


Chapter 2

The Role of Hybrid Transformers in Sustainable Energy Automation

Ezgi Güney

 <https://orcid.org/0000-0003-4868-0626>

Sinop Universty, Turkey

ABSTRACT

This chapter provides a comprehensive examination of Hybrid Transformers (HTs) as key components in the transition to sustainable and intelligent energy systems. It begins with an overview of the background and importance of HTs, emphasizing their role in improving grid efficiency, power quality, and renewable energy integration. Structural design and operating principles are analyzed, including series, parallel, and multilevel configurations. The chapter also explores enabling technologies such as wide bandgap semiconductors, modular power converters, and AI-based control algorithms. Performance and efficiency analyses address core, conductor, and switching loss reduction strategies. Furthermore, the chapter highlights the contributions of HTs to smart grids, energy management systems, and renewable energy-storage integration. It concludes by discussing key technical challenges, offering potential solutions, and identifying future research directions to support the development and deployment of HTs in advanced power infrastructures.

DOI: 10.4018/979-8-3373-2737-2.ch002

INTRODUCTION

The fast development of power systems, which together with the increasing demand for energy and the standards for sustainability demand technological developments, calls for creative solutions in power transmission and distribution infrastructure. HTs have become a revolutionizing tool. These transformers mix the dependability and durability of conventional transformers with the flexibility and efficiency of power electronics. HTs are an essential part of modern energy systems because of its capacity to offer harmonic filtering, reactive power compensation and dynamic voltage management. This is because they mix the recently created semiconductor-based control with the traditional magnetic core-based transformation.

Smart grids, the integration of renewable energy sources and automated power management systems all depend on HTs as a necessary element. The higher percentage of dispersed renewable energy sources introduces significant grid instability concerns, voltage fluctuations and power quality difficulties. Unlike conventional transformers, hybrid transformers actively control energy flow by using Power Electronic Converters (PECs). This helps them to reduce energy losses while yet keeping constant grid operation. These devices are very vital for the power networks of the future because of their flawless integration with Internet of Things (IoT), grid optimization motivated by Artificial Intelligence (AI) and next generation automation protocols.

This chapter offers a comprehensive overview of HT technology together with issues including structural design, operating concepts, efficiency gains and real-world applications. The discussion of this issue includes thorough research on the application of HTs in demand side management, industrial automation and the incorporation of renewable energy sources. Furthermore, looking at other crucial challenges include temperature management, standardizing, cybersecurity concerns and financial constraints; finding answers is also covered. Among the subjects covered in the last part of the chapter, which offers ideas on possible future research areas, are Wide Bandgap (WBG) semiconductors (Silicon Carbide-SiC and Gallium Nitride GaN), artificial intelligence driven predictive maintenance and sophisticated cooling systems.

Apart from their wider uses in the electrification of transportation, microgrid systems and hybrid energy storage systems, hybrid technologies also assist to upgrade electricity distribution networks. This is so as hybrid technologies are considered as disruptive developments. Regarding improving the sustainability and efficiency of next generation power systems, it is rather essential to have a strong awareness of the main components, operational benefits and possible evolution of hybrid technologies.

28 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/the-role-of-hybrid-transformers-in-sustainable-energy-automation/386326

Related Content

Maximizing Multicultural Online Learning Experiences with the Social Presence Model, Course Examples, and Specific Strategies

Aimee L. Whiteside and Amy Garrett Dikkers (2012). *Computer-Mediated Communication across Cultures: International Interactions in Online Environments* (pp. 395-413).

www.irma-international.org/chapter/maximizing-multicultural-online-learning-experiences/55581

Application of Technology of Information in Database Management in the Human Population: Approximate Calculation of the Number Population

Kujtim Ragmi Mustafa and Ragmi Mustaf Mustafa (2021). *International Journal of Information Communication Technologies and Human Development* (pp. 17-32).

www.irma-international.org/article/application-of-technology-of-information-in-database-management-in-the-human-population/272748

Smart Education: A Deep Learning Approach for Sustainable Language Learning

Usharani Bhimavarapu (2026). *Strengthening Language Education Through ICT Integration: Bridging SDG4 With Digital Innovation* (pp. 131-150).

www.irma-international.org/chapter/smart-education/388615

Social Media Information or Misinformation About COVID-19: A Phenomenological Study During the First Wave

Brindha D., Kadeswaran S. and Jayaseelan R. (2022). *International Journal of Information Communication Technologies and Human Development* (pp. 1-14).

www.irma-international.org/article/social-media-information-or-misinformation-about-covid-19/302081

Public Sentiment on Ayodhya Verdict by the Supreme Court of India: A Temporal Analysis on Twitter Data

Geetanjali Sahi (2022). *International Journal of Information Communication Technologies and Human Development* (pp. 1-17).

www.irma-international.org/article/public-sentiment-on-ayodhya-verdict-by-the-supreme-court-of-india/295561