Chapter 5

Sustainable Agriculture and Renewable Energy Integration

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Abstract

Studies emphasize the significance of renewable energy in fostering economic gains and augmenting functionality. On the other hand, minimal study has been done on the planning and execution of renewable energy systems that incorporate ecosystem biodiversity—which sustains the local flora, fauna, and human populations—into account. The study addresses the creation of a robust greenhouse model with cutting-edge energy technologies, such as solar panels and fuel cells, which encountered challenges with their local application since they consumed both heat and electrical energy. Compared to traditional methods, modern agriculture utilizes more energy and is largely dependent on fossil fuels for operations like heating, machinery operation, fertilizer production, and grain drying. This leads to a significant increase in greenhouse gas emissions, of which 35% originate in developing countries. Combining retrofitting and an energy audit, this study identified ways to reduce the amount of energy consumed and greenhouse gas emissions on an agricultural property. To optimize renewable energy output, four alternative energy systems—including solar and bio-energy—were identified after load profiles were examined and retrofits were put into operation. The article investigates the advantages, drawbacks, and prospects for employing renewable energy in agriculture as a substitute of conventional energy. For stakeholders and academics interested in sustainable energy methods, it provides an in-depth examination of alternative energy sources and their applicability for energy management. The analysis highlights the necessity of enhancing energy management through a more comprehensive strategic approach. Despite the many advantages of low-carbon energy, this article explores the rewards and difficulties associated with renewable energy projects in rural regions and makes policy recommendations to support this transition.

Keywords

Bio-Organic Greenhouses, Biofuel Conversion, Biogas, Climate Change, Fossil Fuels, Renewable Energy

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1. Introduction

Sustainable agriculture must utilize renewable energy to mitigate its negative effects on the environment and its dependency on fossil fuels. To precisely determine agricultural sustainability, however, measurements for renewable energy must be modified on frequent intervals [1]. Examining energy storage alternatives, conversion techniques, and renewable energy sources in non-living environments. Employing a mathematical model to calculate renewable power output, the best hybrid system for an isolated farm's energy consumption self-sufficiency can be determined [2]. To optimize the production of renewable energy, a thorough simulation assessed four different energy sources, including solar thermal and photovoltaic tiles. The best economical solution for tackling the issues of energy consumption and greenhouse gas emissions was determined to be solar photovoltaic and thermal panels [3]. Due to uncertainties in the economy and regulations, farmers are reluctant to embrace on-farm renewable energy systems (RES). Custom business models and financing options that handle the perceived high levels of uncertainty in comparison to usual returns and payback times must be created and marketed in order to overcome these barriers [4]. Studies have shown how important it is to have accurate and consistent methods for assessing how much energy is used in agricultural systems and to carry out meta-analyses to look at different approaches [5]. Sustainable agricultural alternative, bio-organic greenhouses encourage ideal development and growth of plants throughout the year round, especially especially during the winter. They enhance local fruit and vegetable production and boost agricultural productivity by providing ideal temperature and humidity conditions for short-term crop cultivation [6]. Utilizing renewable technology is rendered practical by the increasing demand for electrification in agriculture, especially for electric tractors and agricultural robots. While technological improvements, financial savings, and government support may accelerate the adoption of sustainable renewable technology in agricultural operations, investors require to be updated of new innovations [7]. Due to its local applicability and sustainability, biogas is a method that has been extensively investigated. Still, there is an increasing amount of research being done on the circular economy notion. Of particular interest are issues like dual land use, complicated energy systems, and energy storage [8]. Renewable energy sources are becoming more popular, especially in fragile societies like Small Island Developing States and those with complex ecosystems, as a result of climate change, which is mostly caused by the use of fossil fuels [9]. Figure 1 below shows the advent of renewable energy sources in agriculture sector.

2. Renewable Energy Solutions for Farms

With the goal of minimizing voltage drops and power losses, Reactive Energy Utilization Technology (REUT) is an intelligent farm energy consumption system that has undergone testing and evaluations in trials. It estimates the best wind power scenarios by monitoring control variables [10]. Energy consumers are becoming prosumers with the advent of smart grid technology and microgeneration of renewable energy, which is encouraging the transition to low-carbon energy and social acceptance. However, embracing and employing renewable energy sources presents significant challenges for rural populations [11]. Farmland smart monitoring systems controlled by artificial intelligence (AI) may be powered by wind energy and train turbulence through the integration of Internet of Things (IoT) sensors. By erecting vertical axis wind turbines, the aim is to raise farmers away from difficult situations employing conventional agricultural practices [12]. IoT is implemented in smart agriculture, buildings, cities, and industrial monitoring applications leveraging wireless sensor networks (WSNs). Non-rechargeable batteries with a specific energy capacity power conventional WSN nodes. Battery State of Charge (SoC),

Figure 1. Renewable energy sources

deployment type, and duty cycle all determine WSN life expectancy [13]. Technological developments indicate that smart farming and precision agriculture in the future will be greatly enhanced by the adoption of agri-robotics and solar-powered autonomous vehicles, which will also assist in satisfying the growing demands of food production [14]. For intermittent renewable energy sources, recent research on renewable ammonia synthesis provides both an affordable and sustainable storage solution. As fertilizer and energy storage media, this procedure employs nitrogen from the air and hydrogen from renewable electrolysis [15]. Employing binary logistics regression and descriptive statistics, we may bridge the knowledge gap about farmers' attitudes toward sales and how they satisfy the requirements of animal husbandry, nutrient management, and carbon supply. looking into the factors that influence farmers'

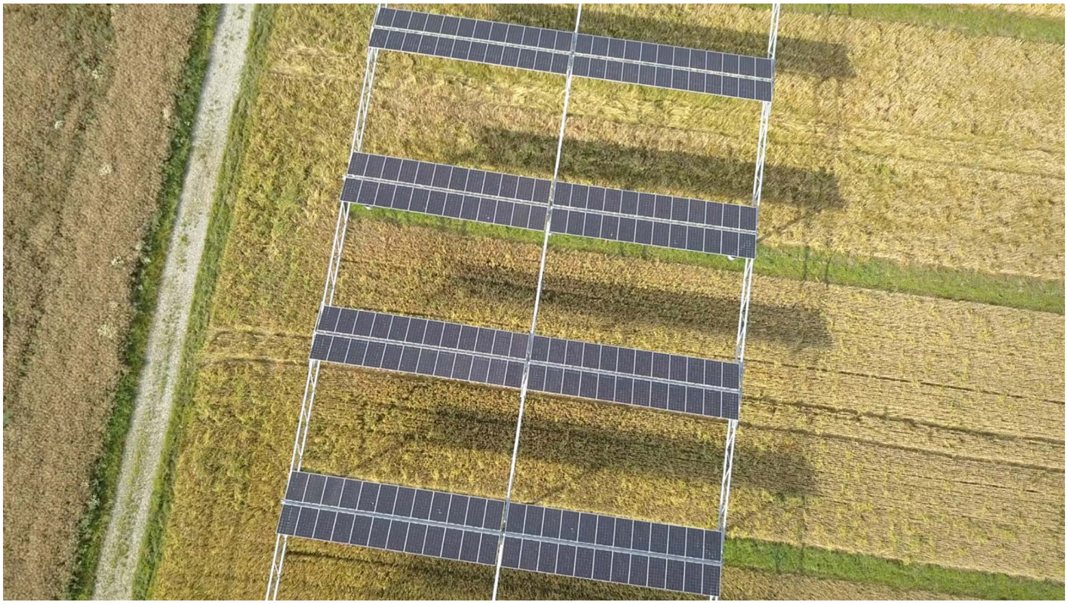

Figure 2. Solar photovoltaics (PV) in agricultural field

willingness to sell, what obstacles they face, and possible incentives [16]. Research on hydrogen generators with experimentation suggests approaches for assessing the generator's performance at starting and in the event of abrupt supply variations. This highlights the need of taking the generator's dynamics into account when choosing a suitable device for variable renewable energy sources [17]. Transporting irrigation water can be affordable in rural locations with geothermal energy sources. Post-treatment processes are necessary to meet the high energy requirement for desalination in agriculture. The desalination process requires renewable energy sources owing to escalating fossil fuel costs and greenhouse gas emissions [18]. In agriculture, the adoption of renewable energy sources like solar, wind, and hydroelectric water pumps can help lessen the impacts of climate change. But both higher- and lower-income countries must move quickly to implement coordinated strategies for switching to renewable energy [19]. Numerous nations will embrace a balanced strategy combining distributed and centralized energy systems in the future. Farms have the potential to generate renewable energy because of their biomass resources and open area. For farmers looking to grow their renewable energy enterprises, national experts suggest wood, biogas, and solar photovoltaics (PV) [20]. Figure 2 below shows the employment of solar photovoltaics (PV) in agricultural field. From machines to fertilizers, energy is essential to agricultural output. Farmers' input energy expenses are impacted by high costs and volatile markets. Producers may save costs by utilizing energy-efficient practices and renewable energy sources including geothermal, biomass, wind, and solar power [21]. There is potential for biofuel conversion in the global cultivation of agricultural biomass, but it is important to take into account conflicting requirements, short- and long-term effects, soil quality, and the biofuel conversion process [22].

3. Recommendations

After thorough scrutiny of the literature and technologies that are current transforming the agricultural renewable energy system, we propose following recommendations.

- Relevance for farmers, industry representatives, and renewable energy producers is ensured by stakeholders like energy policy experts, legislators, and representatives of agricultural organizations, who offer insightful information on the real-world difficulties and applications of renewable energy technology.
- Further research, concentrating on methane and methanol reactors, will combine green hydrogen facilities with power-to-X technology. Since hydrogen has a larger potential for global warming than previously believed, it will also look at energy use and emissions connected to hydrogen leaks from occurring.
- The integration of renewable energy sources with appliances, with an emphasis on energy efficiency enhancement for affordability, necessitates investment in novel technology for agricultural value chains.
- With the goal to provide food security, combat climate change, and advance sustainable development goals, renewable energy in agriculture may strengthen energy management techniques. To address the depletion of non-renewable resources, the most appropriate course of action is to identify and utilize renewable energy sources as a substitute for fossil fuels.
- The research offers significant perspectives on the growing utilization of renewable energy in agriculture, including its advantages for productivity and environmental sustainability. It also explores at the co-occurrence of connected keywords and the theme distribution of pertinent publications in various nations.
- To utilize agricultural biomass for energy generation in a cost-effective and efficient manner, clear instructions are necessary so that farmers may make the necessary adjustments and grow crops that use less energy.
- Simplifying protocols and minimizing complexity can be achieved by implementing important metrics for energy interventions in agricultural food chains. Prioritizing small-scale technologies may boost the income and well-being of farmers, and supplying energy to isolated areas can encourage the growth of new businesses.

Conclusion

Since the agri-food chain accounts for one-third of the world's energy consumption, sustainable development relies on the efficient management of energy resources. The energy inputs required for modern behaviors are greater, therefore supporting renewable energy technology may help mitigate the impacts of climate change. Over the years, there has been a substantial amount of research on the robust and efficient utilization of renewable energy in agribusiness. By strengthening renewable energy sources, the global agriculture industry may lessen its dependency on fossil fuels, enhancing both climate protection and global food security. Water shortage is a serious problem, and as water is essential for crop development and sustainability, the agri-food chain should think about recycling leftover geothermal brine for agriculture. With the goal to minimize greenhouse gas emissions, promote energy efficiency, and advance sustainability, this research analyzes the application of renewable energy sources, including solar, biomass, wind, and geothermal, in agriculture. It also emphasizes the necessity of cooperation by highlighting obstacles and limitations to integrating these technologies. Policies to overcome these obstacles vary throughout nations since each has different institutional, physical, and strategic characteristics, and policies supporting these projects exhibit distinct effects. Rural renewable energy programs confront several obstacles.

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References

1. Bathaei A., Štreimikienė D. (2023). Renewable Energy and Sustainable Agriculture: Review of Indicators. *Sustainability*, *15*(19), 14307.
2. Maican E., Vlădut V., Vîlcu C., Soricã C., Dorian M., Mirea D. P., Bogãþeanu R. (2019). Hybrid renewable energy systems for isolated farms. *A review*.
3. Minoofar A., Gholami A., Eslami S., Hajizadeh A., Gholami A., Zandi M. ... Kazem H. A. (2023). Renewable energy system opportunities: A sustainable solution toward cleaner production and reducing carbon footprint of large-scale dairy farms. *Energy Conversion and Manage-ment*, *293*, 117554.
4. Pombo-Romero J., Langeveld H., Fernández-Redondo M. (2023). Diffusion of renewable energy technology on Spanish farms: drivers and bar-riers. *Environment, Development and Sustainability*, *25*(10), 11769–11787.
5. Paris B., Vandorou F., Balafoutis A. T., Vaiopoulos K., Kyriakarakos G., Manolakos D., Papadakis G. (2022). Energy use in open-field agriculture in the EU: A critical review recommending energy efficiency measures and renewable energy sources adoption. *Renewable and Sustainable Energy Reviews*, *158*, 112098.
6. Aschilean I., Rasoi G., Raboaca M. S., Filote C., Culcer M. (2018). Design and concept of an energy system based on renewable sources for greenhouse sustainable agriculture. *Energies*, *11*(5), 1201.
7. Gorjian S., Fakhraei O., Gorjian A., Sharafkhani A., Aziznejad A. (2022). Sustainable food and agriculture: employment of renewable energy technologies. *Current Robotics Reports*, *3*(3), 153–163.
8. Pestisha A., Gabnai Z., Chalgynbayeva A., Lengyel P., Bai A. (2023). On-farm renewable energy systems: A systematic re-view. *Energies*, *16*(2), 862.
9. Dhunny A. Z., Allam Z., Lobine D., Lollchund M. R. (2019). Sustainable renewable energy planning and wind farming optimization from a biodiversity perspective. *Energy*, *185*, 1282–1297.
10. Lin X., Sun X., Manogaran G., Rawal B. S. (2021). Advanced energy consumption system for smart farm based on reactive energy utilization technologies. *Environmental Impact Assessment Review*, *86*, 106496.
11. Streimikiene D., Baležentis T., Volkov A., Morkūnas M., Žičkienė A., Streimikis J. (2021). Barriers and drivers of renewable energy penetration in rural areas. *Energies*, *14*(20), 6452.
12. Doshi M., Varghese A. (2022). Smart agriculture using renewable energy and AI-powered IoT. In *AI, edge and IoT-based smart agricul-ture* (pp. 205–225). Academic Press.
13. Sharma H., Haque A., Jaffery Z. A. (2019). Maximization of wireless sensor network lifetime using solar energy harvesting for smart agriculture monitoring. *Ad Hoc Networks*, *94*, 101966.
14. Das G. P., Gould I., Zarafshan P., Heselden J., Badiee A., Wright I., Pearson S. (2022). Applications of robotic and solar energy in precision agriculture and smart farming. In *Solar energy advancements in agriculture and food production systems* (pp. 351–390). Academic Press.
15. Palys M. J., Wang H., Zhang Q., Daoutidis P. (2021). Renewable ammonia for sustainable energy and agriculture: vision and systems engineering opportunities. *Current opinion in chemical engineering*, *31*, 100667.
16. Ymeri P., Gyuricza C., Fogarassy C. (2020). Farmers' attitudes towards the use of biomass as renewable energy—A case study from southeastern europe. *Sustainability*, *12*(10), 4009.
17. Uchman W., Kotowicz J., Sekret R. (2022). Investigation on green hydrogen generation devices dedicated for integrated renewable energy farm: Solar and wind. *Applied Energy*, *328*, 120170.

18. Tomaszewska B., Akkurt G. G., Kaczmarczyk M., Bujakowski W., Keles N., Jarma Y. A. ... Kabay N. (2021). Utilization of renewable energy sources in desalination of geothermal water for agriculture. *Desalination*, *513*, 115151.
19. Rahman M. M., Khan I., Field D. L., Techato K., Alameh K. (2022). Powering agriculture: Present status, future potential, and challenges of renewable energy applications. *Renewable Energy*, *188*, 731–749.
20. Rikkonen P., Tapio P., Rintamäki H. (2019). Visions for small-scale renewable energy production on Finnish farms–A Delphi study on the op-portunities for new business. *Energy Policy*, *129*, 939–948.
21. Majeed Y., Khan M. U., Waseem M., Zahid U., Mahmood F., Majeed F. ... Raza A. (2023). Renewable energy as an alternative source for energy management in agriculture. *Energy Reports*, *10*, 344–359.
22. Saleem M. (2022). Possibility of utilizing agriculture biomass as a renewable and sustainable future energy source. *Heliyon*, *8*(2).