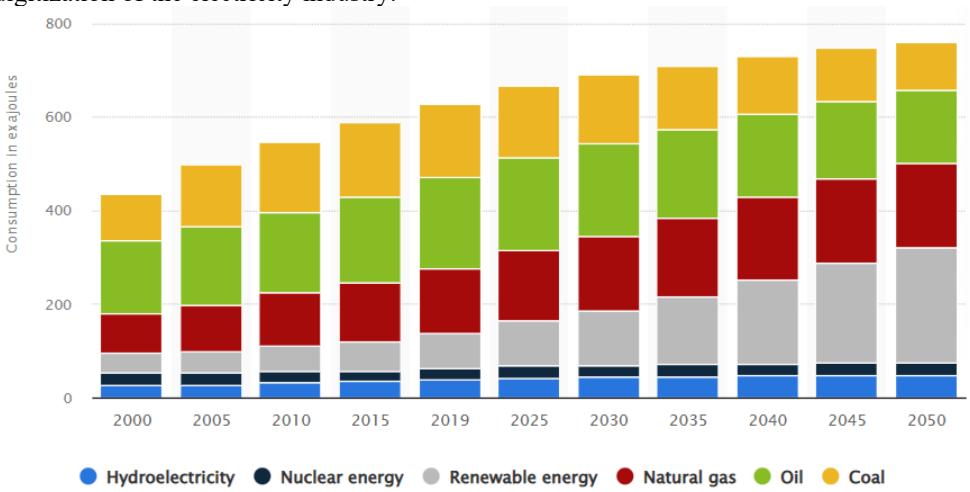

Fig. 3. Energy consumption worldwide from 2000 with a forecast until 2050 [14].

Decarbonization of the electricity industry is feasible, which confirms the replacement of fossil fuels with energy from renewable sources [10-13]. Fig. 3 shows global energy consumption, which has increased dramatically in recent years and is projected to continue on the same growth trend. The total consumption of renewable energy in 2000 was 42 exajoules, but it is expected that by 2050 the consumption of energy from renewable sources will reach approximately 247 exajoules [14].

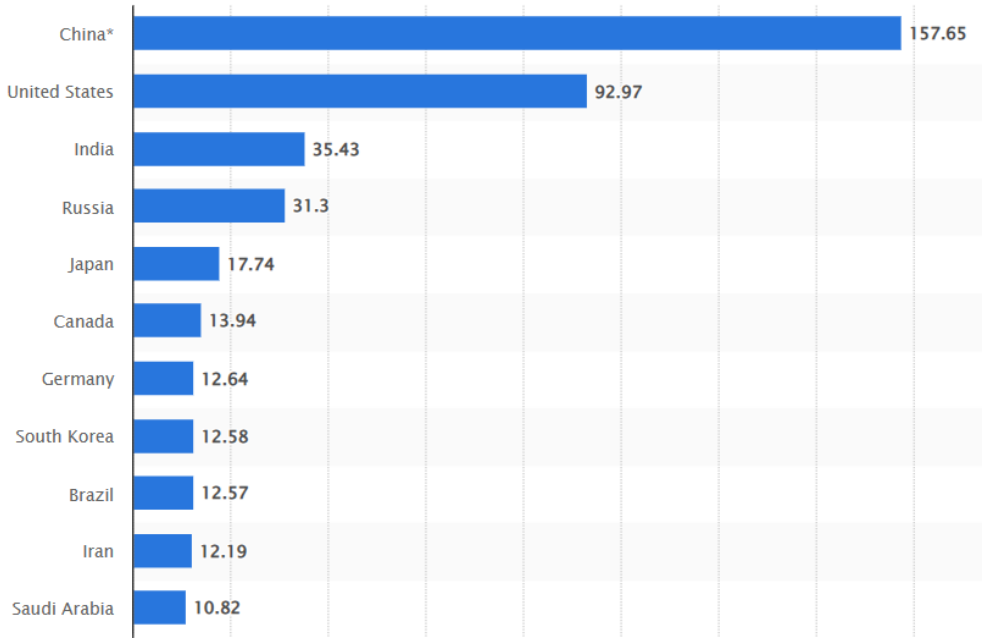

Fig. 4. Primary energy consumption worldwide in 2021, by country [15].

Fig. 4 shows that the global distribution of energy consumption is disproportionately high among individual countries, e.g. in 2021, China, the USA and India were the largest consumers of primary energy in the world [15].

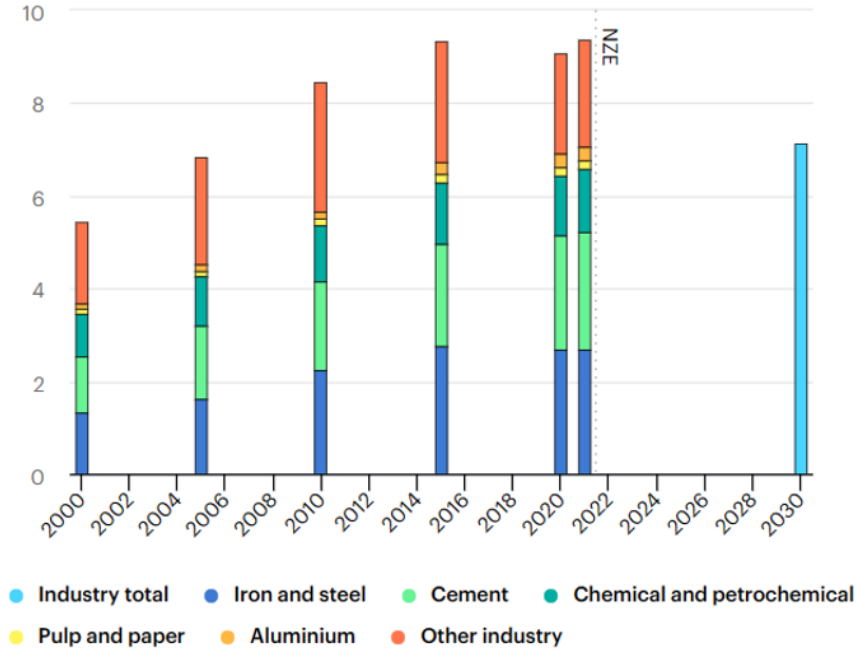

Fig. 5. Direct CO_2 emissions from industry from 2000 with a forecast until 2030 [16].

Fig. 4 shows that industrial activity in 2021 was responsible for 9.4 Gt CO_2 emissions, representing a quarter of global emissions. By 2030, industrial emissions will drop to around 7 Gt CO_2 [16]. Improvements have already been made in energy efficiency and the use of renewable energy, and positive policy and innovation steps have been taken. Greater material and energy efficiency, faster use of renewable fuels, and faster development and deployment of low-carbon production processes – including carbon and hydrogen capture and storage – are all essential requirements. Governments can accelerate progress by, among other things, reducing the risks associated with the development of new technologies, using modern tools and adopting mandatory CO_2 reduction and energy efficiency policies. The energy audit is not only an important device that contributes to the improvement of the economic and social sphere, but it is also used for energy management and the transformation of energy saving management into a standardized one. An energy audit contributes to the control of energy consumption in enterprises in accordance with national energy regulations and standards. Carrying out a corporate energy audit requires the control and analysis of energy consumption in enterprises within production and non-production processes. The management of companies thus has the opportunity to find out the current state of energy consumption and subsequently ensure the setting of corrective measures and propose practical improvements, including technological transformation plans.

2 Content and legislation of the energy audit

Energy audit means the control, verification, analysis and evaluation of production and non-production processes and financial processes of energy consumption in the enterprise by energy audit units in accordance with the relevant national regulations on energy savings

[17]. An energy audit is an effective tool for strengthening energy management and energy savings in businesses. Depending on the purpose of the energy audit, the content can be the following:

- analysis of energy management,
- analysis of the state of energy use,
- analysis of the energy flow,
- analysis of energy consumption indicators,
- analysis of the efficiency of operation of energy equipment,
- analysis of energy cost indicators in the enterprise,
- energy measurement and statistical status,
- calculation of energy savings,
- review of the financial and economic analysis of energy-saving technical measures.

Organizations most often implement certifications according to:
ISO 9001 (QMS) is for quality management systems,
ISO 14001 (EMS) is for environmental management systems,
ISO 45001 (OH & S) is for health and safety management.

Certification according to the ISO 50001 standard, which defines a commitment to continuous improvement of energy management and ensures compliance with related legislative and regulatory requirements, is of great benefit to the organization.

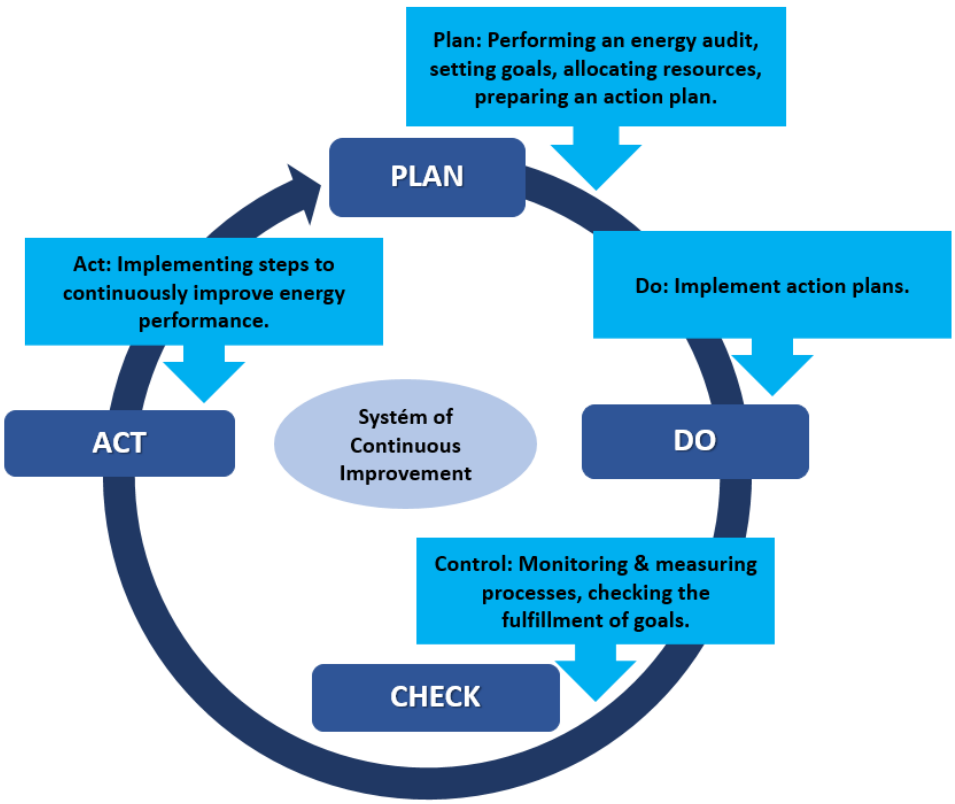

Fig. 6. Illustration of system of continuous improvement PDCA

Benefits of ISO 50001 certification include:

- increasing energy efficiency,

- financial savings,
- continuous improvement of energy efficiency,
- compatibility with legal and regulatory requirements,
- integration with existing management systems,
- expanded marketing possibilities and opportunities.

The ISO 50001 standard is based on a system of continuous improvement Plan-Do-Check-Act (PDCA), which implements energy management into the daily practice of the organization.

3 The type of the energy audits

An energy audit can consist of the following activities:

- setting goals,
- definition team,
- preparation,
- implementation,
- evaluatation,
- submitting a report.

It is important to know that an energy audit can be performed with different depths of analysis, according to the needs of specific organizations. Energy audit can be divided into three types [18-20]:

- preliminary energy audit,
- special energy audit,
- comprehensive energy audit.

As a result, with the selection of the appropriate type of audit for a specific production plant or for a certain organization, it is possible to perform the best analysis with an efficient expenditure of time and without burdening the budget. Below is a brief description of the three types of audit.

Preliminary energy audit: also called simple audit, screening audit or walk-through audit, this is the uncomplicated and fastest type of audit; includes minimal interviews with employees, a brief overview of accounts including historical statistics, familiarization with processes in the organization and inspection of machinery, equipment so that the auditor is aware of possible areas of energy waste or inefficiency; a preliminary energy audit can find energy saving potential and define measures to improve energy efficiency in a relatively short time.

Special energy audit: also called a purpose audit, it can be considered as an extension of the preliminary audit to collect more detailed information about the performance of specific machines or equipment and for a more detailed evaluation of energy saving options, including a financial analysis of the necessary investments; a special audit can, for example, be focused on a specific production process or lighting system or on a heating and air conditioning system with the aim of achieving energy savings. Special targeted audits therefore include detailed surveys of specific areas with analysis of energy flows and costs.

Comprehensive energy audit: also called Detailed Energy Audit; for the comprehensive analysis and assessment of the energy system, a detailed energy audit is necessary, which requires a detailed energy audit implementation plan and a detailed time schedule; a comprehensive energy audit uses computer models to simulate the operation of buildings, machines and equipment based on weather, set production and non-production processes, operating conditions and hours, etc.; a comprehensive energy audit requires metering

equipment to fully collect energy consumption data from business usage data; a comprehensive energy audit requires testing energy-using machines and equipment for replenishment important information and data; comprehensive energy audit perform energy savings analysis on major energy equipment or energy use systems and find/propose energy saving projects. Energy-saving technological transformation programs must then be designed; at the end of the comprehensive energy audit, an economic, technical and environmental evaluation must be carried out; deep analyses and more accurate estimates of energy savings are related to higher costs for the implementation of a comprehensive energy audit.

The team responsible for carrying out the energy audit must always consist of workers:

- familiar with legal standards in the field of electric power,
- knowledgeable in the field of monitoring energy savings,
- competent in accounting, statistics and economic management,
- experienced in issues of the environment and sustainable development,
- aware of the role of energy audit.

4 The role and importance of an energy audit

Based on what has been written above, we can state that a detailed analysis is most important when conducting a corporate energy audit. An on-site inspection and test may be used to perform an energy audit. When performing an energy audit, it is necessary to find the source of various data and then evaluate their relevance. In addition, it is also important to analyse the accuracy of the statistical evaluation of energy and material balance measurements. Moreover, it is also necessary to have available resources and effective means to check and verify relevant data and information. The proposal of energy savings and remedial measures is possible only based on data that is completely accurate and reliable and which is based on knowledge of the production and non-production processes of the organization. In the audited organization, the system of powers, duties and responsibilities at all levels of management should be clearly defined. No less important is the setting of communication in the organization, which, in addition to sharing daily activities, also takes care of spreading the vision, goals, and strategies.

At the end of the energy audit, the recommendation of the energy specialist is presented, which includes a description of the optimal variant, its annual energy savings, investment costs, annual operating costs, adjusted energy balance, economic and ecological evaluation and a draft of the concept of the energy management system [21, 22].

4.1 Economic Benefits of Energy Audit

An energy audit shows how to improve the economic and social benefits of the organization and thereby increase market competitiveness. An energy audit allows businesses to analyse and control the state of energy consumption over time. Then, as part of an energy audit, it is beneficial for the organization to check weak points in energy management and find potential for energy savings. An energy audit enables the audited organization not only to achieve economic and social benefits, but also to reduce consumption and improve efficiency. Energy audit is important for strengthening energy management and transforming the management of all processes into a standardized way, which enables the company's management to accurately analyse the daily management of energy savings and supervise the state of energy consumption. The economic evaluation is carried out according to several criteria:

- the main decision criterion, for choosing the optimal variant - the net present value,
- the additional evaluation criteria are the internal the yield percentage and the real payback period criterion.

Net present value is the sum of the discounted cash flows over the life of the project. This criterion shows us the investment's contribution to the value of the organization and is suitable for determining the economic efficiency of investments. It is also possible to use this criterion to compare investments with each other if they have the same lifespan. When choosing a suitable investment, we choose the investment that achieves a higher positive values. If the value of both compared investments is negative, then I will choose the one with the least negative value.

The internal yield percentage will determine the profitability of the project with regard to the time value of money. The internal yield percentage determines the value of the discount for which the net present value is equal to zero, and we realize the investment if the value of the internal yield percentage is higher than the discount. The disadvantage of this criterion is the complexity of the calculation during a longer lifetime or the impossibility of finding a solution, for example in the case of a negative cash flow.

The real payback period is the time it takes to pay off the investment with discounted cash flows in mind. When choosing a suitable investment, we choose the investment that achieves a lower payback period.

4.2 Impact of Energy Audit on the Environment

Fossil fuels pollute the environment through their combustion, and therefore it is necessary to evaluate the emission of pollutants into the air, and in the case of individual variants that reduce the consumption of fossil resources, to evaluate the change in emissions of these substances after the implementation of individual variants. The evaluation will be carried out for the polluting substances mentioned in the decree and the emission of the given substances will be evaluated in the current state and the state after the implementation of the proposed variants. If there is an increase in production, an ecological feasibility assessment will be carried out based on the change in pollutant emissions. The amount of pollutant emissions (TZL, $PM_{2.5}$, PM_{10}, SO_2, NO_x, NH_3, VOC) is calculated as the product of the specific production emission and the relevant reference value for the year. Each unit of burned fuel contains a certain amount of carbon dioxide (hereinafter referred to as "CO_2"). The emission factor tells us exactly this amount of CO_2 in a given unit energy of burned fuel. Emission factors are site-specific or general. In addition to the economic costs of greenhouse gases, other dimensions of sustainability as outlined in the adopted 2015 UN Sustainable Development Goals (SDGs) (e.g. health, clean water, responsible consumption and production). Annual growth in energy demand and associated environmental impacts play an important role in the transition to sustainable energy. Renewable energy sources are the best option to minimize pollution and increase energy security.

5 Conclusion

It is beneficial for manufacturing enterprises and organizations to have a more comprehensive understanding of energy management and to lay the foundations for effective energy conservation and emission reduction. A proper energy management system must safely and stably ensure the supply of energy needed for production, and it should quickly detect and correct abnormal energy consumption. The organization must fully understand the positive meaning of energy audit and improve energy management. It is also necessary to combine the work of the energy audit with the work on energy savings in order to reduce consumption and achieve the optimization of all production and non-production processes. Business management should be fully aware that competition between businesses should not only be based on economic benefit, but should also consider social responsibility, energy reduction and environmental protection. Organizations can combine an energy audit with a financial

audit. Organizations should strengthen data quality control, specifically data compliance and the use of data from relevant departments. Organizations should combine data quality control with energy savings management and ensure that energy auditing plays an important role in managing business costs.

Energy auditing requires auditors to master specific standards and relevant methods of statistics, testing and analysis. Furthermore, auditors must be specialists in calculating energy consumption indicators according to the relevant data on the energy input and output of the organization. According to these indicators and propose concrete proposals to achieve energy savings. Therefore, it is necessary to improve the training of workers involved in energy audit work. Therefore, it is necessary to constantly train a specialist in the field of energy audit.

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