Chapter 9
Multi-Objective Optimal Performance of a Hybrid CPSD-SE/HWT System for Microgrid Power Generation

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ABSTRACT

A new integrated hybrid solar thermal and wind-based microgrid power system is proposed. It consists of a concentrated parabolic solar dish Stirling engine, a wind turbine, and a battery bank. The electrical power curtailment is diminished, and the levelised cost of energy is significantly reduced. To achieve these goals, the present study conducts a dynamic performance analysis over one year of operation. Further, a multi-objective optimisation model based on a genetic algorithm is implemented to optimise the techno-economic performance. The MATLAB/Simulink® software was used to model the system, study the performance under various operating conditions, and optimise the proposed hybrid system. Finally, the model has been implemented for a specific case study in Mafraq, Jordan. The system satisfies a net power output of 1500 kWe. The developed model has been validated using published results. In conclusion, the obtained results reveal that the optimised model of the microgrid can substantially improve the overall efficiency and reduce the levelised cost of electricity.

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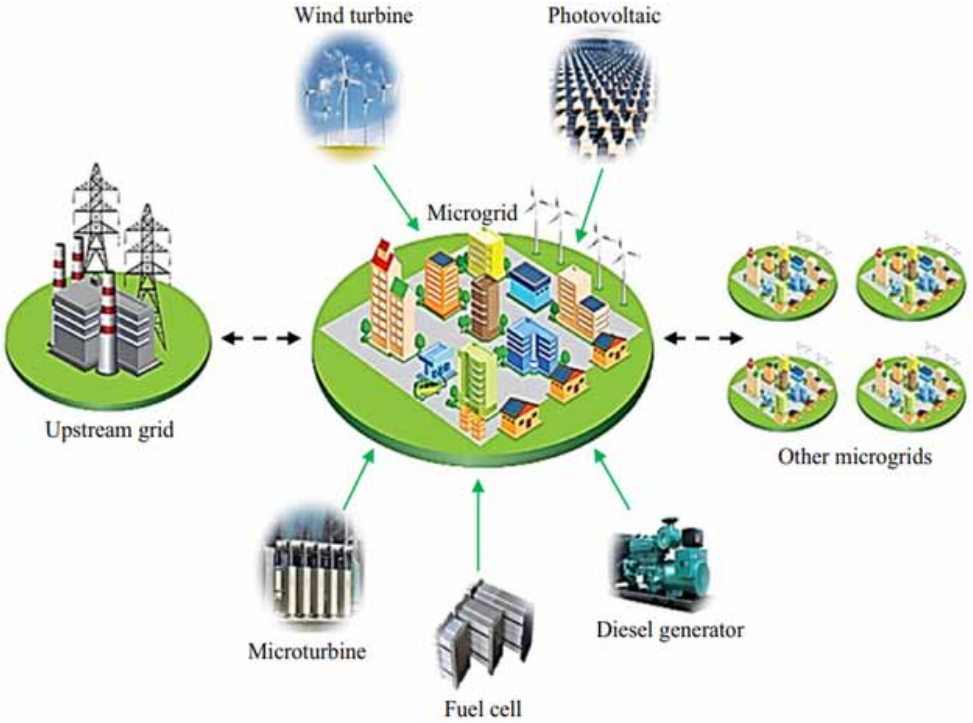
INTRODUCTION

Nowadays, small-scale decentralised distributed generation systems are on track to become the foundation of the worldwide energy network and it is a promising alternative solution to the typical large-scale centralised power plants. Consequently, microgrid systems comprising of a hybrid renewable energy system (HRES) can play a significant role in satisfying the energy demands of remote regions and resolving the energy price inflation and environmental problems posed by the use of fossil fuels in energy production (Motevasel et al., 2013). Therefore, microgrids with HRES would help to eliminate over a hundred million tonnes of CO_2 emissions from the atmosphere each year by providing a reliable, sustainable, and cost-competitive renewable energy supply, thus meeting the global energy needs without compromising the planet's well-being. For instance, integration of HRES with energy storage systems, such as batteries and traditional power systems, such as a boiler or diesel engine into microgrid is considered the popular way of increasing the reliability to meet the energy demand (Belfkira et al., 2011; Kumar et al., 2013), as depicted in Figure 1 (Kabalci, 2021). In consequence, the HRES microgrids are more reliable and economical when compared to the single renewable energy system (Dufo-López et al., 2011).

Figure 1. Microgrid with its multiple demand and source connections (Kabalci, 2021).



Solar and wind energy resources are widely used in microgrids. Nevertheless, these resources need proper management in order to facilitate their power operations to mitigate the implications of the intermittent output. To fully utilise this process, the sizing optimisation methodologies should be applied by