ENERGY AS THE MAIN PILLAR OF DEVELOPED ECONOMIES

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Abstract

Developed economies and their growth are influenced by energy markets. The problems that are linked with energy markets are looking for solutions in economic, ecological, safety and other issues. The publications on the topic of energy can distinguish the sub-topic of renewable resources and nuclear energy as the two are sources having great potential for the future. This publishing has its context in comparison of old energy sources change for newer ones. These come along with the rise of newer technology in everyday life such as electromobility. The efficiency of each energy source is ambivalent. Therefore, this paper aims to describe a literature review based on selected academic texts.

Most production processes are oriented on the efficiency principle. This was the third keyword for the active learning model that was employed to search relevant documents and academic papers on electricity and economy, the other two keywords. The learning model found 544 papers out of which only eight were considered for this paper. Based on a formal selection of examined papers, the result is a perspective of energy policies and the implementation of technological solutions in developed economies. The synergy of policy and technology results in regional economic effects. The paper provides a literature review that enhances future research design, the design and the systematization of knowledge in the scope of energy economics.

Key words: energy, efficiency, nuclear energy, renewable energy

JEL Code: Q01, Q40, Q43

Introduction

Insight into energy indicators is provided by European Commission (Sicherl, 2011) showing the evaluation of Theme 6 "Share of electricity from renewable sources" for the time of 2000-2008. This new way of measuring informs on countries' changes than environmental strategies implementation.

1 Literature review in an objective manner

The important parameters of energy production (for instance in electric energy) are effectiveness and economy. These parameters are included in many academic papers. In this one, we have used a method of machine learning that helps identify the set of papers that are significant for these two parameters from different perspectives.

1.1 General remarks on the method

The method of computer research on literature can be manifold, e.g. Computer-assisted clustering or automated text classification. It gives better insight into what is already known and helps to provide a framework for research designs (Antons et al., 2023). The machine learning (ML) used in this paper was in line with the paradigm of "pre-train" and fine-tuning. (Liu et al., 2023) This search was trained with the first 20 papers that were sufficient (the relevance was saturated, and it has stopped increasing) for further generation. To provide an extra fact on the method of ML – it is being used also for the diagnostics of skin disease (AlDera & Othman, 2022). This kind of evidence suggests that the tool has strong analytical possibilities.

1.2 The interest of researchers in the efficiency of energy use

Using the literature review method (Snyder, 2019) after screening abstracts we identified and generated a sample of 544 papers. ML, Active learning – ASReview from Scopus database provided results for further analysis. Papers in the sample were ranked and classified. The ranking method prepared list, where the papers were selected according to criteria of year of publishing since 2018. Classification is illustrated in Fig. 1. Papers were from journals such as: Energies (27), Energy (11), Energy economics (11), International Journal of Energy, Environment and Economics (9), Electricity Journal (7), Applied Energy (6 pieces), BWK - Energie-Fachmagazin (3) and so on. Majority were journals 70.40 % (383) and conferences 22.43 % (122), serial publication 4.41 % (24), and the rest were chapters 2.76 % (15). While this was the whole dataset from Machine learning into Fig.1 were included only outcomes since 2010, although there were outcomes published before this year. After this criterion it is obvious that serial publications (usual abbreviation SER) disappeared from the analysis. Similarly, it is for category of chapters (usual abbreviation CHAP) that after year 2010 are again not found in this analysis. Journals (usual abbreviation JOUR) are the most frequent way of announcing new trends in this field of study, while conferences (usual abbreviation CONF) are standard

procedure for communication among scientists. It can be concluded that there is a growing popularity since 2017.

Figure 1. shows that interest in the topic of efficiency is increasing among academics. Publishing in Journals was surpassing publishing in Conference proceedings. Consumers themselves as proven in another survey such as (The National Archives, 2022). The Attitudes Tracker or National Archives allowed finding data on smart meter use in Great Britain (The National Archives, 2022).

Fig. 1: Comparison of publishing efforts for years 2010-2021
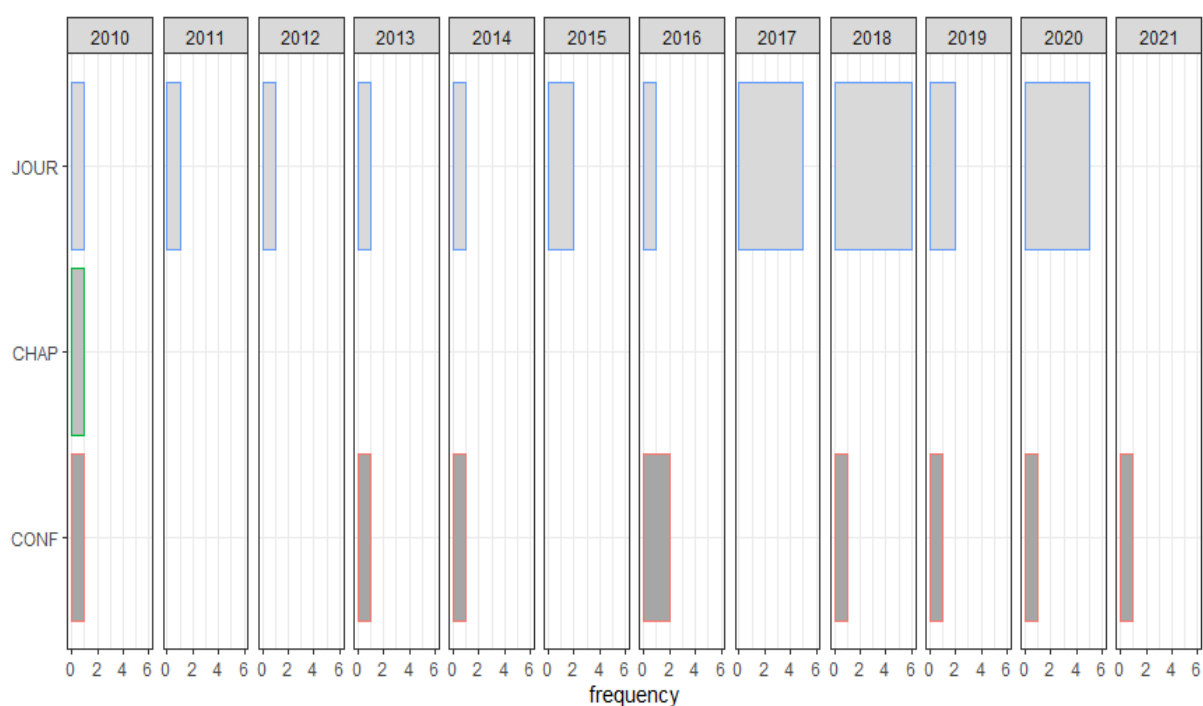
Source: prepared based on data from systematic review using Python ASReview and GNU R software.

Note: JOUR – journals, CHAP – chapters, CONF – conferences.

Table 1. introduces four papers selected for analysis. Wind power plants and small modular reactors are two rivals for efficiency and economy in production. However, some concerns persist regarding safety and sustainability. The other two papers serve as examples of efficiency. All selected papers differ in the method they use for evaluation of efficiency. This can be both an advantage for our review to grasp the differences and disadvantage because there is limitation for better comparison of evaluation methods. This paper preferred diversity of methods to be noticed. At the same time it could be suggested for next ML to include the method to the key words.

Tab. 1: Issues linked to the first four papers

Papers cluster	Rivals in a production method		Efficiency examples	
Issues	Wind power plants	Small modular reactors	Microgrid	Iran
Emphasis on	Sustainability	Safety	Efficiency	Efficiency
Linked with	Economy and efficiency (plant life-cycle)	Nuclear and non-nuclear parts	Combined cooling, heat and power efficiency, ecology	Negative importance of subsidies, deformation of price
Methods of evaluation	Integrated efficiency indicator	Failure tree approach, QRA, and PRA models	ANP-entropy, NPV	Comparison of indices
Year of publishing	2020	2018	2021	2021

Source: own, Note: QRA and PRA stand for quantitative risk assessment and probabilistic risk assessment, respectively. ANP – analytic network progress, NPV- net present value.

2 Analysis of four papers selected based on ranking and year of publication

The first of the four papers (Kasner et al., 2020) is devoted to wind power efficiency. The wind power sector is quickly developing sector among other possible sources of electricity production. In general wind power plants cover a great area (approximately the area of Tunisia). Production of wind power plants is considered to be clean during change of the wind energy to electricity - it does not come from direct emission of harmful substances. However, wind power plants are constructed from components that had been produced out of materials such as steel, plastic, concrete, oils and fats. The energy that is a source of potential negative environmental consequences is being used during that production. Maintenance of wind power plants during the operation (that is in most cases 25 years and then the plant is dismantled) is itself demanding for the energy sources. The authors of the paper are warning that existing models and methodologies are concerned with environmental analysis and its energy aspects of modernization of wind turbines be it concerning turbines in their life-cycle or those that were already built. Paper is providing a trial of solution for modernization problems of wind turbines to balance energy and material potential.

The aim of modernization is the general repair of equipment, components and other items of power plants to prolong the durability of selected phases in their life cycle under the condition of sustaining the high quality and efficiency of electric energy production. The aim

is a high energy, environmental and economic efficiency; low harmful effects regarding e.g. operational functions, environmental and other technical systems.

The study aims to develop a methodology for the evaluation of the efficiency of spent costs on energy and environmental during 25 years of life-cycle of wind power plants of 2MW of power and in the case of the same power plant prolong the durability of its life-cycle for 50 years by sustainable modernization. Analytical and research workflowPOSTUP is a model of methodology approach that is a valuable source of data for sustainable life-cycle management of wind power plants in the economy focused on performance and sustainable energy and material sources. Evaluation of ecology and energy efficiency of modernization of the wind powerplant is realized in the paper by applying integrated efficiency indicator. There are suggested two indicators for the efficiency evaluation of modernization:

- Return on costs of modernization
- Sustainability of modernization

Analysis of ecology costs during the life-cycle of modernization of wind power plants showed that higher environmental costs in the form of negative consequences on the eco-system and on human health were observed in the case of 50 years of the environmental cycle of wind power plant. Unless the suggested values were not compared to one 25-year lif-cycle of the wind power plant, but the addition of two life cycles (with dismantling and recycling after 25 years or storage of facility on the landfill plus installation of a new facility for 25 years of operation). Based on that fact, it is obvious. that use of power plant in 50 years of modernization after 25 years of functioning leads to the lower evaluation of eco-indicator and emission of greenhouse gasses of about 40-50% in comparison with the use of two wind power plants during the same time.

The authors` suggested indicators of modernization are fitted to the evaluation of economies with closed loop which is an economic system within which the consumption sources, energy, emission and volume of waste are minimalized in a closed process loop.

Substantial meaning has the fact that as a consequence of extending the life-cycle of wind power plant is limited for the use of natural resources, similar to the energy employed for their elements production and consequently the parts and their use is postponed. Sustainable modernization is fitted into sustainable development strategies where the production of electricity is rising to secure development and it also decreases the ecological and energetical unit costs of produced electricity.

The authors suggested creating motivational programmes using legal changes in wind power plants on the side of investors and producers. These programmes should include

sustainable modernization resulting in a decrease in the ecological burden that is linked with energy production from wind.

The authors suggested methodology and models developed for the evaluation of modernization effects are universal. These evaluations could be applied also to other technical equipment. Similarly, mentioned indicators are one of the elements for measuring the effects of modernization and at the same time, they are a way of support for the operator and those who are managing the life cycles of individual equipment.

Thanks to keywords four papers were selected for detailed analysis. These papers are focusing on issues where efficiency is the key issue. Fig. 2 shows further emphasis on the given paper is analyzing. In general, all of the papers consider an attitude towards energy saving. It is a combination of technology used (e.g. wind, nuclear, microgrid) and subventions to support such technology in their infant stages (e.g. Iran).

Fig. 2: Scheme of issues in analyzed four papers
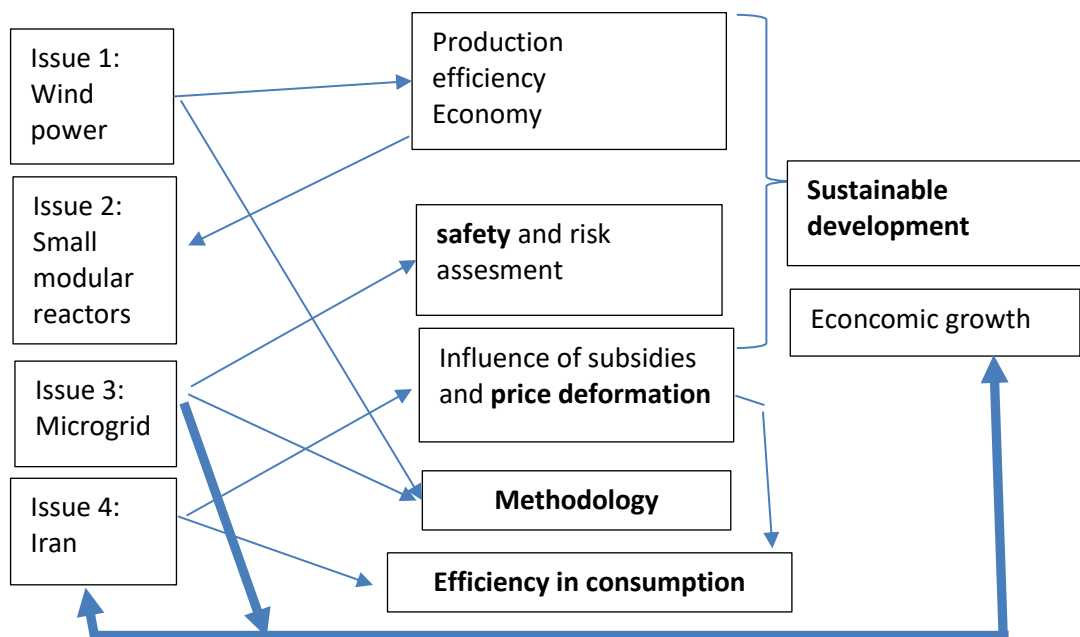
Source: own

The second paper was (Kowal et al., 2018) with the title „A general framework for integrated risk assessment of Nuclear/non-nuclear combined installations on market-oriented Nuclear Industry ". The paper`s initial idea is that the development of new nuclear technology is leading towards decentralized small or middle-sized modular installation with parameters

adjusted to concrete use and needs such as the production of processed heat, hydrogen-based chemistry and hydrazine with high significance to the chemical industry.

High-temperature reactors (HTR) and dual fluid reactors are an example of building industrial applications. The authors of this paper point out that the implementation of these concepts is a challenge for the evaluation of safety concerning nuclear and non-nuclear parts of equipment. Those were not (till the publishing of the analyzed paper) taken into consideration sufficiently by safety studies. It is the very fact that is triggering the development of a new framework for integrated risks when assessing the combined nuclear/nonnuclear equipment. Paper is an attempt to classify and solve the most difficult problems that are linked to problems of energy. Possible solutions are suggested there.

Lots of safety problems regard the interdependencies of nuclear and chemical parts of equipment that are considered for use in nuclear reactors as a suitable source of energy for various chemical processes. To enhance the safety of such a combination (nuclear and nonnuclear equipment), it must exist a new systematic approach that allows the functioning of the integrated agreement (license) process. The development of a new framework for the integration of risk assessment is one of the attempts required. Two methods are suggested for implementation here, namely the method of chemical QRA (Quantitative Risk Assessment) and nuclear PRA (Probabilistic Risk Assessment). The former is based on the failure tree approach and the latter is uncertainty and sensitivity analysis. The advantages and disadvantages of both are shown. Based on that the alternative approaches to block framework are suggested by authors. As claimed by the authors this framework is possible to apply in real studies and conditions of real life.

In 2021 Chinese authors Shuangchen Yuan, Zhijia Wu and Long Yan bring about the issue of microgrids. Papers title is „A Comprehensive Evaluation Model for Microgrid with CCHP"(Yuan et al., 2021). Microgrids with multi-energy complementarity are important for the improvement of energy effectivity, use and achievement of sustainable development. Combined cooling, heating and power (CCHP) provides electricity, heat and cooling energy is widely used in microgrids. The popularity of CCHP in microgrids includes some tasks. The paper suggests complex assessment for microgrids with CCHP. The model can reflect the characteristics of a microgrid with CCHP from five points of view: economy, environment, reliability, energy efficiency and technology. For a solution to the model, it is suggested to combine the method of ANP (Analytic Network Progress) and entropy. In the numerical test, in comparison with various microgrid schemes was the model and method found useful. The

development of technologies from renewable sources is a pressing issue due to the shortage of other energy sources.

Microgrid was found positive due to a combination of variable energy. Combined cooling, heating and power can improve energy efficiency in a microgrid. The CCHP studies for the assessment of microgrids are crucial for their development. The ANP-entropy, the multifactorial analysis, uses characteristics of microgrids. Results serve for planning and construction of microgrid projects.

The last paper analysed here was written by Iran author Ali Mohammadipour titled "Causes and Consequences of Reforming in Electricity Production and Consumption Pattern on Promoting Sustainable Development in Iran: An Economic Analysis" (Mohammadipour, 2021). In line with Paris Agreement from 2015 this study searches energy efficiency of Iran's industry in comparison to the world's standards. In 2018 ranked Iran on second place in the number of subsidies to electro energy industry and subsidies to fossil fuels in the world. Bearing in mind that fossil fuels are the main material for electric power plants. Results of the study suggest that despite the privatization of the electrical industry since 2008 centralization of economic management and providing extent direct and indirect subventions have led to the spreading of inefficiency in the production and consumption of energy. The main cause of the inefficiency is that prices do not include all costs and do not give the exact information. Nonetheless, the energy demands and energy technology for the consumption of electricity have a rising trend compared to other developed countries. This suggests a decrease in energy efficiency in Iran's economy. The basic index of electricity production is behaving in exactly the opposite direction than in Island, Switzerland Norway, Sweden and Luxemburg. This fact is against the goals of sustainable development. It is substantial to use the good practices of countries that have already solved reforms of electricity prices. Components of such good practice are summaries as follows:

1. Decrease subsidies to the energy sector complexly. A decrease of subsidies only for the determined source of energy does not solve the inefficiency and can even deepen the problem. The price deformation would be only sterilized.

2. "Heavy investment in sustainable development by the government is crucial." (Mohammadipour, 2021)

3. „Due to the heavy cost of building renewable power plants and the study of Kiani et al. (2017 In: (Mohammadipour, 2021)) on the necessity of government action in this regard, while reducing subsidies, resources should be utilized to improve the

electricity generation process. In the absence of this improvement, all policies in the area of sustainable development can lead to failure." Ibid.

4. Another energy solution in higher costs is the transformation of the production process of electricity from fossil fuels to renewable sources in the sense of using the potential of water energy. Therefore, the government should formulate a plan efficient in an increase of use of existing water power plants and building of new ones.

This study searches production processes and consumption of electrical energy concerning the question of the environment, It tries to provide a solution for including the principles of sustainable development for the functioning of the electrotechnical industry.

Conclusion

It is said: "Overthinking is the biggest waste of human energy… just take action". Energy is created and consumed in various ways. As the economy is shifting towards a "spaceship" economy that thinks about environmental issues and not only about economic growth. The whole society and its individuals are changing their behavior in actions. Particularly in the scope of electricity, it is such actions as implementing and using smart metering, using solar panels, wind-power gadgets, subsidies on both technologies to be at work sooner and other actions that have been mentioned above.

This paper provided an overview of the literature from the perspective of efficiency in energy production. This led to results that included issues of safety and sustainability. This brings conclusion that renewable resources are efficient in its substance, but there are environmental issues linked to it. This means externalities that are also economic problem as well as societal one. It shows that generally accepted opinion that gives equation sign between production of electric energy from renewable resources and ecological production of electrical energy is not totally correct. Before decision making on energy strategy of country, it is advisable to understand this issue. For instance, wind-power plants are one of the fastest growing productions of electricity in the renewable resource's productions. However, its operation includes problems such as: demanding on sources (minerals) and problems with recycling after finishing operational phase. This results in need of prolonging the average life-cycle of operation of power-plant of 25 year, i.e. total 50 years. Besides this the operation itself changes behavior of animals in the area of power plant, that can become serious ecological problem. For instance, decrease of the number of birds of prey above 80% in the area. For

instance, environmental issue of wind power plants that influences life of animals around turbines (they change behavior). There is a need to examine in similar mode the other types of production from renewable resources for there are other issues. For instance, biomass energy production is not more environmentally friendly than coal energy production.

This paper goal was to provide literature review using objective method of machine learning (ASReview) and this way emphasize some known facts, that are in practice not used fully.

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