DOI: https://doi.org/10.30525/2256-0742/2024-10-1-153-162

# IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN ENERGY CONSUMPTION CALCULATIONS TO REDUCE EXCESS GENERATION IN THE CONTEXT OF UKRAINE'S RECOVERY

**Oksana Kuzmenko[1], Viktoriia Chorna[2], Lyudmyla Kozhura[3]**

**Abstract.** In authors' opinion, the relevance of implementing artificial intelligence in the calculation of energy consumption in order to reduce excess generation lies in several key aspects: 1) efficient use of resources (by analysing data and predicting energy consumption patterns using artificial intelligence, the operation of the energy system can be optimised, ensuring efficient use of energy resources and avoiding excessive electricity generation); 2) reduction of losses (artificial intelligence can help identify and eliminate problematic segments in energy systems, leading to a reduction in energy losses during transport and distribution); 3) consumption forecasting (artificial intelligence can predict and respond to energy consumption peaks, ensuring the stability of energy supply and avoiding overloading of energy systems); 4) resource conservation and emissions reduction (efficient management of energy consumption using artificial intelligence can lead to reduced fuel consumption and greenhouse gas emissions, promoting more sustainable and environmentally friendly development).

Artificial intelligence is a field of computer science that deals with the creation of programs and systems capable of performing tasks that typically require human intellectual abilities. These systems can exhibit cognitive functions such as image recognition, language understanding, decision making, self-learning and planning. Artificial intelligence uses methods and techniques from computer science, mathematics, linguistics, philosophy and other fields to design and implement intelligent systems.

Artificial intelligence in the energy sector is the application of AI methods and technologies to optimise energy production, transmission, distribution and consumption. This includes the development of algorithms and systems that can automatically analyse large amounts of data, predict energy demand, optimise energy processes, maintain the stability of energy networks and reduce energy losses. The application of artificial intelligence to energy can help increase the efficiency of energy production, reduce environmental impact and improve the reliability of energy systems.

The *subject* of the study is the introduction of artificial intelligence in the calculation of energy consumption in order to reduce excess generation in the context of Ukraine's recovery.

The *research methods* for introducing artificial intelligence into the calculation of energy consumption in order to reduce excess generation in the context of Ukraine's recovery are a system of general scientific and special methods of scientific knowledge.

The *purpose* of the study is to determine the possibilities of introducing artificial intelligence into the calculation of energy consumption to reduce excess generation in the context of Ukraine's recovery.

*Results*. Investing in the use of artificial intelligence to calculate energy consumption in order to reduce excess generation in the context of Ukraine's recovery can be done through various investment instruments, including: venture capital (investments in start-ups and companies developing artificial intelligence technologies to optimise energy consumption); project financing (financing of specific projects using artificial intelligence to analyse and optimise energy consumption); corporate investments (investments in the development of in-house artificial intelligence systems for energy efficiency management at industrial enterprises); stock market

[1] Kyiv National Economic University named after Vadym Hetman, Ukraine
E-mail: kov2101@gmail.com
ORCID: https://orcid.org/0000-0002-0830-766X
[2] Kyiv National Economic University named after Vadym Hetman, Ukraine *(corresponding author)*
E-mail: demidenkov@ukr.net
ORCID: https://orcid.org/0000-0002-6072-0283
[3] Research Institute "Law Institute of the Kyiv National Economic University named after Vadym Hetman", Ukraine
E-mail: lepel@ukr.net
ORCID: https://orcid.org/0000-0003-4100-9530

(investments in shares and bonds of companies specialising in the development and implementation of innovative technologies for the energy sector); crowdfunding (raising funds from individual investors on platforms dedicated to the development of artificial intelligence projects in the field of energy efficiency).

**Keywords:** artificial intelligence, post-war reconstruction, energy sector recovery, energy consumers, energy efficiency, energy system optimisation.

**JEL Classification:** H11, H30, H61, I38, R50, D72

## 1. Introduction

Ukraine, as a member of the Special Committee on Artificial Intelligence of the Council of Europe, joined the Recommendations of the Organisation for Economic Co-operation and Development on Artificial Intelligence (OECD/LEGAL/0449) in October 2019. In the conditions of Ukraine's recovery, facing economic difficulties and after armed conflict, the relevance of implementing artificial intelligence for calculating energy consumption becomes extremely important. First and foremost, this will allow electricity production to be optimised by accurately predicting consumer demand. Artificial intelligence can analyse vast amounts of real-time energy consumption data, taking into account factors such as weather, socio-economic conditions and other variables that affect demand. This will help avoid over-generation, which in turn will reduce fuel and resource costs, increase energy system efficiency and reduce $CO_2$ emissions into the atmosphere, contributing to more sustainable and environmentally friendly development.

In addition, the use of artificial intelligence in energy resource management can act as a catalyst for innovation in the energy sector. Artificial intelligence can help introduce new energy-saving and renewable energy production technologies, which is a crucial step in ensuring Ukraine's energy security and independence. The introduction of AI can also stimulate the development of local technology companies and create new high-tech jobs, contributing to the country's economic recovery and increasing its competitiveness in the international market.

However, there are many questions about the efficiency and accuracy of artificial intelligence tasks. Thus, in authors' opinion, the relevance of introducing artificial intelligence to calculate energy consumption in order to reduce excess generation lies in several key aspects: 1) efficient use of resources (by analysing data and predicting energy consumption patterns using artificial intelligence, it is possible to optimise the operation of the power system, ensuring efficient use of energy resources and avoiding excessive power generation); 2) reduction of losses (artificial intelligence can help identify and eliminate problematic segments in power systems, which will lead to a reduction in energy losses during transportation and distribution); 3) consumption forecasting (artificial intelligence allows predicting and responding to peaks in energy consumption, ensuring the stability of energy supply and avoiding overloads in power systems); 4) resource saving and emissions reduction (effective energy management using artificial intelligence can lead to a reduction in fuel consumption and greenhouse gas emissions, contributing to a more sustainable and environmentally friendly development).

Therefore, the implementation of artificial intelligence in the energy sector has significant potential for resource optimization, ensuring efficiency and stability of energy systems, and contributes to reducing negative environmental impact.

## 2. Methodology of Research

Scientific-theoretical and legislative support for the implementation of artificial intelligence in the calculation of energy consumption in order to reduce excessive production in the context of Ukraine's recovery is studied and analysed in the works of such authors as O.M. Suhodolya scientific work "Artificial intelligence in energy" – studied the main directions of use of "artificial intelligence" technologies in the energy sector. The priority areas of application of modern technologies in energy supply systems are identified. The problems that impede the rapid implementation of artificial intelligence at the corporate and public levels are noted. The article provides recommendations on the priorities for stimulating the development and application of artificial intelligence technologies in the energy sector of Ukraine (Suhodolya, 2022); O. G. Zachek, Yu. I. Dmytryk and V. V. Senyk explored the current issues of the application of artificial intelligence in law enforcement activities and its role in increasing the effectiveness of the fight against crime; B. S. Stogniy, O. V. Kirylenko, A. V. Prakhovnyk and S. P. Denisyuk studied the development of intelligent power grids and their prospects in Ukraine (Zachek, Dmytryk, Senyk, 2012); N. V. Dzyubanovska formulated the concept of the "energy network of the future", identified the main challenges facing today's energy system, which require new innovative approaches and solutions, and conducted an analysis of the possibilities of applying artificial intelligence algorithms to increase its efficiency (Dzyubanovska,

2023); Y. V. Krutohorskyi noted the instruments for stimulating the implementation of energy-saving technologies in industrial enterprises (Krutohorskyi, 2014); T. V. Serdyuk and S. Yu. Franishyna studied the peculiarities of the implementation of the energy saving policy in Ukraine and other countries (Serdyuk, Franishyna, 2009).

These authors emphasise the need for a comprehensive approach to the issue of implementing artificial intelligence in the energy sector, including scientific, theoretical and legislative support.

The methodological peculiarities of the research of the application of artificial intelligence in the calculation of the consumption of energy resources in order to reduce the overproduction in the conditions of Ukraine's recovery can include various general scientific and specialised methods. General scientific methods include the following:

Method of scientific analysis (study of scientific literature on artificial intelligence, energy and renewable energy sources to obtain information and identify trends in these areas).

Expert surveys (involving experts from various fields, such as energy, information technology, and artificial intelligence) can help gather valuable opinions and recommendations on how to implement artificial intelligence.

Mathematical modelling (creation of mathematical models to analyse different scenarios of artificial intelligence implementation in the energy sector can help predict the possible consequences and effectiveness of such measures).

Statistical analysis (processing of statistical data on energy consumption and excess generation allows to identify trends and dependencies that can be useful for decision-making).

Experimental research (conducting practical experiments or pilot projects to introduce artificial intelligence in the energy sector allows assessing its effectiveness and impact on the system).

Specialised methods include the following:

Legal modelling and forecasting involves developing legal models and scenarios to assess the legal implications of implementing artificial intelligence in the energy resource management system and forecasting its impact on the regulation of energy consumption and generation.

Comparative analysis of legal systems involves a comparative study of the legal systems of other countries regulating the use of artificial intelligence in the energy sector in order to identify best practices and opportunities for adaptation to Ukrainian conditions.

Legal consulting and expertise involves providing legal assistance and expert opinions on the legality, efficiency and ethical aspects of implementing artificial intelligence in the energy sector.

Case law analysis can be used to study court decisions and precedents related to the introduction of artificial intelligence in the energy sector, identify key issues and provide recommendations for their resolution.

Risk management involves analysing potential legal risks associated with the introduction of artificial intelligence technologies in the energy system and developing strategies to manage them.

These methods make it possible not only to study the legal aspects of the introduction of artificial intelligence in the energy sector, but also to develop effective solutions and recommendations for managing this process in the context of Ukraine's recovery.

## 3. The Essence and Peculiarities of the Implementation of Artificial Intelligence in Energy Consumption Calculations to Reduce Excessive Generation in the Context of Ukraine's Recovery

### 3.1. The Significance of Artificial Intelligence in Energy Consumption Calculations to Reduce Excess Generation in the Context of Ukraine's Recovery

Artificial intelligence is a branch of science that deals with the development of programs and algorithms that enable computers to perform tasks that previously required human intelligence (Artificial intelligence (AI) – what is it, how does it work, and why is it needed, 2022).

The Concept of Artificial Intelligence Development in Ukraine defines artificial intelligence as an organised set of information technologies, the application of which makes it possible to perform complex tasks using a system of scientific research methods and information processing algorithms, obtained or independently created during work. It also includes the creation and use of one's own knowledge bases, decision-making models, information processing algorithms, as well as the determination of ways to accomplish set tasks (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept of Artificial Intelligence Development in Ukraine" No. 1556-p, 2020).

One of the main obstacles to the widespread adoption of artificial intelligence in Ukraine is the lack of financial resources. The development and implementation of AI-based software requires significant investment. However, even with limited financial resources, existing open resources can be used to develop relevant software. Another important reason is the lack of qualified specialists in the field of artificial intelligence. Ukraine lacks professionals with the necessary experience in developing

AI-based software. Therefore, training and retraining of specialists is necessary to ensure the effective use of this technology. Ukraine is actively working to develop the innovation sector and implement digital technologies in various fields. The goal of these initiatives is to create a competitive, innovative economy that will help improve the quality of life for citizens and ensure the sustainable development of the country. Nevertheless, one of the most important ethical issues related to artificial intelligence is the question of transparency and accountability of algorithms used in decision-making systems.

In today's context, energy networks play a critical role in providing electricity and heat to millions of people and businesses around the world. Energy networks also support the operation of critical infrastructure systems such as transport, healthcare, communications and information technology. However, population growth and the rapid development of the global economy are leading to increased demand for energy, which may result in insufficient capacity of the energy network.

In addition, the modern energy system faces several other challenges that require new innovative approaches and solutions, including reducing greenhouse gas emissions, improving the efficiency and security of energy systems, and developing renewable energy sources. Reducing greenhouse gas emissions and combating climate change are critical challenges for humanity and have a direct impact on the future of the planet and life on it.

Many countries are adopting national legislation and programmes to reduce greenhouse gas emissions. The European Union, for example, has committed to reducing emissions by 40% from 1990 levels by 2030 and to zero by 2050. In addition, industrial companies around the world are taking steps to reduce greenhouse gas emissions, including switching to the use of renewable energy sources such as solar and wind power, which reduces their dependence on fossil fuels and reduces greenhouse gas emissions (Dzyubanovska, 2023).

Artificial Intelligence (AI) will enable a balance between electricity production and consumption, ensure efficient management of power grids and reduce inefficient spending. This will reduce dependence on traditional energy sources and cut greenhouse gas emissions. Through deep learning algorithms, AI can be used to optimise energy networks that deliver electricity, allowing for more efficient use and reduced greenhouse gas emissions. It can also help identify complex patterns and interdependencies in production processes, making it easier to identify additional opportunities for improving energy efficiency. Using deep learning algorithms, monitoring systems are being developed that analyse real-time data on the operation of the energy network and predict possible equipment failures and outages. They can also enable more effective management of energy networks and increase their resilience to various impacts. Energy-efficient control algorithms for large energy systems will ensure energy security and anticipate potential cyber-attacks on energy infrastructure (Dzyubanovska, 2023).

Data analytics in the energy sector can be used to predict electricity demand. This will help reduce excess energy production, which leads to greenhouse gas emissions, and ensure more efficient use of resources. Electricity demand is reflected in the final energy consumption indicator, which characterises the total amount of energy used by the population, businesses and other sectors of the economy to meet their needs. Based on the forecasted energy consumption, a number of measures can be taken to ensure efficient production and supply of electricity: if electricity consumption is expected to increase, sufficient reserve power capacity can be provided to ensure energy supply during peak hours; if electricity consumption is expected to decrease, electricity production can be reduced to avoid overproduction and minimise negative environmental impact (Dzyubanovska, 2023).

Forecasts can also be used to ensure optimal operation of the electricity distribution system, reduce energy losses and ensure more efficient use of energy resources. The use of AI to predict energy consumption or energy costs involves the use of various data mining algorithms, including:

Neural networks are one of the most common applications of AI to predict energy consumption. In the case of renewable energy sources, such as solar and wind power, neural networks are becoming an important element of energy production, distribution, and use. AI-powered systems can help collect and analyse weather data to understand when solar or wind power will be most effective. They can ensure optimal use of resources in real time, enabling more efficient energy production and storage. In addition, AI can help plan and predict peak loads and optimise energy networks.

Decision trees, algorithms used to identify dependencies between different factors and determine the importance of each factor in predicting energy consumption.

Genetic algorithms, optimisation methods based on biological evolution, which can be used to find the most efficient parameters of energy consumption forecasting models.

Support vector machines, a machine learning technique used to identify relationships between factors such as historical energy consumption data, population, economic growth, climate conditions and energy cost forecasting.

Bayesian networks, methods of statistical analysis that allow estimating the probability of various outcomes and forecasting energy consumption based on data analysis (Dzyubanovska, 2023).

*Artificial intelligence is a branch of computer* **science** that deals with the creation of programmes and systems capable of performing tasks that usually require human intellectual abilities. These systems can demonstrate cognitive functions such as image recognition, speech understanding, decision-making, self-learning and planning. Artificial intelligence uses methods and techniques from computer science, mathematics, linguistics, philosophy and other fields to develop and implement intelligent systems.

*AI in energy sector* is the application of artificial intelligence methods and technologies to optimise energy production, transmission, distribution and consumption. This includes the development of algorithms and systems that can automatically analyse large amounts of data, predict energy demand, optimise energy processes, maintain the stability of energy networks and reduce energy losses. The application of artificial intelligence to energy can help increase the efficiency of energy production, reduce environmental impact and improve the reliability of energy systems.

### 3.2. Legal Regulation of the Use of Artificial Intelligence in Energy Consumption Calculations to Reduce Excessive Generation in the Context of Ukraine's Recovery

There is no legal definition and regulation of the use of artificial intelligence in Ukrainian legislation, and liability for the illegal use of artificial intelligence is not currently enshrined in regulations (Klian, 2022). The fundamental regulatory document on the use of artificial intelligence in Ukraine is the Concept for the Development of Artificial Intelligence in Ukraine, approved by the Cabinet of Ministers of Ukraine in 2020 (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine" of 2 December 2020 No. 1556, 2020). According to this concept, one of the problems to be solved is the absence or incompleteness of legal regulation of artificial intelligence. According to K.S. Tokareva, Ukrainian legislative acts do not regulate the activities of artificial intelligence. Therefore, cooperation with international organisations is planned to develop standards and an ethical code for the use of artificial intelligence in Ukraine (Tokareva, Savliva, 2021).

Amendments to Ukrainian legislation are urgently needed to create legal instruments regulating the activities of artificial intelligence entities. It is also necessary to provide for legal liability for damage caused by the use of artificial intelligence (Gryshanova, 2023; Globa, 2023). Legislation to regulate the use of artificial intelligence is also being adopted in other countries around the world. The European Commission has proposed a regulation to regulate the use of artificial intelligence, the Artificial Intelligence Act, which is being actively discussed by EU legislators, and on 6 December the EU Council adopted a common position on this regulation. However, it will not become law until the EU Council and the European Parliament agree on a common version of the text. In Canada, the Artificial Intelligence and Data Act (AIDA) is under development. Similar legislation is also being developed in the United States, Brazil and other countries (Kotkov, 2023).

Paragraph 54 of the Government's Priority Actions for 2020 for the first time identified the need to develop and submit to the Cabinet of Ministers of Ukraine a draft act of the Cabinet of Ministers of Ukraine on the approval of the Concept of the Law on the Development of Artificial Intelligence. This included the development of a coordinated state policy to regulate the field of artificial intelligence and eliminate Ukraine's backlog in this area (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Government's Priority Action Plan for 2020", 2020).

On December 2, 2020, the Government approved Order No. 1556-p "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine", which subsequently became the legal basis for the introduction of artificial intelligence in various industries in Ukraine. The implementation of this concept is scheduled until 2030. The concept defines the goals, principles and objectives of the development of artificial intelligence technologies in Ukraine as one of the priority areas of scientific and technical research. The introduction of information technologies, including artificial intelligence technologies, is an integral part of the development of socio-economic, scientific and technical, defence, legal and other activities in areas of national importance. The absence of a conceptual framework for state policy in the field of artificial intelligence hinders the creation and development of a competitive environment in these areas (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine" of 2 December 2020 No. 1556, 2020).

The priority areas for implementing the concept are:

It occupies a significant segment of the global artificial intelligence market and holds leading positions in international rankings (such as the AI Readiness Index by Oxford Insights, AI Index by Stanford University, etc.).

Creation of conditions for participation in the activities of international organisations and implementation of initiatives for the development, regulation and standardisation of artificial intelligence.

Implementation of artificial intelligence technologies in education, economics, public administration, cybersecurity, defence and other areas to ensure Ukraine's long-term competitiveness in the international market.

Provision of access to information (databases, electronic registers, etc.) and its use in the development of artificial intelligence technologies for the production of goods and services.

Promotion of research results in the field of artificial intelligence and improvement of their quality.

Increase of the level of professional training to provide the artificial intelligence industry with qualified personnel.

Protection of the information space from unauthorised interference and ensuring the safe operation of information and telecommunication systems.

Enhancement of public security through the use of artificial intelligence technologies in the development of measures for the social reintegration of convicted persons and the risk of re-offending.

Aligning legislation on the use of artificial intelligence technologies with international regulations (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine" of 2 December 2020 No. 1556, 2020).

In order to achieve the goal of the Concept in the economic sphere, the following tasks need to be fulfilled:

Stimulation of artificial intelligence entrepreneurship by providing innovative enterprises with access to investments, partnerships with venture capital funds, organisation of business events with the participation of Ukrainian IT entrepreneurs abroad, improvement of the business climate, ensuring predictable tax policy, creation of closed information environments for isolated testing of artificial intelligence technologies, development of computing infrastructure for the development of artificial intelligence technologies within priority areas, etc.

Motivation of business entities to implement artificial intelligence technologies to improve their efficiency by providing them with access to educational programmes/information portals on artificial intelligence technologies.

Development of a Roadmap for retraining people whose jobs may be automated in the next five to ten years.

Introduction of public procurement for artificial intelligence systems, IT specialists and data scientists.

Stimulation of partnerships between the state and business in the field of innovative projects, as well as improvement of legislation in the relevant area (The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine" of 2 December 2020 No. 1556, 2020).

### 3.3. Methodology for Using Artificial Intelligence to Calculate Energy Consumption to Reduce Excess Generation in the Context of Ukraine's Recovery

The method of planning using artificial intelligence to calculate energy consumption in order to reduce overproduction in the conditions of Ukraine's recovery involves the use of algorithms and intelligent systems for optimising and forecasting energy consumption. This method is based on the analysis of large amounts of data on energy consumption, weather conditions, economic and social factors. Artificial intelligence enables the development of optimal energy distribution strategies, taking into account current needs, forecast indicators and the efficiency of resource use. The use of this method contributes to reducing energy losses, optimising the operation of energy systems and minimising negative environmental impacts.

This method is implemented by creating computer models that are used to analyse and forecast energy consumption at different levels, such as buildings, cities or regions. The first step is to collect data on energy consumption, weather conditions, economic and social factors. This data is then processed and analysed using artificial intelligence algorithms that can identify patterns and interdependencies. Based on this analysis, models are created that can predict future energy consumption and develop optimal resource allocation strategies. These models can be used to make energy planning decisions, including determining optimal system load times, distributing energy between different sources, and reducing energy losses. In this way, the method can optimise the use of energy resources and ensure more efficient operation of energy systems.

The monitoring method using artificial intelligence to calculate energy consumption with the aim of reducing excess generation in the conditions of Ukraine's recovery involves systematic data collection, analysis and interpretation of energy consumption data to identify potential areas for energy efficiency and optimisation of resource use. This method involves the use of various sensors, meters and data collection systems to obtain real-time information on energy consumption. The data collected from these sources is processed using artificial intelligence algorithms to identify patterns, trends and anomalies in energy consumption. Based on this analysis,

recommendations and strategies are developed to optimise energy efficiency, such as implementing new technologies, distributing energy more efficiently and planning energy saving measures. The monitoring methodology is a key step in the implementation of energy efficiency management systems and helps to ensure continuous improvement of energy efficiency under the conditions of energy recovery in Ukraine.

This method is applied by setting up a monitoring system that continuously collects real-time energy consumption data. This data can be obtained from special sensors, metering devices or other sources that collect information on energy consumption. Once collected, the data is analysed using artificial intelligence algorithms to identify patterns, trends and anomalies in energy consumption.

Subsequently, based on the results of the analysis, specific strategies and recommendations are developed to optimise energy consumption and improve energy efficiency. These may include the introduction of new technologies, changes in equipment operating modes, more efficient energy distribution, and the implementation of energy-saving measures.

These recommendations and strategies can be implemented in enterprises, private households, as well as at the level of municipal and national energy systems. The use of the monitoring method contributes to increasing the efficiency of energy use, reducing excess energy production and promoting sustainable energy renewal in Ukraine.

The incentive method using artificial intelligence to calculate energy consumption with the aim of reducing overproduction in the conditions of Ukraine's recovery involves the use of stimulation systems based on artificial intelligence algorithms to encourage energy consumers to use energy more efficiently. This method includes various mechanisms such as price differentiation of tariffs, incentive programmes for energy efficient technologies, information campaigns and educational events to raise consumer awareness about energy efficiency. The essence of the methodology is to change the behaviour of energy consumers by providing incentives to reduce consumption during peak hours or to use alternative energy sources. As a result, energy consumers become more informed and proactive in planning and optimising their energy consumption, leading to a reduction in excess energy production and contributing to the sustainable recovery of the Ukrainian energy system.

From year to year, attention to the introduction of energy-saving technologies is growing both on the part of the government and the management of enterprises. However, despite this, the overall level of adoption of advanced technologies remains low, leading to a loss of competitiveness, negative environmental impact and reduced profitability (Krutohorskyi, 2014).

This method is implemented through the development and implementation of various incentive mechanisms that encourage energy consumers to use energy more efficiently. This may include the introduction of price differentiation in electricity tariffs to encourage consumers to use energy during off-peak hours. In addition, incentive programmes for energy-efficient technologies can be introduced, providing incentives or financial rewards for using energy-efficient equipment or adopting energy-saving practices. Furthermore, information campaigns and educational events can raise consumers' awareness of the importance of energy efficiency and help them realise the benefits of reducing energy consumption. All these measures aim to encourage consumers to change their behaviour in order to reduce excess energy production and optimise the use of energy resources.

The investment method of using artificial intelligence to calculate energy consumption in order to reduce excess generation in the context of Ukraine's recovery involves the development and implementation of investment strategies based on the analysis of large data sets using artificial intelligence algorithms.

The method is based on the use of energy consumption data, energy forecasts, and other factors such as economic indicators, technological trends, and legislation to make optimal decisions on the allocation of investments in the energy sector.

The application of this method allows investors to make informed decisions about investing in energy projects aimed at reducing excess energy production and improving energy efficiency, taking into account the risks and potential benefits.

This method can be used to identify promising areas for the development of the energy sector, support innovative technologies and stimulate the development of renewable energy sources in the context of Ukraine's energy recovery.

Investments are made in state-of-the-art equipment, machinery or the production of innovative products or services.

Investing in the use of artificial intelligence to calculate energy consumption in order to reduce excess generation in the context of Ukraine's recovery can be done through various investment instruments, including:

1. Venture capital – investments in start-ups and companies developing artificial intelligence technologies to optimise energy consumption.

2. Project financing – financing of specific projects using artificial intelligence to analyse and optimise energy consumption.

3. Corporate investments – investing in the development of proprietary artificial intelligence systems for energy efficiency management at industrial enterprises.

4. Stock market – investing in shares and bonds of companies specialising in the development and implementation of innovative technologies for the energy sector (Kalenyuk, Bohun, & Djakona, 2023).

5. Crowdfunding is raising funds from individual investors on platforms dedicated to the development of AI projects in the energy efficiency sector (Tsymbal, Kalenyuk, 2023).

These instruments provide investors with the opportunity to invest in various projects and companies aimed at using artificial intelligence to optimise energy consumption and reduce excess energy generation in Ukraine.

The method of regression analysis, when used in conjunction with artificial intelligence to calculate energy consumption aimed at reducing excessive energy production in the context of Ukraine's recovery, involves analysing the relationships between energy consumption and various influencing factors using statistical methods. The main objective of this method is to predict the volume of energy consumption based on historical data and other parameters influencing energy consumption.

The essence of the method is to construct a mathematical model that describes the relationship between variables, such as time series of energy consumption, temperature indicators, economic factors, and so forth. This model can be developed using various machine learning and artificial intelligence algorithms, such as linear regression, polynomial regression or neural networks.

Once the model is built, its efficiency and forecasting accuracy are analysed using test data. This method can be used to forecast energy consumption for future periods, which makes it possible to optimise power systems, prevent excessive energy production and reduce energy costs in the context of Ukraine's energy recovery.

This method is applied by analysing a large amount of data on energy consumption and its dependence on various factors such as temperature, time of day, economic indicators, production volumes, etc. Data is first collected from various sources such as sensors, meters, databases, etc. Subsequently, machine learning and artificial intelligence algorithms based on regression analysis methods are used to build a mathematical model that reflects the relationship between energy consumption and influencing factors. This model analyses a large amount of data and studies the relationships between different parameters.

After the model is built, it is tested on new data to check its effectiveness and forecasting accuracy. This allows to identify trends and understand which factors have the greatest impact on energy consumption and how it can be optimised.

The results obtained can be used to make decisions on energy supply, energy production planning, energy efficiency and reduction of excess energy generation in the context of energy recovery in Ukraine.

The cumulative sum method, within the framework of the application of artificial intelligence to the calculation of energy consumption aimed at the reduction of excessive energy production in the conditions of Ukraine's recovery, involves the analysis of the accumulated sum of energy consumption data over a certain period of time. The essence of the method is to add the current value of energy consumption to the previous accumulated value at each step of the analysis, thus forming a cumulative sum. This allows changes in energy consumption to be tracked and trends to be identified.

The cumulative sums method enables to determine the level of energy consumption over time and understand the dynamics of its changes. This approach can be useful for predicting future energy consumption, identifying anomalies in consumption, and determining effective strategies to reduce excess energy generation and improve energy efficiency.

## 4. Perspective Directions for the Implementation of Artificial Intelligence in Energy Consumption Calculations to Reduce Excess Generation in the Restoration of the Ukrainian Energy System

Artificial intelligence is a powerful technology that can help address some of the most pressing issues in the energy sector, such as reducing greenhouse gas emissions, improving efficiency and increasing reliability. This article explores how artificial intelligence is used in the energy sector and how it can benefit both consumers and producers.

1. Smart grid management. One of the main applications of artificial intelligence in the energy sector is smart grid management. A smart grid is a network for the generation, transmission, distribution and consumption of electricity that can monitor and optimise the flow of electricity in real time using data from sensors, smart meters, weather forecasts and other sources. Artificial intelligence can help optimise the operation of the smart grid by analysing data from sensors, meters, weather forecasts and demand patterns, and adjusting electricity supply and demand accordingly. For example, AI can help balance the integration of renewable energy sources such as solar and wind, which are variable and intermittent, by predicting their output and coordinating with other sources such as batteries and gas turbines. AI can also help

detect and prevent faults, outages and cyber-attacks on the grid by monitoring the health and performance of the system and taking corrective action when necessary.

2. Predictive maintenance. Another application of AI in the energy sector is predictive maintenance. This involves using artificial intelligence to monitor the condition and performance of energy assets such as power plants, turbines, pipelines and transformers, and to identify and diagnose potential failures before they occur. This can help reduce downtime, extend equipment life and save costs.

3. Energy efficiency. The third application of AI in the energy sector is energy efficiency. AI can help improve the energy efficiency of buildings, vehicles, appliances and industrial processes by analysing data and providing insights and recommendations to reduce energy consumption and losses. AI can optimise heating, ventilation and air conditioning (HVAC) systems in buildings by analysing data from sensors, thermostats, movement patterns and weather forecasts and adjusting temperature and air exchange accordingly. In addition, AI can optimise fuel efficiency in vehicles by analysing data from sensors, GPS, road conditions and driver behaviour, and adjusting speed, acceleration, braking and routing accordingly.

First, the application of AI to energy saving requires efficient technologies, not too diverse ones. Second, AI should have a lasting energy-saving effect in different application scenarios, rather than just looking for a single case to achieve the highest energy-saving effect. Finally, the impact of AI on stable control and subsequent changes in control characteristics should be fully understood before applying this method.

For example, Microsoft has developed an artificial intelligence solution called Azure IoT Central, which can connect and manage millions of Internet of Things devices and provide insights and actions to improve energy efficiency.

Another example is the Nest thermostat. Developed by Nest Labs and later acquired by Google, the Nest thermostat is a learning thermostat that optimises heating and cooling, using energy only when it is needed.

4. Energy trading. Another application of artificial intelligence in the energy sector, which may not yet be widespread, is energy trading. AI can help facilitate the trading of energy commodities such as electricity, gas, oil and carbon credits by analysing data on markets, prices, supply and demand trends, regulations and weather forecasts, and providing insights and predictions on optimal trading strategies. For example, AI can optimise the bidding and scheduling of generators and electricity consumers in wholesale markets by predicting market prices and demand curves and maximising profits or minimising costs. AI can also optimise the trading of carbon credits in emissions markets by predicting carbon prices and emissions levels, maximising profits or minimising penalties.

5. Energy efficiency in industry. Industrial energy efficiency involves the use of algorithms and artificial intelligence technologies to analyse and optimise the use of energy resources in industrial processes. This includes the use of monitoring and forecasting systems for energy consumption, as well as automated control of energy systems and equipment. The aim is to make efficient use of energy resources, reduce excess energy generation and lower energy costs in industrial production. Artificial intelligence makes it possible to analyse large amounts of data, identify energy consumption patterns and develop optimal strategies to reduce costs and increase productivity.

6. An artificial lighting system that uses artificial intelligence to calculate energy consumption with the aim of reducing excess generation is an innovative approach to optimising electricity use. This system uses artificial intelligence algorithms to adapt the lighting in premises to different conditions and user needs for efficient energy use. It can automatically adjust lighting brightness, turn lights on or off based on room occupancy, and optimise power consumption based on weather conditions and lighting characteristics. This significantly reduces electricity costs and improves the energy efficiency of the lighting system.

## References:

Suhodolya, O. M. (2022). Artificial intelligence in energy: analyst. report. Kyiv: NISD, 49 p. DOI: https://doi.org/10.53679/NISS-analytrep.2022.09

Stogniy, B. S., Kirylenko, O. V., Prakhovnyk, A. V., & Denisyuk, S. P. (2012). The evolution of intelligent electrical networks and their prospects in Ukraine. *Technical Electrodynamics*, Vol. 5, p. 51–67. Available at: http://dspace.nbuv.gov.ua/bitstream/handle/123456789/62229/08-Stogny.pdf?sequence=1

Dzyubanovska, N. V. (2023). Innovative approaches to the formation of the energy network of the future with the use of artificial intelligence. *Innovative Economy*, Vol. 1 (93), p. 158–163. DOI: https://doi.org/10.37332/2309-1533.2023.1.21

Krutohorskyi, Y. V. (2014). Tools for stimulating the implementation of energy saving technologies at industrial enterprises. *Efficient Economy*, Vol. 12. Available at: http://www.economy.nayka.com.ua/?op=1&z=5838

Serdyuk, T. V., & Franishyna, S. Yu. (2009). Peculiarities of implementation of energy saving policy in Ukraine: achievements and ways of improvement. *Bulletin of the Khmelnytskyi National University*, Vol. 1, p. 52–56. Available at: http://journals.khnu.km.ua/vestnik/pdf/ekon/2009_1/zmist.files/_12.pdf

Artificial intelligence (AI) – what is it, how does it work, and why is it needed. Available at: https://termin.in.ua/shtuchnyy-intelekt/

The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept of Artificial Intelligence Development in Ukraine" of December 2, 2020, No. 1556-p. Available at: https://zakon.rada.gov.ua/laws/show/1556-2020-%D1%80#Text

Anastasiia Klian. Legal regulation of artificial intelligence in Ukraine and the world. GOLAW. 02.03.2022. Available at: https://golaw.ua/ua/insights/publication/pravove-regulyuvannya-shtuchnogo-intelektu-v-ukrayini-ta-sviti/

The Order of the Cabinet of Ministers of Ukraine "On Approval of the Concept for the Development of Artificial Intelligence in Ukraine" of 2 December 2020 No. 1556. Available at: https://zakon.rada.gov.ua/laws/show/1556-2020-%D1%80#Text

Tokareva, K. S., & Savliva, N. O. (2021). Peculiarities of legal regulation of artificial intelligence in Ukraine. *Legal Bulletin*, Vol. 3(60), p. 148–153. Available at: https://www.google.com.ua/url?esrc=s&q=&rct=j&sa=U&url=https://jrnl.nau.edu.ua/index.php/UV/article/view/15967/23255&ved=2ahUKEwigrav1n7j-AhXthv0HHTTeDv84ChAWegQIBBAC&usg=AOvVaw28DCqkdlvGIOj_-Ug9thXv

Gryshanova Nadia. Legal regulation of artificial intelligence: a Working Group has been established at NAAU. LEAGUE: LAW. 03.09.2023. Available at: https://jurliga.ligazakon.net/news/218005_pravove-regulyuvannya-shtuchnogo-ntelektu-u-naau-stvoreno-robochu-grupu

Globa Konstantin, Vakhlis Inna. The Law of Ukraine "On Artificial Intelligence": does it exist? Legal newspaper online. 13.03.2023. Available at: https://yur-gazeta.com/publications/practice/informaciyne-pravo-telekomunikaciyi/-zakon--ukrayini-pro-shtuchniy-intelekt-vin-e.html

Ihor Kotkov. AI Act: What the EU thinks about artificial intelligence. Legal IT Group. 31.01.2023. Available at: https://legalitgroup.com/ai-act-shho-yes-dumaye-pro-shtuchnij-intelekt/

The Order of the Cabinet of Ministers of Ukraine "On Approval of the Government's Priority Action Plan for 2020" of 9 September 2020 No. 1133-p. Available at: https://zakon.rada.gov.ua/laws/show/1133-2020-%D1%80#Text

Kalenyuk, I., Bohun, M., & Djakona, V. (2023). Investing in intelligent smart city technologies. *Baltic Journal of Economic Studies*, Vol. 9, No. 3, p. 41–48. DOI: https://doi.org/10.30525/2256-0742/2023-9-3-41-48

Tsymbal, L., & Kalenyuk, I. (2023). Digital transformation of the global education market. *Baltic Journal of Economic Studies*, Vol. 9, No. 5, p. 266–274. DOI: https://doi.org/10.30525/2256-0742/2023-9-5-266-274

Received on: 05th of February, 2024
Accepted on: 19th of March, 2024
Published on: 05th of April, 2024