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AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

Energy Management of Electric Vehicles Charging Stations Considering Uncertainties

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

Eslam Alaa Eldeen Zenhom Basiony

Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2017

Supervised By

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Prof.Dr. Mostafa Ibrahim Mohamed Marei

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Cairo - (2021)

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Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering , Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract

The use of electric vehicles (EVs) is rapidly increasing worldwide due to their environmental benefits. In the meantime, renewable energy sources (RESs) are becoming important sources of electricity generation due to their environmental and economic benefits. Thus, the environmental and economic aspects of EVs can be considerably increased if the charging station is powered by RESs. However, the integration of EVs and RESs in electric networks has many challenges due to the uncertainties of EVs users' behaviors in addition to the intermittency of power generation from RESs due to their dependance on the weather conditions.

Uncoordinated charging of EVs has several adverse effects on the charging stations and the electric network. So, energy management of the charging stations by scheduling the connected EVs is essential. Electric vehicles can operate in the grid-to-vehicle mode when they charge from the grid and in the vehicle-to-grid mode when they discharge their energy to the grid. Thus, they can assist charging stations to minimize their operation costs by allowing the charging stations to use them as distributed storage.

The main objective of this thesis is to develop a charging/discharging strategy for EVs located in a parking lot integrated with a photovoltaic system to ensure optimal operation in the day ahead. The time-of-use (ToU) price is used to minimize the day-ahead operation cost of energy trading to the charging station. Two models are used in the study, the deterministic and stochastic models. In the deterministic model, the optimization problem is formulated and solved using improved whale optimization algorithm which simulates the hunting behavior of humpback whales and hybridized with the mutation part of the differential evolution algorithm to improve the optimal solution. In the stochastic model, the randomness and uncertainties of electric vehicles and the intermittency of the

photovoltaic system are considered and handled using Monte Carlo Simulation (MCS). The stochastic scenarios are generated and included in a cost minimization problem, which is formulated as a mixed-integer linear problem and solved using CPLEX optimizer.

Realistic data related to EVs, ToU pricing and photovoltaic generation is used in the study to provide realistic results. Several case studies have been simulated to compare the coordinated charging/discharging strategy for EVs with the coordinated charging (without discharging) and uncoordinated charging. The results show the effectiveness of the proposed strategy as the cases prove that coordinated charging/discharging gives better results compared to other strategies in terms of the total daily operation cost of the charging station. However, this strategy requires the charging station operator to pay incentives for EVs to encourage them participate in the charging/discharging program.

Key words: Charging Station, Coordinated, Charging/Discharging, Electric Vehicle (EV), Operation Cost, Renewable Energy Source (RES), Scheduling, Uncertainty.

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