

Chapter 21

Prospect of Artificial Intelligence Towards Demand Response, Control, and Predictions in Integrated Microgrid Renewable Energy Systems

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ABSTRACT

Microgrids play a vital role in sustainable energy systems, and this is accomplished by integrating renewable energy sources like solar, wind, biogas, and tide energy. Optimization resources are done through real-time monitoring with advanced data analytics which would adjust stably to changing environmental contexts. Renewable energy sources are more successful when it comes to competing with traditional sources of energy by maximizing the potential energy yield. Regarding demand response, this paper explores the application of AI methods, looking at both price- and incentive-based programs. Regarding their use and effectiveness, this article considers a variety of control targets, input sources, and applications. To sum up, the purpose of this review analysis is to provide valuable insights into the selection of AI approaches, with an emphasis on demand-side applications for future energy systems, along with control and prediction techniques using AI. This article offers direction and assistance for the creation of sustainable integrated energy systems.

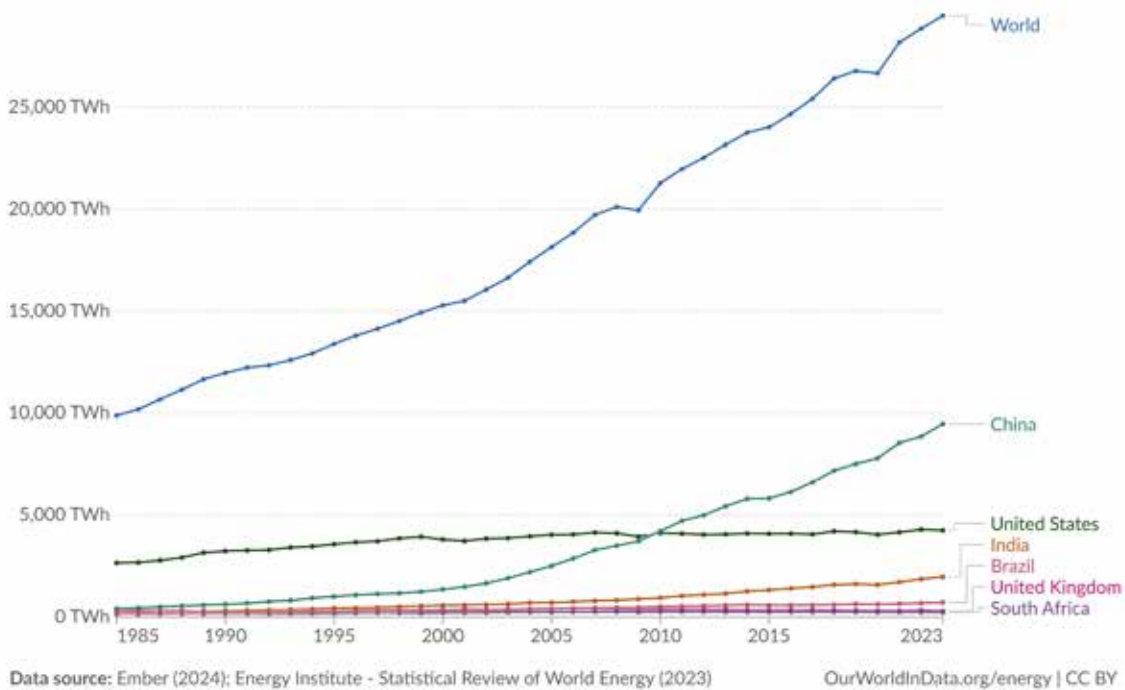
1. INTRODUCTION

Worldwide energy demand has been growing mostly due to rising urbanization, industrialization, population increases, technological advancements, energy access programs, and sector-specific needs. Also, the depletion of traditional energy resources and environmental concerns have led to a shift towards renewable energy deployment. Though greenhouse gas emissions reduction, energy diversification, sustainability, cost competitiveness, and so on are Additional benefits associated with green energy

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deployment, there are drawbacks, nonetheless. The primary downsides of deploying renewable energy include intermittency, energy storage, land use and resource constraints, high initial costs, transmission and grid integration, resource variability, technological limitations, and environmental impact (Figaj, 2024, Rani et al., 2023). To supply power to isolated regions remote from the main electric grid, researchers attempted to combine renewable sources in isolated microgrids. Alternatively, they attempted to link them with the grid to boost stability and dependability. The changeover to sustainable, low-carbon energy is made possible by the integration of non-renewable energy systems with renewable energy systems, which builds a stable and balanced energy infrastructure (Hirsch et al., 2018). Electricity generation from 1985 to 2023 by various countries and consolidated world generation data is presented in figure 1.

Figure 1. Global electricity generation from 1985 - 2023 (Energy Institute - Statistical Review of World Energy (2023). (n.d.). Data Source: Ember (2024); Energy Institute - Statistical Review of World Energy (2023))



1. Watt-hour: A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is equivalent to 3600 joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.

Non-renewable energy sources can provide backup power in the event of inadequate renewable energy generation or system failures, ensuring a consistent supply of electricity. Also, non-renewable energy sources play an important role in grid stability by providing steady power generation, especially when renewable sources like sun and wind are variable. Energy security is increased by reducing reliance on a single energy source through the diversification of the energy mix with non-renewable and renewable

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