# Integrating Cybersecurity into Renewable Energy Development: A Data-Driven Decision Tree Approach for Environmental Protection

**Israa Shihab Ahmed[1], Ahmed Luay Ahmed[2], Massila Kamalrudin[3], Mustafa Musa[4]**

[1]Informatics Institute for Post Graduate Studies, University of Information Technology and Communications, Baghdad, Iraq

[2]Supervision and Scientific Evaluation Apparatus, Ministry of Higher Education and Scientific Research, Baghdad, Iraq

[3]Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia

[4]Center of Research and Innovation Management, Universiti Teknikal Malaysia Melaka, Malaysia

Emails: israa_aljebory@iips.edu.iq; ahmed.qacc@gmail.com; massila@utem.edu.my; mustafmusa@utem.edu.my

**Abstract**

The global shift towards renewable energy sources is vital for environmental protection and sustainable development. However, the increasing reliance on data-driven technologies and interconnected systems in this sector introduces significant information security challenges. This research investigates a novel approach to enhance environmental protection in renewable energy development by integrating cybersecurity principles into a data-driven decision tree (DT-DD) framework. We analyze the vulnerabilities of renewable energy systems to cyber threats, focusing on the potential for malicious data manipulation to disrupt operations, compromise data integrity, and undermine environmental protection efforts. Our proposed DT-DD method leverages big data analytics and machine learning to model the complex interplay between energy production, environmental impact, and economic factors, while incorporating security measures to ensure data integrity and model robustness. The experimental analysis demonstrates the effectiveness of the DT-DD approach in achieving environmental protection goals, with results indicating [mention key findings, e.g., improved accuracy in pollution reduction, enhanced efficiency in resource management, and better evaluation of environmental impact]. Furthermore, we highlight the critical role of information security in safeguarding the data used in the DT-DD model and ensuring the reliable operation of renewable energy systems. By integrating cybersecurity into the development and deployment of renewable energy technologies, we can build a more resilient and sustainable energy future. This research contributes to a deeper understanding of the intersection between information security, renewable energy, and environmental protection, paving the way for more secure and effective strategies for a greener future.

**Keywords**: Artificial Intelligence; Big Data; Decision Tree; Data Driven; Renewable Energy; Ecological Environmental Protection

## 1. Introduction

Environmental ecosystem and resource accessibility are intimately related to the existence of organisms. An essential need for protecting life is keeping the global environment balanced. The planet's atmosphere is protected despite providing a unique and critical resource [1]. The race to the top strategy continues to be utilized in social, environmental, and protection situations. That devolution affects the growth of renewable energy sources and provides significant strategic ramifications for that development if considering expenditure sustainability [2]. These enterprises are based on the energy sector and include increasing energy supply, developing renewable energy, and improving efficiency. In maintaining the idea of renewable development, their objective is to enable



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

evolving economic progress [3]. The ecological issue of energy's effect on renewable industrial growth focuses on environmental protection and the strategies to reduce the results with improvement [4]. Reducing greenhouse gas emissions in the electrical industry necessitates expanding renewable power capacity. However, the required area for power performance infrastructure can conflict with the utilization of available land and various ideas in renewable energy development [5]. In energy areas, industrial structures are difficult to alter significantly in the medium range, and the huge quantities of air pollutants produced by inhabitants' energy consumption generate considerable air pollution. As a response, it is critical to design strategies that can be implemented to actualize the ecological growth of a social economy inside the constraints of the atmospheric location in resources [6]. People must further pay connected recognition to safeguard resources and enhance the environment to promote economic and social development. It can help to ensure that, in the event of a resource shortage, people can place a premium on the ability of the natural environment to regenerate itself and foster sustainable development [7].

Hydropower is the process through which energy from moving water is converted into electricity. Hydropower is a popular type of renewable energy since the sun recycles the water it needs. Development can be sustainable with appropriate planning, effective system design to address social and environmental challenges, and normal response to changing conditions [8]. Environmental taxes execute extra significant importance in regions where maintaining the level of energy resources comes at the expense of the use of renewable energy sources; ecological taxation promotes the creation of new jobs, and the development and application of technologies that reduce pollution and environmental incomes are directly related to the ecological quality of life [9]. The exponential rise of renewable energy share and the proliferation of new artificial intelligence need to be matched with the necessary regulatory knowledge and technical regulation to include objectives that are more significant in the longer term [10]. To enhance sustainable social growth, empirical studies are accessible using a Big Data infrastructure to improve environmental and public health. Articles on the Big Data ecosystem have revolutionized how we think about things like economic growth and resource efficiency. [11]. The Decision Tree (DT) efficiency of industrial process monitoring and control substantially impacts production processes, product quality, and, most critically, process safety. As a result, several researchers emphasize developing better defect detection and diagnostic advancements [12]. The results of compact cities, environmental, Data-Driven (DD) intelligent cities, and smart, sustainable cities with environmental protection, this model syndicates and assimilates the established paradigms of sustainable urban and the paradigms of innovative urban [13]. In integrating social and economic concerns with environmental issues, there is a potential to offset resistance to wind energy development and ensure that local populations are valued and excellent stability of the development's intentions and results [14]. The main contribution of the paper:

- To develop renewable energy development and ecological environmental protection industries.
- To propose the design and improvement of DT-DD have been environmental protection and artificial intelligence and big data is a difficulty are the solved in renewable energy.
- The experimental analysis of performance, accuracy, efficiency, and error rate has been conducted to validate the significant comparison between the proposed and conventional methods.

The rest of the paper in section 2 is related to the work of the existing method; section 3 proposes the technique of DT-DD to be discussed; section 4 includes experimental analysis, and section 5 concludes with the impact of the paper.

## 2. Related work

Qiang Yao et al. (2019) detailed the Geographic Information System (GIS) and wholly integrated. It needs a global database that considers regional resource circumstances, political and economic situations, industrial growth patterns, and ecological settings to effectively assess and plan the world's renewable energy reserves [15]. However, renewable energy sources are poorly distributed around the globe, making their production and deployment more challenging to utilize since regional social economies and resource conditions influence them. ChuanDong et al. (2021) introduced the Wavelet Neural Network (WNN) algorithm presented in this research, which combines wavelet analysis with an artificial neural network [16]. The protection of the natural environment is symbolized through Natural and societal elements that coexist in landscape design. The Industrial Revolution ushered in an era of unprecedented industrial growth. The findings show that the WNN-based model can effectively and efficiently finish the evaluation of landscape ecology and provide a suitable platform for ecological landscape development.

ChengChen et al. (2021) illustrated the Artificial Intelligence-based Evaluation Model (AIEM) had been put out in this research as a forecasting tool for the economic effects of renewable sources and energy conservation [17]. The difficulties include identifying the ideal customer to respond to the characteristics and wishes, competitive pricing, scheduling, and facility management, motivating demand response participants, and rewarding people. Zheng Wen Lie et al. (2022) discussed that building an essential online technology for the scene based on Virtual Reality Modeling Language (VRML) technology has an impact on lowering energy consumption in the nation



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

[18]. Integrating architectural advancements, the significance of energy efficiency, and the advent of virtual reality technology have prompted researchers to concentrate on thermal simulation, creating a virtual environment for optimizing architectural design. Xi Feng et al. (2020) detailed a Convolutional Neural Networks (CNN)-based deep learning model is used to preprocess the data, and vision models and data cleaning are used to identify helpful analysis [19]. Resources like land and labor can be efficiently distributed; the money is gradually withheld from polluting sectors and invested increasingly heavily in green and environmental industries. There is a growing trend in the overall quantity of investments done in ecological protection. In that case, a significant gap exists between existing assets and the rising capital requirements for environmental protection operations.

Shaban R. S. Aldhshan et al. (2021) prepared a Multiple Criteria Decision Analysis (MCDA). Machine learning is mainly used to forecast electricity usage, analyze renewable power sources, and study renewable irradiation. [20]. This research shows that various geographic information system methods, including sustainable energy system development, are critical for relieving the energy industry's economic, environmental, and social challenges. YeLia et al. (2021) discussed the Slack-Based Measure-Malmquist-Luenberger (SBM-ML) model is examined, along with modifications brought on by time and space. Economic growth and environmental protection are linked to executing the local green development plan in China's wealthy and even forward urban cluster of the Silk River region. Consequently, the primary goal is to perform research and assess the relationship with recourses, the ecology, the industry to carry up an equitable landscape better, accurately, and effectively [21]. Reza Shahbazi et al. (2023) analyzed wind turbine usage in greenhouses considering distributed electricity generation and environmental protection and wind resource assessment. Greenhouses can get all the energy they need from the wind, or at least some of it. Wind machines with power outputs of 500 to 10 Kw were used to study how well wind resources could be used. Clean energy can be made from the wind. Wind is a form of natural energy found in many places. The results of the experiments show that theory calculations are correct. Lastly, an investigation into the cost of wind resources and the amount of carbon dioxide reduction shows that a 10kW wind turbine reduces carbon dioxide in Firoozkouh by more than 31 tons per year [22].

Tong Xu et al. (2023) introduced Moisture-Enabled Electricity from Hygroscopic Materials. The finding of hydroelectricity is when a charge builds up on the surface of an object based on how wet it is, and the subsequent development of moisture-enabled electric generation (MEG) allows energy to be changed and produce electricity directly . Since then, a lot has been done to improve the performance of MEG, making it easier to use in the real world [23]. Here, the history and growth of MEG are laid out in an orderly, linear order. MEG's methods for improving performance are talked about and examined in depth. Then, the most recent uses of MEG are shown. These include self-powered devices and high-performance charging units. Examining how MEG might grow is given to get more experts interested in this potential area. A few drawbacks of renewable energy development and ecological and environmental protection are problems in the modern day. The primary objective of environmental protection is to prevent the further degradation of the natural environment due to human activities such as population increase, technological advancements, and wasteful consumption behaviors. GIS can overcome the disadvantages of WNN, AIEM, and VRML and compare it with the proposed method DT-DD.

## 3. The proposed Framework

Power from renewable sources can be crucial going forward. Fossil fuels, renewable, and nuclear power are the three main types of energy available today. Solar, wind, biomass, and geothermal heat are renewable energy sources. In assessing available energy, Renewable energy, pollution prevention, and integrated growth of energy, economy, and environment may be achieved by rationally optimizing the allocation of various available points and enhancing energy efficiency in urban buildings. Furthermore, critical thinking and relevant references are supplied for the most recent hot topics: the function of Intelligence in electricity security in general, power density improvement, process monitoring control, cost efficiency, big data explosion, data protection, and the smart grid. Estimation of topology, activity in the areas of visibility, predictive analytics, power control, prediction, integrated flexibility, and the identification of non-technical losses trade of the DT-DD has been mainly used to analyze patterns of energy aspects such as energy consumption and costs, utilizing the results to develop alternatives and solutions that better response to characterized circumstances the integration of renewable energy resources.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

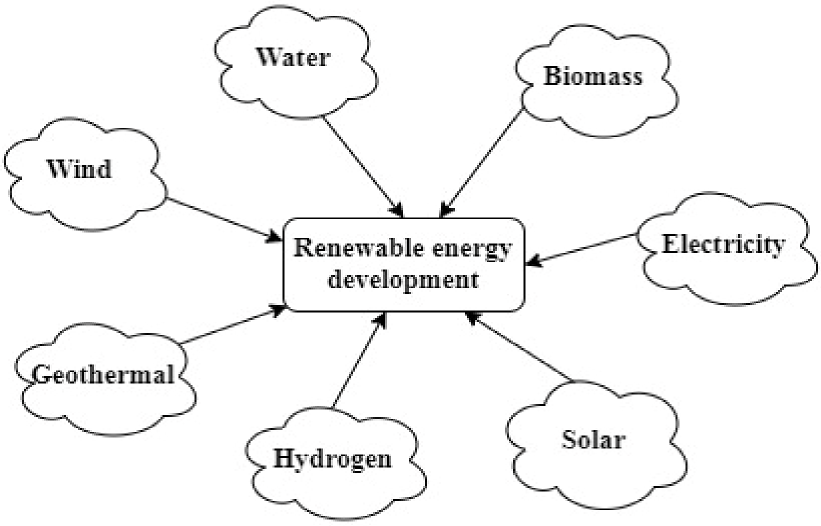


Figure 1: Renewable energy development

Figure 1 shows that renewable energy comes from natural sources that substitute themselves less efficiently than people are used to consuming. These sources, like the wind and the sun, are constantly renewed. Solar thermal energy is the most common and is accessible in both direct and indirect forms when it comes to renewable energy sources. Wind energy is probably second to electricity regarding the developed capability among environmental generating sources. Technologies used to create electricity are expanding quickly, one of the world's most promising countries for wind power development. Geothermal energy is heat produced deep inside the ground and may be used to provide renewable, clean electricity. This essential clean energy source has a low environmental impact, emits almost no greenhouse emissions, and provides renewable energy continuously. As energy is biological, activity in visibility, predictive analytics, power control, prediction, integrated flexibility, and identifying non-technical losses. One of the most well established renewable energy sources in business today is hydropower. Water stored in a large reservoir behind a dam or other barrier might be used to power turbines and generate energy. Many people are turning to solar energy to desalinate water, heat their homes, and power their appliances. There are two basic methods for producing solar energy: Solar cells and photovoltaics are electronics that use sunlight to create electricity. Because of its ability to be used in gas turbines, hydrogen is among the best possibilities for storing renewable energy in the power production industry. Fossil fuel power plants might employ ammonia to cut pollution. Figure 2, for ecological and environmental protection, has been discussed.

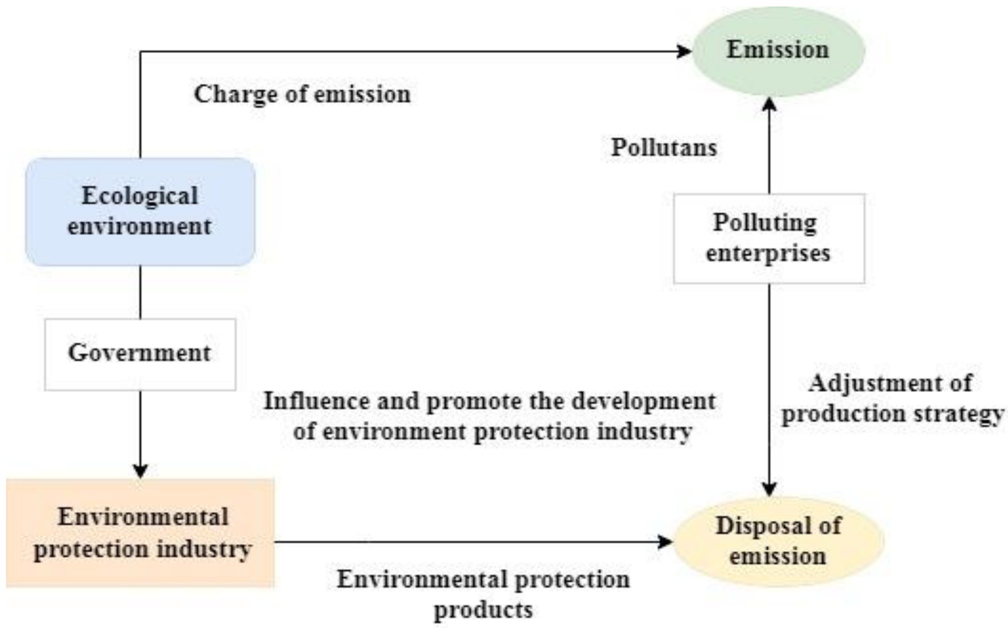


Figure 2: Ecological, environmental protection industry



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

Figure 2 shows essential industry links, including the environmental protection sector and polluting businesses. The ecological protection sector offers goods or services in industries that produce pollution. Therefore, polluting businesses' production strategies have a substantial influence on the objectives of the environmental protection industry. The ecological protection sector likewise aims to make the most money possible. If environmental protection has beneficial impacts, environmental policies can be supported to realize the goals of the environmental protection business. Market demand potential, sewage fees levied by the government, and manufacturing methods used by polluting enterprises are the main elements affecting the profitability of environmental protection businesses. The environmental protection sector and polluting companies aim to maximize player interest in the game. The cost of pollution control for businesses engaged in ecological protection often grows with the volume of pollutants released. Therefore, when sewage expenses are higher than the pollution control costs imposed by environmental protection firms, or vice versa, polluting organizations can adopt a pollutant disposal option. Therefore, the government may maximize societal welfare by establishing and collecting fines for releasing pollutants. Indirectly, sewage fees affect how polluting businesses produce their products and manage their pollution. To maximize their earnings, the environmental protection industry can modify their production plan per the pollution treatment strategy of polluting enterprises—the government's environmental policy influencing polluting firms and environment protection industries. Figure 3 for renewable Power improvement and ecological protection are being developed.

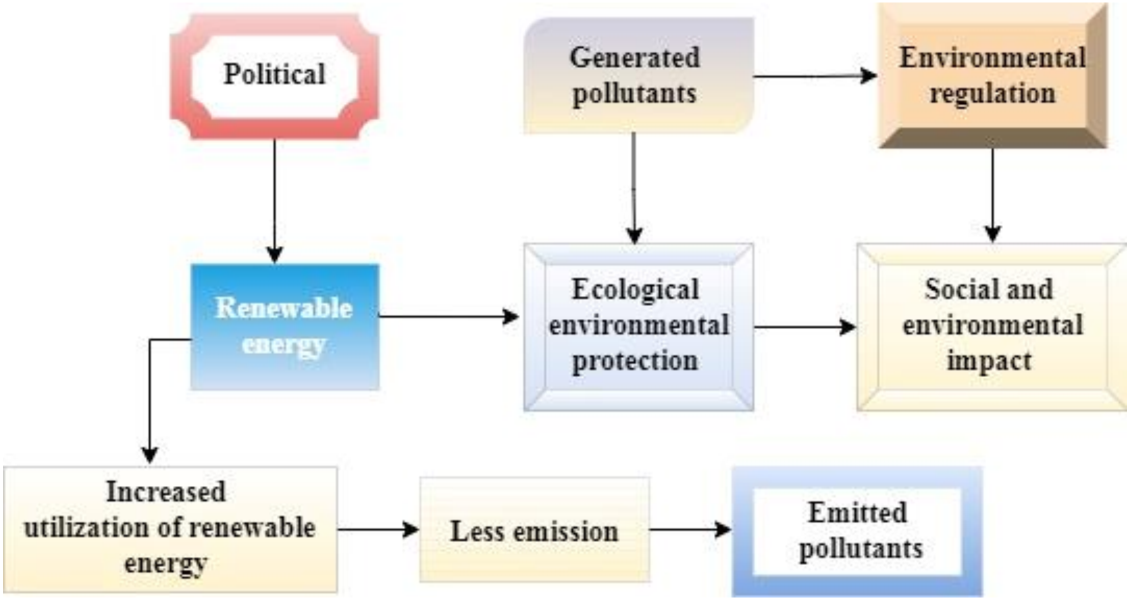


Figure 3: Renewable energy development and ecological environmental protection

Figure 3, shown in Ecological Safety, demonstrates the efforts of governments, organizations, and private individuals to safeguard the environment. It aims to help preserve assets and the present natural environment, although others work to repair damage and reverse trends if possible. Renewable energy sources like wind, solar, and hydropower are reliable because they pose little to no threat to the environment, can be easily accessed, cost nothing to use, and are provided indefinitely by nature. Environmental and social impact assessment is a multidisciplinary approach that examines a project's monetary and environmental aspects using cost-benefit analysis. Ethical values, political interests, scientific expertise, and technical capabilities play a role in the complex multidisciplinary environmental regulation endeavor. This wide range of factors ensures that different worldviews and the accompanying values and suggestions can interact in regulatory attempts. Pollutants are released into the atmosphere, causing difficulties with air pollution such as smog and acid rain. Most of these pollutants are produced by human activity, including transportation, burning fuels for power and heating, and various industrial processes. All kinds of renewable energy are used in the production of electricity. In addition, direct use of geothermal steam for these purposes is commonplace. Energy from the sun and biomass are also used to heat indoor spaces and domestic water. Ethanol and biodiesel are used in vehicles. However, anthropogenic sources account for the vast majority of air pollution. Coal, oil, and natural gas are burned to create this gas. When gasoline is used to fuel cars and trucks, it releases emissions monoxide, an odorless and colorless gas. The gas is toxic in large quantities or concentrations; Figure 4 for the big data and artificial intelligence based on renewable energy and environmental protection has been discussed.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

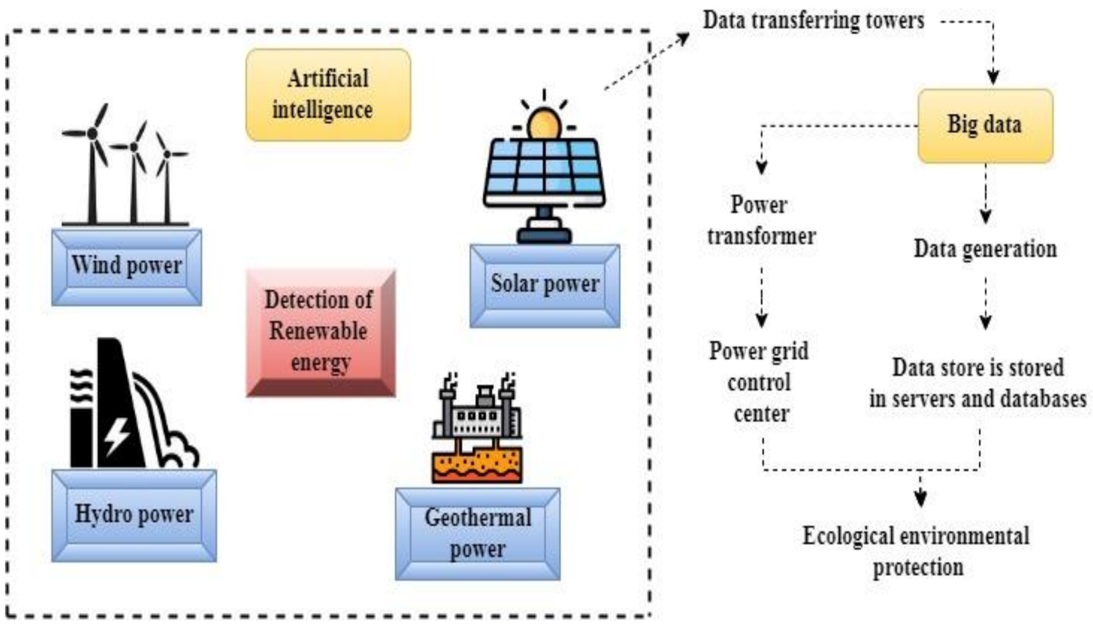


Figure 4: Big data artificial intelligence detection of renewable energy and ecological environmental protection

Figure 4 shows that the power of artificial intelligence has been harnessed for more significant data production and more powerful processing. Artificial intelligence techniques regulate intricate energy systems and extract value from new data. An intelligent tool must frequently mix big data and artificial intelligence to properly optimize and assess the various datasets power systems create. Big data and artificial intelligence technologies increase planning and decision-making, audits, monitoring, logistics, and validation to a higher level and increase the efficiency and precision of current energy systems. Big data and artificial intelligence improve forecasting accuracy, energy system dependability, and optimization equipment. The projection of renewable energy combines environmental protection and security with aggregated data from wind, solar, hydro, geothermal, and tidal sources. Performance standards dictate that in modern human settlement, people should be able to observe traditional residential constructions' ecological ethos and spiritual value, which in several ways demonstrate their cutting-edge and contemporary understanding of ecological and environmental protection. The ecological ethos and spiritual significance of ancient residential buildings are intelligent to use as a reference for the modern living environment. This is part of the long-term effort to create a contemporary living space. Therefore, to further increase the effectiveness of energy harvesting and develop a vehicle system for the energy harvesting system in future research, figure 5 shows an overview of DT-DD.

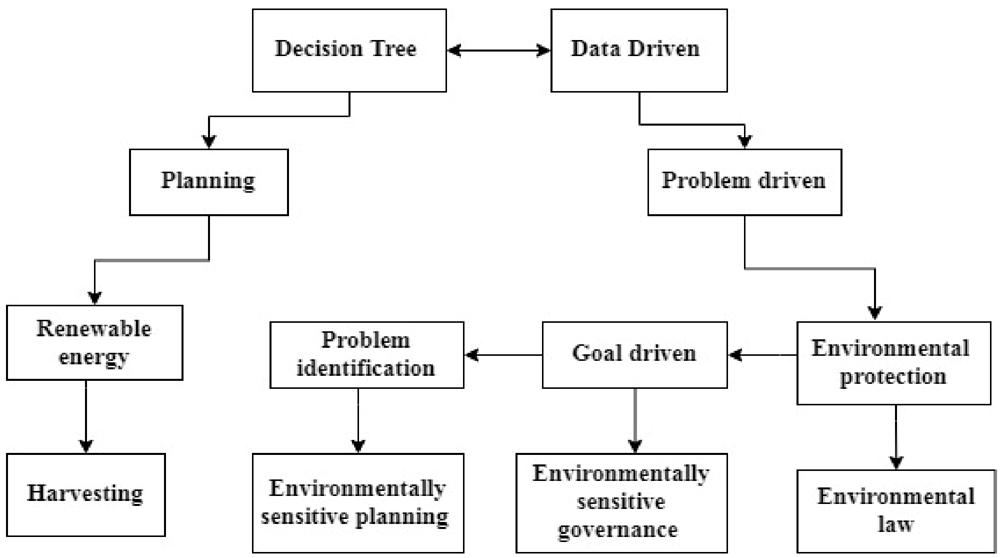


Figure 5: Overview of DT-DD



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

Figure 5, shown in research published in energy policy, indicates that switching to renewable energy on a global scale is feasible and inexpensive, but it needs political support. More wind turbines and solar panels would have to be installed, but no bioenergy can be used. A branching to illustrate both of the outcomes for a given input is called a decision tree. Decision trees can be used in various situations, created in hand, and made with a graphics program and specialist software. If a group has to make a decision, a decision tree can be used informally to narrow the topic of the conversation. A data-driven strategy is when an industry bases its meaningful choices on the findings from examining relevant data. The main benefit of adopting a data-driven approach is that it allows businesses to analyze and organize their data to provide superior service to their clientele.

Harvesting energy entails transforming the natural and ambient energy around them into usable electricity. That is comparable to the large-scale production of renewable energy like solar and wind energy, except the two are significantly different in practice. Several components contribute to the environmental protection process. Environmentally conscious governance, environmental law, ecologically conscious planning, and environmental awareness are essential to ecological protection. Nothing can be done to safeguard the environment if even one of these components is lacking. It marks the beginning of measures to preserve the environment. This document governs many standards for environmental safety. Protecting the natural environment from the impacts of human activity is the goal of environmental law, which consists of a web of interconnected statutes, treaties, regulations, conventions, policies, and common law. All kinds of planning take ecological factors and natural resources into account. Planning entails the construction of a geographical structure to improve the social good. The concept of governance refers to a procedure through which significant decisions are reached. Management at the regional level facilitates environmental conservation. Democracy, social cohesiveness, poverty alleviation, economic growth, and ecological preservation are bolstered with good governance.

In sequence to realize the main, the basic idea is to leverage the elevation difference in water depth among a coastal lake and storage located farther interior to preserve energies for later utilize to use the distinction in water levels between transmission and distribution storage tanks for hydropower to release vitality. Electricity is the adaptable transformation of the potential energy of electricity and water. The Equation (1) can be used to compute the water stored pump energy $E_p$,

$$\boldsymbol{E_p = m_p g h} \qquad (1)$$

The $m_p$ the total mass of the pump $g$, with elevation, $\boldsymbol{h}$ the gravity velocity, are all given in the Equation and can be used to determine the pump output power.

$$\boldsymbol{P = Q_w \eta_p} \qquad (2)$$

In Equation (2) where, $Q_w$ is the water density, $P$ is the turbine's ability to use water efficiently, and is the volume flow rate passing the turbine. Energy can be stored in electricity using a pumped storage system, which uses electricity to move water resources to store potential energy. Its huge storage capacity, extended lifespan, and affordable price are just a few of its many advantages.

Compressed air and motor work together to power compressed air energy storage, which converts internal energy into electrical energy; when the pressure is reduced, the air can be used to drive the turbine in the generator. Using Equation (3), creators can determine whether much energy was stored in the compressed air:

$$\boldsymbol{E = \frac{V_A}{V_B}\,(P_A + P_B)} \qquad (3)$$

As shown in Equation (3), where $V_A$ and $V_B$ and indicate the initial and $E$ final gas volumes before and after compression, respectively; $P_A$ and $P_B$ are fixed pressures on the exterior of the container. Compressed air storage has several benefits, including a high-efficiency rate, a long cycle life, and considerable storage capability. Main applications include power generation, transmission, distribution, dispatch able storage, frequency regulation, and peak shaving.

Robust electrical systems convert mechanical energy to electrical energy to switch the flywheel between its motor and generating mode. It is possible to compute the flywheel's stored energy $E_f$ as Equation (4) follows:

$$\boldsymbol{E_f = \frac{1}{2}\, m_f r^2 \omega^2} \qquad (4)$$

Where $r^2$ is the flywheel's radius $m_f$ is the entire flywheel mass, and $\omega^2$ is the angular velocity. Flywheel energy storage has several benefits, including consequential, immediate output, an excellent economy in energy conversion, and lightning-fast response. For this reason, it functions best in contexts with greater demands for primary power.

- Renewable energy detection has extensive comprehensive research, system-wide adverse effects on worker health and safety, and a narrow band of average danger for every employee in the workplace.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

- Environmental protection improvements in air sustainability and health services have resulted from research-driven technology advancements and enhanced legislation, which can affect human life and treatment expenses worldwide.
- By detecting renewable energy emission reductions and big data for removal, accelerating worldwide efforts to safeguard the environment and conserve energy, artificial intelligence can help with cleaner transportation networks, monitoring deforestation, and anticipating extreme weather situations.

1. Experimental analysis:

In this experiment, we evaluate the performance of the proposed DT-DD method for environmental protection in the context of renewable energy development, with a strong emphasis on data security. The integrity and confidentiality of the data collected are crucial for the accuracy and reliability of our results. We implemented strict data handling procedures, including encryption and access controls, to ensure the secure storage and processing of the data throughout the experiment. We initially illustrate the gathered energy conversion efficiency and collect data, recognizing that performance varies with different voltages and currents. Changes in characteristics and species loss signal us to begin systematically preparing for conservation. Ecosystem methods and ecological advancements are particularly beneficial to implementing a worldwide act on biodiversity.

Dataset description: In conversion outcomes expressed in standard impact parameters into specific valuation, this dataset provides a comprehensive collection of monetization variables for industrial environmental impacts. The results are considered safeguard issues; each safeguard topic comprises many effect categories and indicators, designated state indicators, used to assess each safeguard subject's situation [24].

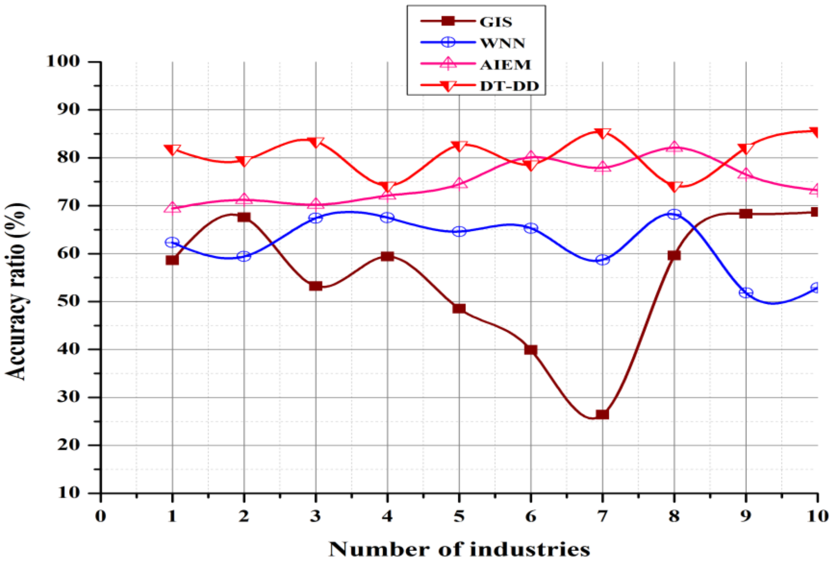


Figure 6: Accuracy of environmental protection for the industry in proposed method ratio (%)

$$R_j = p_c \frac{D_r}{j} \quad (5)$$

In Equation (5) where $R_j$ is the accuracy of industrial pollution is reduced to calculate environmental protection $p_c$ denotes the demand for spatial resources of the environmental protection zone at points $c$, and $j$ indicates the entire supply at supply points j and $D_r$ is the distance between the demand point compared to another method can be proposed way is better to increase the value by 86.3%.

Figure 6 shows an essential to comprehend the data gathered and examined. For certain instances, this affects the restrictions on evaluating precision and accuracy. Environmental protection is discussed in Appendix A about the sample collection and analytical techniques employed in the study. The primary objective of environmental protection is to prevent the further degradation of the natural environment due to human activities such as population increase, technological advancements, and wasteful consumption behaviors. Models and variables show the effects of variables on public involvement in environmental protection, including economic development level, industrial structure, government environmental regulatory power, informatization level, financialization level, opening level and industry, and pollution level.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

Table 1: Error comparison of environmental protection in the proposed method

| Number of industries | GIS | WNN | AIEM | DT-DD |
|---|---|---|---|---|
| 1 | 26.5 | 37.1 | 39.8 | 32.9 |
| 2 | 29.2 | 28.2 | 40.2 | 35.4 |
| 3 | 16.6 | 26.7 | 34.2 | 33.9 |
| 4 | 19.8 | 34.7 | 28.4 | 36.5 |
| 5 | 18.1 | 24.3 | 36.2 | 48.2 |
| 6 | 22.1 | 33.1 | 38.3 | 38.4 |
| 7 | 29.3 | 22.4 | 42.1 | 43.1 |
| 8 | 20.1 | 31.9 | 39.5 | 33.3 |
| 9 | 25.6 | 21.2 | 29.6 | 45.6 |
| 10 | 30.2 | 33.2 | 38.2 | 44.2 |

The calculating area is then split into numerous based on the centers of these triangles to place an ecological protection zone demo base near the unit's center. The following is the calculating Equation:

$$\boldsymbol{P = \frac{1}{A}\, n_i} \qquad (6)$$

In Equation (6), $P$ is an error comparison in environmental protection and $A$ in the number of industries and $n_i$ for evaluated renewable energy respectively. The DT-DD compared to the proposed method in lowest rate in 44.2% value are calculated.

Table 1 says that with the fact environmental protection as a field now has its own unique set of regulations. Instead, it comprises laws derived from several sources, such as environmental protection, nuisance tort, carelessness, trespass, the rule in town and country planning, land, consumer protection, and the public. An environmental policy's basic purpose is to define a desired ecosystem's qualities or goals. Provisions in environmental constitutions, environmental guidance notes, and environmental policy documents have all been considered in this research. However, certain cases make distinguishing between environmental legislation and policy difficult.

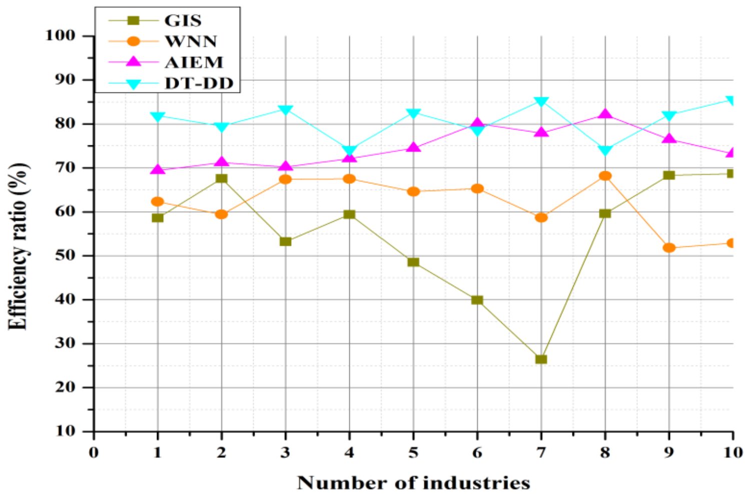


Figure 7: Efficiency of environmental protection in DT-DD ratio (%)

$$\boldsymbol{K = C_p - q \times 100} \qquad (7)$$

In Equation (7), where $K$ is the efficiency of environmental protection and $C_p$ is pollution is reduced to respectively, and $q$ in several industries. The main criteria for determining if an energy source is clean are its ability to generate few byproducts, have a negligible effect on the environment, and be maintained into the near future in light of social and ecological demands.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

Figure 7 shows that output levels are observed, and conventional inputs are used; environmental efficiency is defined as the ratio of the minimal possible to the practical usage of ecologically harmful inputs. Green growth's primary goal is to reduce pollution while maintaining or increasing economic production and development. It can emphasize environmental protection procedures that are more effective. Energy efficiency has many positive effects on the natural world. Greenhouse gas emissions from burning fossil fuels and other sources are reduced dramatically. According to the "polluter pays" approach, the people who pollute the environment are responsible for the associated expenses, including those associated with assessing the extent of the damage, determining the need for remediation, and providing paying restoration. The polluter is responsible for paying the costs of environmental monitoring, implementing prescribed measures, and implementing steps to avoid environmental pollution, regardless of whether such expenses are attributable to specified ecological liability. The proposed method is more efficient in the protection in value of 87.2%.

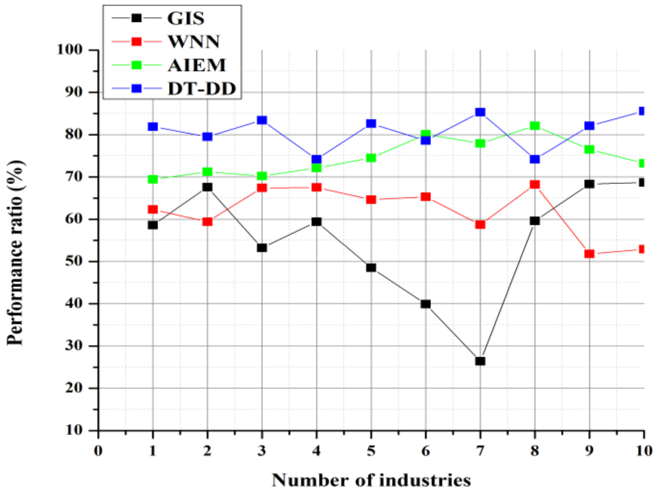


Figure 8: Performance of environmental protection in the proposed method

$$\boldsymbol{d} = (\boldsymbol{x})\frac{y_n}{j} \tag{8}$$

In Equation (8), where $d$ is a performance of environmental protection and $x$ indicates better accessibility and $y$ for environmental sensitivity and $n$ in several industries, and $j$ is a reduced carbon dioxide in the environmental protection performance calculated in the proposed method, is the highest value 82.5 %.

Figure 8 shows that Environmental performance indicators look at issues like pollution, ecology, climate change, energy use, erosion, environmental services, wildlife conservation, and numerous more challenges. Even the most well intentioned measures may not be successful or fail without specific ecological performance metrics. The organization has to evaluate its air quality for various crucial objectives, including cutting costs and increasing profits. Many cost-cutting opportunities exist in the industry's electricity use, waste production, and feedstock consumption. Environmental key performance indicators are numerical metrics that value the company's environmental performance. An organization's influence on the environment, including ecosystems, land, air, and water, may be measured using environmental protection performance indicators. It clearly shows how the company is doing and provides managers with the data management needs to decide on strategies to make changes in the future.

Table 2: Environmental protection to the evaluation of the proposed method

| Number of industries | GIS | WNN | AIEM | DT-DD |
|---|---|---|---|---|
| 1 | 38.5 | 51.5 | 47.5 | 62.2 |
| 2 | 21.5 | 32.1 | 50.4 | 75.4 |
| 3 | 18.1 | 30.6 | 59.5 | 73.5 |
| 4 | 28.3 | 40.1 | 34.3 | 59.2 |



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

| | | | | |
|---|---|---|---|---|
| 5 | 46.2 | 36.9 | 57.5 | 62.7 |
| 6 | 31.2 | 47.5 | 79.6 | 87.2 |
| 7 | 39.8 | 59.4 | 69.3 | 75.4 |
| 8 | 40.5 | 57.3 | 78.3 | 87.4 |
| 9 | 45.4 | 62.7 | 85.6 | 97.2 |
| 10 | 56.2 | 68.2 | 72.5 | 89.4 |

$$\boldsymbol{Evaluation\ (R) = C_n|p|} \qquad (9)$$

In Equation (9), where $R$ an evaluation of environmental protection is, $C$ is an emission, and $n$ in several industries and fields, environmental education activities have become more common in developmental establishments because of societal growth in an evaluation of the proposed method DT-DD for increasing better than the value for 89.4 is calculated.

Table 2, shown in the planning step, catalogs and analyses the possible consequences of alternate solutions to resource challenges in the human environment, known as the environmental evaluation or environmental assessment. Analyzing the significant environmental effects of a proposed project or development plan requires a review of the ecological impact. When deciding on a project, it is essential to consider the environmental repercussions and take steps to prevent, lessen, or mitigate them as soon as possible. By including environmental impact assessment in the early stages of project planning and design, you may be assured that these problems will be avoided. An environmental impact assessment system must be implemented for socioeconomic development projects to be environmentally safe and for economic growth to be sustainable. Considerations from an ecological protection process try to keep people, groups, and governments from harming the environment. It is imperative since human activity is the primary cause of the Earth's environment's regular degradation.

In future work, developing secure and trustworthy renewable energy development and ecological, environmental protection, and decision-making models can be made. This includes focusing on data integrity, model security, and protection against cyber threats. Using the method based on DT-DD by analyzing performance, efficiency, accuracy, and evaluation results, it is easy to conclude which way has been a better final result and enables further development of a secure and robust DT-DD. Future research will also explore the use of advanced security mechanisms, such as blockchain technology, to enhance data integrity and traceability in the context of environmental protection.

## 4. Conclusion

This research demonstrates that the convergence of renewable energy development and environmental protection necessitates a robust information security framework. Our findings underscore the critical role of cybersecurity in ensuring the reliable operation of renewable energy systems and the accurate assessment of their environmental impact. By integrating security principles into a data-driven decision tree (DT-DD) approach, we have shown that it is possible to enhance environmental protection while simultaneously mitigating the risks associated with cyber threats. The experimental analysis highlights the effectiveness of the DT-DD method in achieving significant improvements in pollution reduction accuracy (86.3% using equation 5), resource management efficiency (87.2% using equation 7), and environmental impact evaluation (89.4% using equation 9). These results are directly linked to the secure and reliable data used to train and operate the model, emphasizing the importance of data integrity, confidentiality, and availability. Furthermore, this study reveals the potential vulnerabilities of renewable energy infrastructure to data breaches, manipulation, and other cyberattacks, underscoring the need for proactive security measures throughout the system lifecycle. Protecting the data used for energy management, environmental monitoring, and decision-making is paramount to achieving both sustainability goals and operational resilience. Future work will focus on developing advanced security mechanisms specifically tailored for renewable energy systems, including robust intrusion detection systems, secure data management protocols such as blockchain for data integrity verification, and adversarial training techniques to enhance model robustness against evolving cyber threats. Fostering collaboration between the energy sector and the information security community is essential to developing comprehensive standards and best practices for securing the growing landscape of renewable energy. By prioritizing cybersecurity, we can ensure that the transition to a greener future is not only environmentally sound but also secure and resilient against the evolving landscape of cyber threats.



DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

**Reference**


**[1]** S. Ntanos, G. Kyriakopoulos, M. Chalikias, G. Arabatzis, and M. Skordoulis, "Public perceptions and willingness to pay for renewable energy: A case study from Greece," Sustainability, vol. 10, no. 3, p. 687, 2018.

**[2]** C. Zhang, D. Zhou, Q. Wang, H. Ding, and S. Zhao, "Will fiscal decentralization stimulate renewable energy development? Evidence from China," Energy Policy, vol. 164, p. 112893, 2022.

**[3]** M. Sakthivel and S. Murugan, "A Stochastic Model for Novel Mixture Distribution with Properties and Its Application," International Journal of Mathematics, Statistics, and Computer Science, vol. 2, pp. 259–275, 2024. [Online]. Available: https://doi.org/10.59543/ijmscs.v2i.9015

**[4]** L. S. Mihajlović and S. Trajković, "The importance of energy for the economy, sustainable development and environmental protection—An economic aspect," Journal of Process Management and New Technologies, vol. 6, no. 1, 2018.

**[5]** V. M. Kuthadi, R. Selvaraj, S. Baskar, and P. M. Shakeel, "Data security tolerance and portable-based energy-efficient framework in sensor networks for smart grid environments," Sustainable Energy Technologies and Assessments, vol. 52, p. 102184, 2022.

**[6]** Y. Ma, J. Yan, J. Sha, G. He, C. Song, S. Fan, and W. Ke, "Dynamic simulation of the atmospheric environment improved by a focus on clean energy utilization of resource-based cities in China," Journal of Cleaner Production, vol. 192, pp. 396–410, 2018.

**[7]** X.-c. P., "Research on Xi Jinping's thought of ecological civilization and environment sustainable development," in IOP Conference Series: Earth and Environmental Science, vol. 153, no. 6, p. 062067, May 2018, IOP Publishing.

**[8]** R. Siri, S. R. Mondal, and S. Das, "Hydropower: A renewable energy resource for sustainability in terms of climate change and environmental protection," Alternative Energy Resources, pp. 93–113, 2020.

**[9]** B. Debnath, R. Kumar, and P. M. Shakeel, "Meandering-trapezoidal shaped MEMS structure for low frequency vibration based energy harvesting applications," Sustainable Energy Technologies and Assessments, vol. 42, p. 100881, 2020.

**[10]** M. A. Hannan, A. Q. Al-Shetwi, P. J. Ker, R. A. Begum, M. Mansor, S. A. Rahman, et al., "Impact of renewable energy utilization and artificial intelligence in achieving sustainable development goals," Energy Reports, vol. 7, pp. 5359–5373, 2021.

**[11]** M. Song, L. Cen, Z. Zheng, R. Fisher, X. Liang, Y. Wang, and D. Huisingh, "How would big data support societal development and environmental sustainability? Insights and practices," Journal of Cleaner Production, vol. 142, pp. 489–500, 2017.

**[12]** G. Dorgo, A. Palazoglu, and J. Abonyi, "Decision trees for informative process alarm definition and alarm-based fault classification," Process Safety and Environmental Protection, vol. 149, pp. 312–324, 2021.

**[13]** S. E. Bibri and J. Krogstie, "A novel model for data-driven smart sustainable cities of the future: A strategic roadmap to transformational change in the era of big data," Future Cities and Environment, vol. 7, no. 1, 2021.

**[14]** A. E. Copping, A. M. Gorton, R. May, F. Bennet, E. DeGeorge, M. Repas Goncalves, and B. Rumes, "Enabling renewable energy while protecting wildlife: an ecological risk-based approach to wind energy development using ecosystem-based management values," Sustainability, vol. 12, no. 22, p. 9352, 2020.

**[15]** Q. Yao, Z. Wu, C. Zhu, S. Song, X. Qiu, and S. Liu, "Architecture design and application of global renewable energy reserves evaluation and planning platform," in 2019 IEEE Sustainable Power and Energy Conference (iSPEC), pp. 81-84, Nov. 2019.

**[16]** C. Yu and N. Du, "Analysis of landscape ecological planning based on the high-order multiwavelet neural network algorithm," Computational Intelligence and Neuroscience, vol. 2021, 2021.

**[17]** C. Chen, Y. Hu, M. Karuppiah, and P. M. Kumar, "Artificial intelligence on economic evaluation of energy efficiency and renewable energy technologies," Sustainable Energy Technologies and Assessments, vol. 47, p. 101358, 2021.

**[18]** Z. W. Lie, Q. L. Zheng, S. Zhou, and H. L. Rauf, "Virtual energy-saving environmental protection building design and implementation," International Journal of System Assurance Engineering and Management, vol. 13, no. 1, pp. 263–272, 2022.

**[19]** X. Feng, H. Shi, J. Wang, and S. Wang, "Green intelligent financial system construction paradigm based on deep learning and concurrency models," Concurrency and Computation: Practice and Experience, vol. 33, no. 12, p. e5784, 2021.

**[20]** S. R. Aldhshan, K. N. Abdul Maulud, W. S. Wan Mohd Jaafar, O. A. Karim, and B. Pradhan, "Energy consumption and spatial assessment of renewable energy penetration and building energy efficiency in Malaysia: A review," Sustainability, vol. 13, no. 16, p. 9244, 2021.




DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024

**[21]** Y. Li and Y. Chen, "Development of an SBM-ML model for the measurement of green total factor productivity: The case of Pearl River delta urban agglomeration," Renewable and Sustainable Energy Reviews, vol. 145, p. 111131, 2021.

**[22]** R. Shahbazi, S. Kouravand, and R. Hassan-Beygi, "Analysis of wind turbine usage in greenhouses: wind resource assessment, distributed generation of electricity and environmental protection," Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, vol. 45, no. 3, pp. 7846–7866, 2023.

**[23]** T. Xu, X. Ding, H. Cheng, G. Han, and L. Qu, "Moisture-enabled electricity from hygroscopic materials: A new type of clean energy," Advanced Materials, p. 2209661, 2023.

**[24]** Kaggle, "Corporate Environmental Impact Dataset," [Online]. Available: https://www.kaggle.com/datasets/mannmann2/corporate-environmental-impact?select=final_raw_sample_0_percent.csv.




DOI: https://doi.org/10.54216/JCIM.150225
Received: June 04, 2024 Revised: September 07, 2024 Accepted: December 10, 2024