Chapter 10
Economic Implications of AI-Driven Sustainable Energy:
Unlocking the Potential of Solar Energy

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ABSTRACT

Artificial intelligence (AI) utilizes machine learning algorithms to determine the optimal location for solar panels, predict energy demand, and manage battery storage more effectively, translating into higher energy production and lower running costs. Solar energy production AI automates towards maximum output with minimal operators, enhancing output and minimizing data entry errors as a result. AI-powered predictive maintenance improves the equipment lifetime, reducing unscheduled failures and downtime. Long-term economic impacts are job creation as AI enables new jobs such as energy analytics, automation, and smart grids. In addition, AI-based solar energy not only draws significant investments but also contributes to the growth of global markets and accelerates sustainable energy efforts in regions around the world. Governments embrace AI in energy policies that subsidize and incentivize adoption, rendering solar energy more economical and ubiquitous, paves the way for a resilient, AI-enabled green economy of the future.

1. INTRODUCTION

The shift towards sustainable energy is a global change in energy systems aimed at reducing dependency on fossil fuels and minimizing nuclear fuel usage. For the last two decades, growing concern about carbon emissions, environmental degradation, and energy security has prompted governments, businesses, and research institutions to pursue alternative energy sources. Solar energy and other renewables have become popular due to their ubiquity, scalability, and decreasing prices. This shift to a photovoltaic (PV) technology in developing and developed countries with the aid of energy storage (Kannan & Va-

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keesan, 2016). The other international collaborations like the Paris Agreement underscored the necessity of shifting to a sustainable energy balance, inspiring nations to pledge to lower greenhouse gas (GHG) emissions and promote cleaner energy sources (Izam et al., 2022). The growth in solar energy systems was driven by various policy frameworks including feed-in tariffs, tax incentives, and renewable energy certificates which incentivized businesses and consumers to invest in solar energy systems. A variety of multinational firms, including tech companies, are using renewable energy in their operations to go carbon neutral.

However, while solar energy infrastructure is expanding rapidly, complications concerning efficiency, intermittency, and grid integration remain. Variables such as availability of sunlight, constraints in storing energy, and the expensive nature of solar installations have made it imperative for technologies to evolve and thus maximize production and consumption. This is where artificial intelligence (AI) comes in, providing data driven solutions to increase energy efficiency, grid stability and the economic viability of solar energy projects (Choudhary & Srivastava, 2019). This revolutionary synergy also plays a pivotal role in the faster transition of nations to sustainable energy, making AI and solar energy a match made in heaven that can only lead us toward a more reliable and cost-effective future in energy.

AI and solar energy are maximizing their potential by revolutionizing the solar energy industry and combating pain points in generation, distribution and consumption of energy. Using AI-powered algorithms, rotation and angle of several solar panels can be optimized, weather forecasts can be predicted, and maintenance can be automated. In such a way these machine learning models process real-time and historical data to maximize energy production and reduce losses related to inefficiencies or adverse conditions. AI has had one of the most significant impacts on solar energy in terms of predictive maintenance, where AI-enhanced sensors identify faults, dust build up, or wear and tear on solar panels (Abbe & Smith, 2016). AI helps reduce maintenance costs and prevents losing energy by identifying potential issues before they escalate. AI optimizes battery charging and discharging cycles, improving the energy storage management to create stable power even in low sunlight periods.

AI helps manage smart grids so that solar power can be sustainably infused into national grids. Utilities use AI-powered demand forecasting for balancing the flow of energy between supply and consumption, ensuring that the grid does not run out, or become overloaded, thereby reducing the reliance on non-renewable energy sources (Verma, 2019). IoT-based smart meters offer real-time energy consumption data, helping homes and businesses make informed choices regarding energy usage, leading to cost reductions and enhanced sustainability. AI and solar energy can lead to improved efficiency, less waste and greater economic sustainability in the industry. With rapid advancements in AI technologies, it will play a key role in improving the competitiveness and reliability of solar power over fossil fuel-based energy generation (Shubbak, 2019).

1.1 Importance of AI-Powered Sustainable Energy Solutions in the Economy

AI-enabled systems are contributing to making energy solutions more sustainable, more scalable, and more affordable. The first and foremost benefit of AI-enabled solar energy systems is their ability to lower practical and maintenance expenses. Traditional solar farms often require frequent manual inspections combined with reactive maintenance processes that are expensive and time consuming. Predictive analytics powered by artificial intelligence makes maintenance proactive instead of reactive, hence preventing expensive failures of the system and increasing the overall productivity. Artificial intelligence (AI) also helps in decreasing energy waste by enhancing the efficiency of solar panels