UNIVERSITI TEKNOLOGI MARA

HYBRID EVOLUTIONARY-BARNACLES MATING OPTIMISATION-ARTIFICIAL NEURAL NETWORK BASED TECHNIQUE FOR SOLVING ECONOMIC POWER DISPATCH PLANNING AND OPERATION

NOR LAILI BINTI ISMAIL

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Electrical Engineering)

College of Engineering

January 2024

ABSTRACT

Economic Dispatch is an important component in power system planning and operation. This will lead to the capability of such power transmission in the utility system to perform their planning of power delivery to the consumer with minimal cost and acceptable emission level. Thus, a reliable and robust optimisation algorithm will be a priori in ensuring a profitable operation of the utility. Non-optimal values of generated power in a power system network may cause non-economic phenomena in terms of cost of generation and emission level. Thus a reliable optimisation approach is crucial to ensure the economic operation of the power system. The practice of only considering a single objective may affect the operation since only one objective function is considered. Thus, multi-objective needs to be considered to address this issue which considers more than one objective function. No effort on the possible prediction process may cause limited information on ED ranges. Thus, special efforts need to be conducted to forecast several possible scenarios under the variations of the input variables in ED studies. This thesis presents the Hybrid Evolutionary-Barnacles Mating Optimisation-Artificial Neural Network Based Technique for Solving Economic Power Dispatch Planning and Operation. In this study, a new optimisation algorithm termed Hybrid Evolutionary-Barnacles Mating Optimisation (HEBMO) was initially formulated to solve optimisation problems. The proposed HEBMO optimisation algorithm was employed to solve the convex and non-convex economic dispatch problems. Subsequently, a new multi-objective optimisation technique named Multi-Objective Hybrid Evolutionary-Barnacles Mating Optimisation (MOHEBMO) was developed to solve the minimization problems involving the total generation cost and total emission of harmful gasses in a multi-objective mode. Subsequently, the proposed HEBMO was integrated with an artificial neural network (ANN) for the scheduling of input features of the generator to predict total fuel cost and emission in power system planning. This will allow the power system planners and operators to use the relevant results for consumption at their control center. The first two proposed algorithms are validated on 2 reliability test systems (RTS) to represent a small and medium power transmission model namely the IEEE 30-Bus RTS and IEEE 57-Bus RTS. The third algorithm was validated on IEEE 30-Bus RTS only. Comparative studies were conducted concerning the traditional Evolutionary Programming (EP) and Barnacles Mating Optimiser (BMO) for performance evaluation of HEBMO and MOHEBMO. It is able to minimise the total generation cost and total emission. Integration of HEBMO and ANN has also indicated a great prediction of total generation cost and total emission while satisfying the optimal demand for power generation. This new model was compared with the ANN model for performance evaluation. A comparative study with respect to the traditional ANN revealed that the integration between HEBMO and ANN is much more accurate, indicated by the high value of the correlation coefficient, close to 1.00. All the proposed HEBMO, MOHEBMO, and HEBMO-ANN can be further applied in a larger system within the same research discipline. It is also feasible for application in solving other problems involving optimisation process and prediction.

ACKNOWLEDGEMENT

In the name of Allah, the most Merciful and the most Compassionate. Alhamdulillah, thank you for always giving me strength, blessings, and favors in my life during this seeking-knowledge process.

First of all, I would like to express my profound thanks and gratitude to my supervisor Professor Ir. Dr. Hj. Ismail Bin Musirin for his constant guidance, patience, advice, and dedication throughout this challenging journey. His enthusiasm towards the accomplishment of this thesis is indeed appreciated. It has been a great opportunity and honor to be supervised by him. I would like also to thank both of my co-supervisors Professor Ir. Dr. Nofri Yenita Binti Dahlan and Dr. Mohd Helmi Bin Mansor for their valuable suggestions and continuous support to complete this thesis. May Allah give His blessing to all of them.

My appreciation also goes to my Ph.D. colleagues for their help, ideas, and fruitful discussions. I appreciate the hours we spent together helping each other. I also wish to thank all my siblings, friends, and relatives for their encouragement, support, and motivation to ensure this thesis would come to its completion.

I would like to extend my deepest gratitude to my beloved husband, Nasrul Muhaimin Bin Mohd Nawi, and my three beloved kids, Raeesa Hana, Hadhiya Hana, and Aydan Hayyan for their unconditional love, endless support, patience, sacrifice, and doa. Their full understanding throughout my Ph.D. journey makes me stronger and more confident to make me complete my Ph.D. thesis.

Finally, I dedicate this thesis to my mother ., and to the memory of my late father, Allahyarham Ismail Bin Ya'kub who had never stopped encouraging me to pursue my Ph.D. study. May Allah bless both of them.

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Research Background

A power system is a complex network consisting of generation, transmission, and distribution infrastructure that is designed to generate, transmit and distribute electrical energy to meet the needs of consumers. The central goal of a power system is to reliably provide electricity to consumers at an affordable cost. Economic dispatch (ED) is a key component of power system operations. The ED takes into account the varying costs of electricity generation across different power plants, as well as the current state of the grid, to optimise the allocation of electricity generation.

ED is a process used to determine the most efficient amount of electrical power to be generated to meet the power demand, taking into account constraints, both the equality and inequality constraints resulting in the lowest possible cost. It plays a crucial role in ensuring that the power system is operated efficiently and cost-effectively. It is also an important consideration in the design and operation of power markets, as it helps to ensure that the market price of electricity reflects the true cost of electricity production. Furthermore, ED helps to ensure that the power system is operated reliably, by balancing the supply and demand for electricity in real-time. This helps to prevent blackouts and other disruptions and to ensure that the power system is always able to meet the electricity demand.

Since the early 1970s, the scholar tries to solve the ED problem [1], with cost minimisation as its objective function. Most power generating station is set up as thermal power unit, which is using non-renewable resources, coal, oil, and gas. Due to the maximum capacity of a power plant, the optimisation of generation cost is required. The objective function in ED typically represents the total cost of electricity production, which is a function of the generation of each power plant and the associated cost of generation for each plant. On top of that, several operational constraints need to be considered. This includes generator constraints, transmission line capacities, voltage limits, and reserve requirements.

To determine the optimal generation levels for each power plant in ED, an optimisation algorithm is employed. This algorithm takes into account the load forecast,