

Dirassat & Abhath
The Arabic Journal of Human
and Social Sciences



مجلة دراسات وأبحاث
المجلة العربية في العلوم الإنسانية
والاجتماعية

EISSN: 2253-0363
ISSN : 1112-9751

The Role of Artificial Intelligence in Developing Green Technology Solutions to Improve Business Sustainability

- Global Models in the Field of Renewable Energy -

**دور الذكاء الاصطناعي في تطوير حلول التكنولوجيا الخضراء لتحسين استدامة الأعمال -
نماذج عالمية في مجال الطاقة المتجددة**

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تاريخ القبول : 2026/03/29

تاريخ الاستلام: 2026/01/23

Abstract:

In recent decades, the world has witnessed rapid technological advances that have driven tremendous progress in artificial intelligence, making it a technological innovation that rivals the human mind. It is the cornerstone of developing green technology solutions to enhance business sustainability. This study aims to highlight the role of artificial intelligence in supporting and advancing green technology and the extent to which it contributes to sustainable development by reducing costs, improving efficiency, and promoting innovation across industries. This study also aims to highlight key global models and technologies in the field of intelligent renewable energy, and to identify the benefits and challenges of artificial intelligence in green technology. The study concluded that these models digitize renewable energy using artificial intelligence and that the leading countries in this field are the United States, Germany, China, and the United Kingdom.

Keywords: Artificial intelligence, green technology, sustainable development, renewable energy

المخلص:

شهد العالم خلال العقود الأخيرة تطورات تكنولوجية متسارعة أدت إلى حدوث تطور هائل في مجال الذكاء الاصطناعي، ليصبح من المبتكرات التكنولوجية التي تنافس العقل البشري. حيث يعد الركيزة الأساسية في تطوير حلول التكنولوجيا الخضراء لتعزيز استدامة الأعمال. وتهدف هذه الدراسة إلى إبراز دور الذكاء الاصطناعي في دعم وتطوير التكنولوجيا الخضراء، ومدى مساهمته في تحقيق التنمية المستدامة من خلال دوره في تقليل التكاليف، تحسين الكفاءة والابتكار في الصناعات. كما تهدف هذه الدراسة إلى تسليط الضوء على بعض النماذج العالمية والتقنيات المستخدمة في مجال الطاقة المتجددة الذكية من خلال تحديد الفوائد والتحديات التي تواجه الذكاء الاصطناعي في مجال التكنولوجيا الخضراء. وقد توصلت الدراسة إلى أن هذه النماذج تعمل على رقمنة الطاقة المتجددة باستخدام الذكاء الاصطناعي وأن أغلب الدول الرائدة في هذا المجال هي الولايات المتحدة، ألمانيا، الصين وبريطانيا.

الكلمات المفتاحية: الذكاء الاصطناعي، التكنولوجيا الخضراء، التنمية المستدامة، الطاقة المتجددة

1. INTRODUCTION

In recent years, the world has witnessed tremendous technological developments, leading to the Fourth Industrial Revolution, digital transformation, and the application of artificial intelligence, promoting innovation across various fields of life. Artificial intelligence has become an imperative necessity, as it performs cognitive tasks such as thinking, perceiving, and learning to solve problems and make appropriate decisions.

Among the problems facing the world today are pollution and the depletion of natural resources to achieve development, which have made it imperative to adopt a new policy to limit harmful environmental impacts and promote more sustainable

resource consumption.

Accordingly, companies are striving to become more environmentally conscious by adopting green, or so-called clean, technologies, such as producing recyclable products and using innovative energy technologies, to achieve sustainability.

Research question:

Pollution and the depletion of natural resources are undoubtedly among the most pressing global issues, raising serious concerns about the future of human life.

This research paper focuses on identifying how artificial intelligence technologies can be employed within the framework of green technology to promote sustainability in the renewable energy sector. The main question

that can be asked is:

- To what extent does artificial intelligence contribute to the development of green technology to achieve sustainability in the field of renewable energy?
- This question gives rise to the following sub-questions:
- What is meant by artificial intelligence and green technology?
- What are the most important types of artificial intelligence?
- What are the most important components of business sustainability?
- How can artificial intelligence contribute to improving energy efficiency and developing renewable energy?
- What are the most notable global experiences that have successfully integrated artificial intelligence with green technology in the field of renewable energy?

Study hypothesis: The study seeks to verify the following hypothesis:

Artificial intelligence contributes to advancing green technology in renewable energy to achieve sustainability goals.

Significance of the study: The study identifies the roles of artificial intelligence and green technology in achieving sustainable development. Artificial intelligence has emerged as an innovative solution that improves the efficiency of economic resources and reduces environmental impact, promoting environmental sustainability. The importance of the study is also highlighted by presenting a set of leading global experiences in renewable energy and comparing them to benefit from them and anticipate their application in Algeria, which is striving to achieve a green economy.

Study objectives: These include the following:

- Highlighting the basic concepts associated with artificial intelligence, green technology, and business sustainability.
- Identify artificial intelligence technologies used to support green

technology.

- Highlight the role of artificial intelligence and green technology in promoting business sustainability.
- Present and evaluate leading global experiences in the use of artificial intelligence in the field of renewable energy.
- Propose a set of recommendations that would advance green technology using artificial intelligence to promote sustainable development policies.

Study methodology: This study adopts a descriptive-analytical approach, describing the basic concepts of artificial intelligence, green technology, and business sustainability, and analyzing global models that rely on artificial intelligence in renewable energy.

2. Theoretical framework of artificial intelligence and green technology

2.1 Conceptual framework of artificial intelligence: Artificial intelligence is a form of scientific and technological progress that drives the development of societies in various areas of life. It encompasses a wide range of technologies, from creating machine learning models to big data analysis and beyond.

2.1.1 Definition of artificial intelligence: There are several definitions of this term, including:

Artificial intelligence is defined as 'the theory of creating computer systems that can execute tasks usually necessitating human intelligence, including visual perception, speech recognition, learning, decision-making, and natural language processing' (A. Cardona, , Robert, z, & Kristina, May 2023, p. 12). In other words, artificial intelligence thinks, acts, and speaks like intelligent humans in many cases.

It is also defined as: 'A branch of computer science concerned with the study and creation of computer systems that exhibit some forms of intelligence. These systems have the ability to make very useful inferences about the problem at hand, and can understand natural languages, perception, and other capabilities that require intelligence when performed by humans' (Zamouki & Marzouk, 2023, p. 37). It can be seen from

the definition that artificial intelligence has systems and tools that determine the actions necessary to solve a particular problem and make a particular decision to achieve a specific goal.

Artificial intelligence is defined as 'a machine that can simulate human cognitive processes, execute actions based on those processes, and derive conclusions. It must also be able to rectify its errors. This indicates that an artificial intelligence-based computer will be capable of making decisions in specific situations, akin to humans, and in certain instances, even more effectively' (s3waas, 2025). In other words, artificial intelligence works to solve a problem, makes mistakes in doing so, and learns from them in a self-correcting manner as part of its self-development.

From the above definitions, the following definition can be derived:

Artificial intelligence: 'A computational concept that helps to think intelligently in a manner similar to humans, make decisions, and solve problems in a logical manner to achieve a set of goals set by humans'.

2.1.2 Types of artificial intelligence:

Artificial intelligence is divided according to the following classifications:

2.1.2.1 By capabilities: Different types of artificial intelligence can be classified based on capabilities into (s3waas, 2025):

- a) **Weak or narrow artificial intelligence:** Weak AI, or narrow AI, pertains to AI systems specifically developed and taught for particular tasks or domains. These systems are proficient at executing a singular task or a restricted range of tasks, yet they lack the broad intelligence and adaptability inherent to humans. Instances of narrow AI encompass virtual assistants like Siri and Alexa, recommendation algorithms, image recognition technologies, and language translation applications.
- b) **General AI:** General AI, or powerful AI, denotes AI systems that exhibit human-like intelligence, capable of comprehending, learning, and reasoning

across diverse tasks and domains. General AI systems will possess the capability to execute any cognitive task achievable by humans and may perhaps exceed human intelligence. Nonetheless, genuine general AI remains a theoretical construct and has yet to be realized.

- c) **Strong AI:** The designation 'strong AI' typically denotes a sophisticated variant of artificial intelligence that exceeds human intellect and talents across multiple domains. This notion frequently emerges in science fiction, wherein superintelligent AI may exhibit capabilities such as self-awareness, creativity, emotional intelligence, and problem-solving skills that significantly surpass those of humans.

2.1.2.2 By function: Artificial intelligence can be classified according to the following types (Ghosh & Arunachalam, 2021, p. 25):

- a) **Reactive machines:** These machines operate based on data from specified datasets. These robots lack the capacity to retain historical and prospective data, relying solely on present data. Reactive machines shown by IBM's chess software, Deep Blue, which triumphed over the renowned champion Garry Kasparov, and Google's AlphaGo.
- b) **Limited memory:** These are devices capable of retaining past experiences or memories for a finite duration. Examples of artificial intelligence with constrained memory include autonomous vehicles, which can retain data such as velocity, distance, and regulatory speed limits essential for navigation.
- c) **Theory of mind:** These computers are anticipated to comprehend the psychological and emotional dimensions of the human psyche and respond accordingly. Currently, these machines are regarded as aspirational, although scientists are endeavoring to advance their development in the near future.
- d) **Self-awareness:** These machines pertain to a theoretical notion of super-

intelligent entities, capable of cognition and action, and will possess self-awareness, since they will exhibit consciousness and emotions akin to humans. Research is underway to construct these devices, regarded as the future of artificial intelligence.

2.2 Conceptual framework of green technology: Green technology protects the environment and achieves sustainable development by adopting preventive or remedial strategies that enable the creation of environmentally friendly production methods.

2.2.1 The definition of green technology: There are several definitions of green technology, or what is known as environmental technology, including:

- It is described as: 'The development and utilization of resources, devices, and systems that aid in the protection of the environment and natural resources by mitigating the detrimental impacts of human activity' (Venkadeshwaran K, 2019, p. 231). In other words, green technology helps preserve the environment and natural resources and reduces the negative impacts of human activities.
- The term 'green technology' refers to goods, equipment, or systems that meet the following requirements:
 - a) They reduce environmental degradation and the depletion of natural resources.
 - b) Emits zero or low greenhouse gases (GHGs), is safe to use, and promotes a healthy and improved environment for all forms of life.
 - c) Conserves energy and natural resources.
 - d) Encourages the use of renewable resources (Kumar, 2020, p. 1342).
- Green technology is defined as: 'technology that satisfies present need without jeopardizing the capacity of future generations to fulfill their own needs' (SHIVANGI, 2018, p. 165). In other words, it optimizes the use of economic resources by promoting a healthy environment for all living beings. From the above, the following definition

can be derived:

Green technology is: 'the sum of technologies and tools used to reduce the consumption of natural resources, increase reliance on renewable energy, and work to maintain a safe and healthy ecosystem'.

2.2.2 Green technology objectives: These are as follows (SHIVANGI, 2018, p. 167):

- The primary aim of green technology is to meet societal needs without harming or depleting the Earth's natural resources.
- Addressing present requirements without sacrificing quality. The emphasis is on manufacturing products that are entirely recyclable or reusable.
- Implementing strategies to mitigate waste and pollution through alterations in production and consumption practices .
- Environmental technology, also known as clean technology, encompasses innovations that produce ecologically beneficial products through sustainable methods. The effectiveness of green energy is partially contingent on location, as optimal conditions, such as abundant, intense sunlight, facilitate the rapid and effective development of energy solutions.

3. Developing green technology using artificial intelligence to improve business sustainability:

There are radical, innovative changes in the field of green technology that rival those in information technology. These changes enable the use of several techniques in the field of artificial intelligence, such as generating renewable energy, using environmentally friendly materials in construction, smart farming, and recycling.

3.1 The conceptual framework for business sustainability: Sustainable development has become an inevitable necessity, prompting institutions to pay attention to it and adopt its principles, which led to the emergence of the term business sustainability.

3.1.1 Definition of business sustainability: Business sustainability is a contemporary term, initially employed in an environmental context in 1980; however, the notion of the

environment as the aggregate of external conditions essential for sustaining life traces back to the 19th century, potentially supplanting the term "nature economy," which had been utilized since the 17th century to denote the entirety of the natural world (Blowfeild, 2013, p. 6).

Sustainability is a prevalent, contentious, and essential topic of our era. The phrase sustainability generally denotes continuation. In ecology, sustainability pertains to the capacity of biological systems to maintain diversity and productivity across time. Sustainability for humans pertains to the long-term conservation of natural resources, contingent upon safeguarding the natural environment and its assets (Dhanda; & T.Young, 2013, p. 2).

Sustainable businesses are 'financially viable, self-sufficient enterprises that aim to enhance their social impact by promoting equitable opportunities, human rights, and community welfare for key stakeholders, including employees, consumers, government, and society. They guarantee that their operations (from manufacturing to the consumption of their goods and services) do not adversely affect the environment' (Chungyalpa, 2019, p. 25).

It is defined as: 'Development tactics employed by firms to concurrently fulfill two objectives: the first is to support and sustain the environment, and the second is to produce profit' (Al-Mu'adhidi & Muhammad, 2016, p. 505). This definition focuses on the relationship between an organization's environmental and economic dimensions, going beyond the traditional concept based solely on profit.

From the above, the following definition can be deduced:

Business sustainability is: 'business practices that enable a company to meet the needs of various stakeholders without compromising the needs of future generations by improving economic, social, and environmental performance'.

3.1.2 Components of sustainability: It is now accepted that the concept of sustainability is based on three interrelated

and complementary pillars (Al-Buraidi, 2015, p. 56) :

- a) **The environment:** Preserving and developing all environmental components, including:
 - The natural environment (water, air, soil, energy sources, all forms of life, and ecological systems).
 - The built environment (buildings, factories, and facilities of all kinds).
- b) **Economy:** Increasing the well-being of society and addressing poverty and unemployment through the efficient and effective use and development of resources.
- c) **Society:** Promoting justice, democracy, human rights, and social welfare, and meeting the needs of people now and in the future.

3.2 The role of artificial intelligence in improving energy efficiency: Artificial intelligence has enormous potential to revolutionize energy efficiency across various sectors, providing advanced technologies and methodologies for analyzing, predicting, and improving energy consumption patterns.

3.2.1 Machine Learning: Machine learning emphasizes the development and application of computer algorithms that learn from historical data or experiences for modeling, control, or predictive objectives, employing statistical methods without requiring explicit programming. Machine learning techniques encompass the following (Manuel, Husseini Musa, & Adélia Celestina Nkula, 2024, p. 619):

- a) **Supervised learning:** Entails machines making decisions based on labeled datasets, classified into categories of classification and regression.
- b) **Unsupervised learning:** entails machine learning frameworks derived from unlabeled datasets, classified into clustering and dimensionality reduction techniques.
- c) **Reinforcement learning:** characterized as the process of associating conditions with actions to optimize a designated reward or reinforcement signal, it entails

learning through interactions with the environment.

- d) Deep learning:** Represents the forefront of machine learning methodologies, yielding more precise predictions than conventional techniques.

3.2.2 Machine learning algorithms:

Machine learning methods enable computers to learn from data and make predictions or judgments autonomously, without explicit programming. In the realm of energy efficiency, machine learning algorithms can analyze historical energy usage data to identify trends and relationships, enabling more accurate predictions and optimizations (Olatunde, Okwandu, Akande, & Zamathula Queen, 2024, p. 1245).

3.2.3 Neural networks: A category of algorithms modeled after the architecture and operation of the human brain. They comprise interlinked layers of nodes (neurons) that analyze input data and generate output predictions. Neural networks have demonstrated exceptional efficacy in tasks such as pattern recognition and time series forecasting, making them highly appropriate for analyzing intricate energy data and optimizing energy systems (Olatunde, Okwandu, Akande, & Zamathula Queen, 2024, p. 1246).

4. Leading global models in renewable energy supported by artificial intelligence: A range of successful global experiences in renewable energy using artificial intelligence and green technology will be showcased.

4.1 China Green Horizon Project:

4.1.1 Project description: In 2010 and 2011, media organizations and oversight groups in Beijing observed inconsistencies between data from independent air quality monitoring devices and official government reports. In response to popular demonstrations, the federal government launched a US\$275 billion initiative in 2013 to improve air quality nationwide. The Beijing local government committed an extra US\$160 billion. IBM, the city's technology collaborator in the Green Horizon effort, uses real-time data from optical sensors, air quality monitors, and satellites to forecast

pollution sources and their potential dispersion across the city (dataimpacts, 2025).

4.1.2 Objective and technology used: The initiative, titled 'Green Horizon,' seeks to exceed existing world standards in three critical domains essential to China's sustainable development: renewable energy forecasts, industrial energy efficiency, and air quality monitoring. The Chinese government has recently announced an increased investment in solar, wind, hydro, and biomass energy to reduce its reliance on fossil fuels. IBM has created a renewable energy forecasting system to help energy systems use and manage alternative energy sources (Meza, (2025).

4.1.3 Results: Pressure from air quality statistics prompted substantial investments and aggressive pollution reduction objectives. Beijing intends to decrease concentrations of fine particulate matter, the most hazardous type of air pollution, by 25 percent within four years. The Green Horizon method has proven highly effective in empowering the government to implement preventive measures against pollution; the data has not only pinpointed issues and stimulated political will but has also aided in their resolution. More stringent emissions restrictions and increased penalties for polluters have been implemented (dataimpacts, 2025).

4.2 Google DeepMind Project: One of the leading companies in artificial intelligence, it has revolutionized how this technology is understood and applied.

4.2.1 Project description: DeepMind was established in 2010 by Demis Hassabis, Shane Legg, and Mustafa Suleiman. The company's original objective was to integrate deep learning methodologies with neural networks to develop artificial intelligence systems capable of autonomous learning. In 2014, Google purchased DeepMind for £1.7 billion, granting the business significant resources and exceptional technological assistance.

4.2.2 Goal and technology used: to create general artificial intelligence capable of

executing any human cognitive job, and to leverage this artificial intelligence to address global challenges (Brazi , 2025). Google, in collaboration with its artificial intelligence division DeepMind, has revealed the development of a system to forecast energy output from wind farms utilizing software algorithms and machine learning techniques. This system analyzes turbine capacity and meteorological conditions in a sequential time series to correlate with the electricity generated.

4.2.3 Results: This project enhanced the performance and value of wind energy at these farms by 20% compared to prior periods when forecasting was not employed to align energy consumption capacity with the same timeframe (Qandil , 2025).

4.3 Enel Green Power Project: Enel Green Power focuses on developing and operating renewable energy plants worldwide and is a global leader in clean energy.

4.3.1 Project description: Enel Green Power was founded in December 2008 as a subsidiary of the Enel Group to develop and oversee global renewable energy generation. It manages over 1,300 power facilities across five continents. It possesses operational or under-construction assets in 19 countries and is expanding its business in five additional nations. It has 66.4 gigawatts of renewable energy capacity from wind, solar, hydropower, and geothermal sources. It is pivotal in the energy transition as a foremost global renewable energy enterprise.

4.3.2 Goal and technology used: In its pursuit of 2030, the corporation aims to facilitate electrification and deliver sustainable energy while prioritizing the welfare of individuals and the environment. Sustainability signifies value for all stakeholders. Consequently, it fosters robust partnerships with consumers, partners, investors, institutions, and local communities. Enel Green Power is leading the development and evaluation of innovative solutions that facilitate the energy transition: utilizing big data and digital technologies to enhance the efficiency of wind farms and solar panels; employing drones and robots to

assist in the operation and maintenance of dams and power plants; and implementing batteries for the on-demand storage of clean energy without waste.

4.3.3 Results: It has 66.4 gigawatts of installed renewable energy from a mix of wind, solar, hydroelectric, and geothermal sources. It is pivotal in the energy shift as a foremost renewable energy enterprise globally (Enel Green Power, 2025).

4.4 Comparison of leading global renewable energy models: The following tables illustrate the similarities and differences among the models in their use of artificial intelligence and green technology.

Table 1: Similarities between leading models in the field of renewable energy using artificial intelligence

Criteria	models
Objective	All models aim to reduce pollution and lower carbon emissions.
Use of data	All models rely on artificial intelligence to analyze large datasets and make informed decisions
Support for renewable energy	All models improve production efficiency.
Innovation	All models rely on modern technology that achieves sustainability through environmental and economic impact .

Source: Prepared by the researcher based on data from the models under study.

Table 2: Differences between leading models in the field of renewable energy using artificial intelligence

Models	Using artificial intelligence	Sustainable green technology	Achieving sustainability
China Green Horizon	Predicting where air pollution is generated and how it spreads	Use of real-time data from optical sensors, air quality monitors, and satellites	Improving air quality
Google DeepMind	Predicting the amount of energy produced by wind farms using software algorithms and machine learning tools	Improving wind energy performance and value	Reducing electricity consumption
Enel Green Power	Providing big data and digital technologies to increase the efficiency of wind farms and solar panels	Wind energy, solar energy, hydroelectric energy, geothermal energy	Providing sustainable energy

Source: Prepared by the researcher based on data from the models under study.

5. CONCLUSION

Artificial intelligence is developing innovative solutions that will help achieve environmental goals by reducing carbon emissions and relying on renewable energy sources. It also helps achieve economic goals by reducing operating costs and increasing profitability through business models that support long-term sustainability.

This study aims to integrate artificial intelligence with green technology, representing an important shift towards business sustainability by improving efficiency and conserving natural resources. It also highlights the most significant global experiences in renewable energy and compares them to identify potential benefits.

In light of the above, the following conclusions can be drawn:

- Artificial intelligence has recently experienced remarkable growth, but it is still at a relatively early stage and requires further development.
- Artificial intelligence is a branch of computer science that can be used to design intelligent systems with characteristics similar to human intelligence.
- Green technology enables individuals to live more environmentally conscious lives. Countries pursue it to promote economic growth and improve people's lives by making the environment more sustainable.
- Green technology is environmentally friendly technology used in ways that do

not harm the environment and conserve natural resources.

- Green technology uses new and innovative methods to generate energy and protect the environment.
- Artificial intelligence promotes the adoption of green technologies to conserve natural resources and use them sustainably. It also helps protect the environment while promoting sustainability.
- Artificial intelligence provides advanced technologies for analyzing energy consumption patterns and predicting time series, such as machine learning, machine learning algorithms, and neural networks.
- Many companies are working to reduce their reliance on fossil fuels by adopting new energy sources such as solar and wind. They are also seeking to use other alternatives such as geothermal energy and biomass.
- The Chinese Green Horizon project works to identify sources of pollution and take preventive measures to improve air quality nationwide.
- The Google DeepMind project has developed a machine learning-based mechanism to predict the energy output of wind farms and has improved wind farm energy performance by 20%.
- Enel Green Power relies on generating renewable energy worldwide, such as wind, solar, hydroelectric, and geothermal, to achieve sustainability.
- All models under consideration protect the environment by reducing carbon emissions and promoting the use of renewable energy sources to enhance business sustainability.

The researcher recommended the following:

- Leverage the experiences of successful companies in the field of renewable energy to serve the environment and business sustainability.
- Strengthen partnerships between universities, start-ups, and the

government to develop smart solutions that will achieve business sustainability.

- Use artificial intelligence technologies to analyze energy data and produce cleaner, more sustainable energy.
- Support business incubators that nurture start-ups focused on artificial intelligence and green technology.
- Signing partnership agreements with leading countries in the field of renewable energy to benefit from their experience in using green artificial intelligence.
- Algeria must work to integrate artificial intelligence with renewable energy, as it has vast desert areas that offer solar and wind energy.

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