


# Chapter 2

## AI Renaissance in Renewable Energy: A Path to Sustainability

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### ABSTRACT

*The intersection of artificial intelligence (AI) and renewable energy systems is transforming how energy is generated, distributed, and consumed. This paper explores AI's applications in three key renewable energy sectors: solar, wind, and green hydrogen. AI technologies such as machine learning, neural networks, and predictive analytics address critical challenges such as the variability and intermittency of renewable resources. Additionally, AI-enhanced renewable systems have broader implications, such as democratizing energy access, fostering economic growth, and aligning with global climate goals like the Paris Agreement and the United Nations' Sustainable Development Goals. By leveraging the synergies between AI and renewable energy, society can achieve a cleaner, more resilient, and equitable energy future, critical for combating climate change and promoting global sustainability. This paper highlights the transformative potential of AI while offering insights into overcoming barriers to its widespread adoption in renewable energy systems.*

### 1. INTRODUCTION

Artificial intelligence (AI) plays the role of a game-changer when it comes to integrating into renewable energy systems in order to solve global issues of energy security, climate change and sustainable development towards a more sustainable future. As countries worldwide continue the long journey from

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burning fossil fuels toward renewable energy sources, solar, wind, and green hydrogen are becoming key pillars of the global energy transition. Yet these renewable sources also face a series of inherent challenges: variability, intermittency and operational inefficiencies. This is where AI can change the game: revolutionizing the design, operation, and optimization of renewable energy systems and providing the means to move beyond traditional approaches toward more efficient, reliable, and scalable innovative solutions.

This is a backdrop of the renewable energy and the importance and impact of AI in transforming the renewable energy industry, a brief historical evolution and statement of facts, a tech summary of innovation you all seek in the wake of the fast-transforming energy world.

## **1.1 The Evolution of Renewable Energy**

A brief history of renewable energy development is the history of human efforts to develop sustainable and reliable energy sources. Wind was harnessed to propel sailing ships and to grind grain, and hydropower was harnessed to drive water mills. But the industrial revolution and the later discovery of fossil fuels like coal, oil and natural gas changed energy supply and consumption worldwide. Fossil fuels provide significant energy density and easy to harness powered industries, commerce, and transportation to an unprecedented degree, but at a serious environmental price (DGB Group, 2023).

By the time mid-twentieth century rolled around, issues like air pollution, energy security, and finite fossil fuel reserves, started making people wonder whether they should consider alternative energy sources. During this time, research and development on solar photovoltaics (PV) and wind turbines showed promising technology pathways (IEA 2021). The oil crises during the 1970s additionally illustrated that diversification in energy sources was a necessity and investments in the research of renewable energy sources were pushed to expanded speeds of completion.

Over the last few decades, we have witnessed a major transition in the global energy landscape, fueled by rapid technological advancements, declining costs and increasing awareness of climate change. Displacing fossil fuels, solar and wind energy are now the two fastest-growing sources of electricity generation globally, with green hydrogen surfacing as a complementary decarbonization solution for sectors that are hard to electrify (IEA, 2021). Even so, the combination of new renewable energy into existing grids and markets is only really complicated because it requires innovativeness to address all the complexities for as variability and for grid stability.

## **1.2 The Role of Artificial Intelligence in Modern Energy Systems**

Artificial intelligence has quickly emerged as a major game-changing technology in a variety of sectors: healthcare, finance, manufacturing, transportation, etc. It has also become an important area for innovation, especially in the energy field, and most importantly, renewable energy (Karduri, 2019). Machine learning, neural networks, natural language processing, robotics, and many more are all included in the order of AI. They allow machines to filter through massive troves of data, find patterns, and make decisions without much human intervention (Harvard Business School, 2024).

**Data Availability:** The number of sensors, smart meters and other connected devices. Renewable energy systems produce massive amounts of data connected to weather data, equipment performance, energy consumption, and market phenomena. This makes it highly conducive to make analysis and insights from AI tools.

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