WIND POWER GENERATION EFFECT ON ECONOMIC LOAD DISPATCH IN POWER SYSTEM

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical Power)

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JANUARY 2019

DEDICATION

I wish to dedicate this project report to my late father, who show me the way how to keep learning and never give up in all my undertaking, and my lovely mother, who always trust on me and encouraged me to take up this master degree course when I am not that confidence on myself. Last but not least I dedicated to my beloved wife that support and encourage me throughout my master course and take good care of my family so that I can focus on my study with an undivided attention.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude and appreciation to my thesis supervisor Dr. Mohd Hafiz Habibuddin for his kind and patient guidance and willingness to share his expertise and knowledge to me throughout my project report in order for me to complete it on time.

I would like to acknowledge my entire fellow course mate especially Kelvin Yong, Esty Mohd Yusuf, Joseph Ting and Harnetta. They had given me a lot of ideas and help since the beginning of the project report in Project 1.

I am grateful to all my family member especially my mother and sisters in Sarikei that help me to take care of my family with my 5 kids during the final stage of my report. Not to forget my wife Joanne who always supports me, bear with me when I am under pressure and taking good care of my family well throughout my master degree programme and my project report.

ABSTRACT

Renewable Energy (RE) generation is getting more and more attention due to the awareness of the perseverance of environment and sustainability of resources. While Economic Load Dispatch (ELD) is a heavily researched area which aims to optimize the objective function (i.e. minimizing the total production cost, maximizing the generation profit in deregulated bid market, reserve constrained ELD, etc.) without violating the constraints. RE generation in general and wind power in particularly is well-known for its nature of unpredictability, highly intermittent and uncertainly. This has make the entire power system vulnerable to the instability problem and is intensified once there is large scale high penetration of RE in the existing pre-dominantly fossil fuel thermal power plant. Higher penetration of RE in power system is an unavoidable trend. This will make the ELD highly nonlinear problem even more severe. This paper aims to study the wind power generation effect in ELD particularly on the saving of the total operation cost. Quadratic Programming technique will be used to investigate the Wind Power Plant (WPP) effect in Dynamic Economic Load Dispatch (DELD) problem, after comparison has been made against both Genetic Algorithm and Particle Swarm Optimization in 3 Generator system and 6 Generator system that shows better solution in finding global minima. Several case study tested in order to investigate the wind power effect with no-wind, low-wind, normal wind and high-wind scenarios in solving the ELD problem. The saving of the total cost is ranging from 4% to 11% as reported in the result.

ABSTRAK

Penjanaan Tenaga Boleh Diperbaharui (RE) semakin mendapat perhatian kerana kesedaran terhadap ketekunan persekitaran dan kelestarian sumber. Walaupun Penghantaran Elektrik (ELD) adalah kawasan yang banyak diteliti yang bertujuan untuk mengoptimumkan fungsi objektif (iaitu meminimumkan jumlah kos pengeluaran, memaksimumkan keuntungan generasi dalam pasaran bida yang dikawal-selia, rizab ELD, dll) tanpa melanggar kekangan. Generasi RE secara umumnya dan kuasa angin secara khususnya terkenal kerana sifatnya yang tidak dapat diramalkan, sangat berselang-seli dan tidak menentu. Ini telah menjadikan keseluruhan system kuasa terdedah kepada masalah ketidakstabilan dan dipergiatkan apabila terdapat penembusan RE skala besar dalam loji jana kuasa bahan api fosil pra-dominan yang sedia ada. Penembusan yang lebih tinggi daripada RE dalam system kuasa adalah trend yang tidak dapat dielakkan. Ini akan menjadikan masalah ELD sangat tidak linear dan lebih teruk. Makalah ini bertujuan untuk mengkaji kesan penjanaan kuasa angin (WPP) di ELD terutamanya pada penjimatan jumlah kos operasi keseluruhan. Teknik pemodelan Kuadratik akan digunakan untuk menyiasat kesan WPP dalam masalah DELD, selepas perbandingan dilakukan terhadap kedua-dua Algoritma Genetik(GA) dan Pengoptimuman Swarm Partikel(PSO) dalam sistem 3 Generator dan 6 Generator yang menunjukkan penyelesaian yang lebih baik dalam mencari minimum global. Beberapa kajian kes diuji untuk menyiasat kesan kuasa angin seperti berikut: tanpa angin, angin yang rendah, angin biasa dan angin yang tinggi dalam menyelesaikan masalah ELD. Penjimatan jumlah kos adalah dari 4% hingga 11% seperti yang dilaporkan dalam hasilnya.

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LIST OF ABBREVIATIONS

ELD	-	Economic Load Dispatch
RWM	-	Roulette Wheel Mechanism
PDF	-	Probability Distribution Function
VMD	-	Versatile Mixture Distribution
SELD	-	Static Economic Load Dispatch
DELD	-	Dynamic Economic Load Dispatch
POZ	-	Prohibited Operating Zone
FOR	-	Feasible Operating Region
DPSA	-	Dynamic Programming Successive Approximation
GA	-	Genetic Algorithm
PSO	-	Particle Swarm Optimization
SA	-	Simulated Annealing
EP	-	Evolutionary Programming
DE	-	Differential Evolution
HNN	-	Hopfield Neural Network
EDSA	-	Enhance Direct Search Algorithm
UC	-	Unit Commitment
GS	-	Generation Scheduling
WPP	-	Wind Power Generation
RE	-	Renewable Energy
DER	-	Distributed Energy Sources

LIST OF SYMBOLS

LBF_l	-	Lower Bound of the Transmission line
UBF_l	-	Upper Bound of the Transmission line
$F_i(P_{ij})$	-	Fuel Cost Function of the Power Generation
$a_i P_{ij}^{\ 2} + b_i P_{ij} + c_i$	-	Fuel Cost Coefficient

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Global warming effect on the extreme weather occurs all around the world has alerted the human kinds about the importance of environmental perseverance. One of the main contributors is the emission of the pollutant gases from the fossil fuels which majorly used in the energy power generation. Therefore, many international organizations put a lot of effort to educate, create awareness and foster an encouraging environment and business model to promote the investment, research and development in the renewable energy sources generation. With the advent of the power electronic technology, more and more renewable energy source and distributed generation has been materialized all around the globe. The global status report of renewable by Renewable Energy Policy Network for the 21st Century (REN21) indicated the global renewable power capacity from year 2007 to 2017 as shown in figure 1.1[1]. Figure 1.2 [1]clearly shown that Wind power generation is one of the most popular and promising renewable energy sources which registered steady uptrend for the past decade and hit 539GW installed capacity in the year 2017.

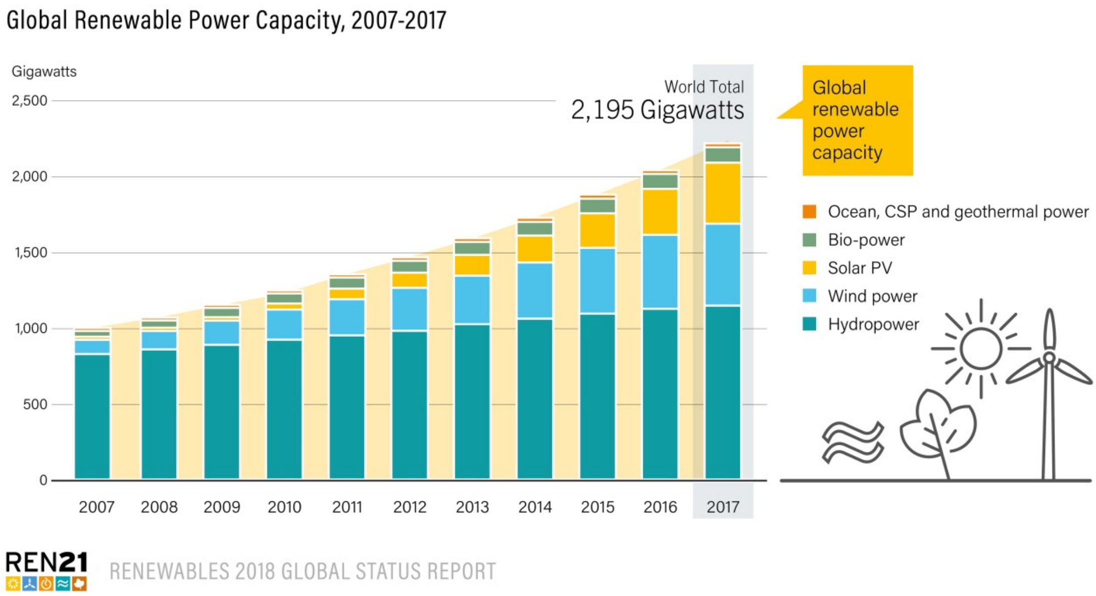

Figure 1.1 Global Renewable Power Capacity from 2007 – 2017 [1]

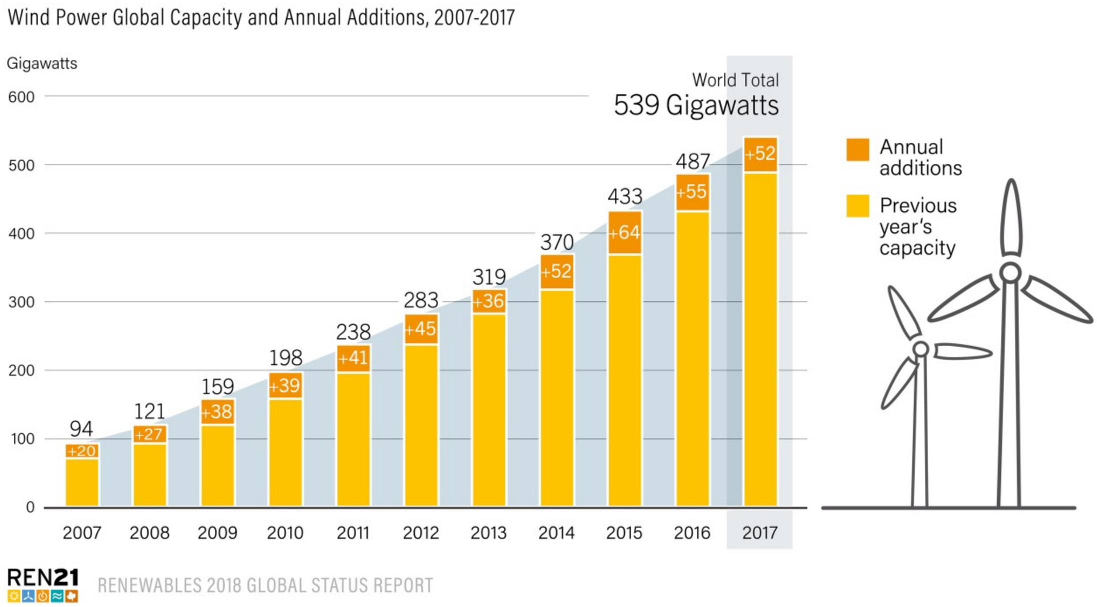

Figure 1.2 Wind Power Global Capacity and Annual Additions, 2007 – 2017

In the electric power system the three main components are: Generation, Transmission and Distribution. Figure 1.3 depicts the typical power system [2].The generating power plants supply the bulk energy to the consumer at distribution side, via the transmission line. Power balance must be achieved in order to ensure the stability of the entire power system, which is to match the energy source generated at generating stations to the load demand at distribution. If the active and reactive power generated is not enough to meet the demand from customer, the mismatch will happen and resulted the dropping of the system frequency and voltage. If there are no remedial action been taken in the short period, blackout are expected and huge economic loss is unavoidable. Therefore there is utmost importance that the power system operator has to manage and control the system to be in secure and stable state. Economic load dispatch (ELD) is the function to ensure the load demand in the system can be met with the least generation cost. In actual practical case, the line losses are quite significant especially in the large power system that involved the long transmission line. With the increasing presence of renewable energy source in the generation portfolio, which generally are high intermittent in nature, to economically dispatch the load becoming more and more complicated.

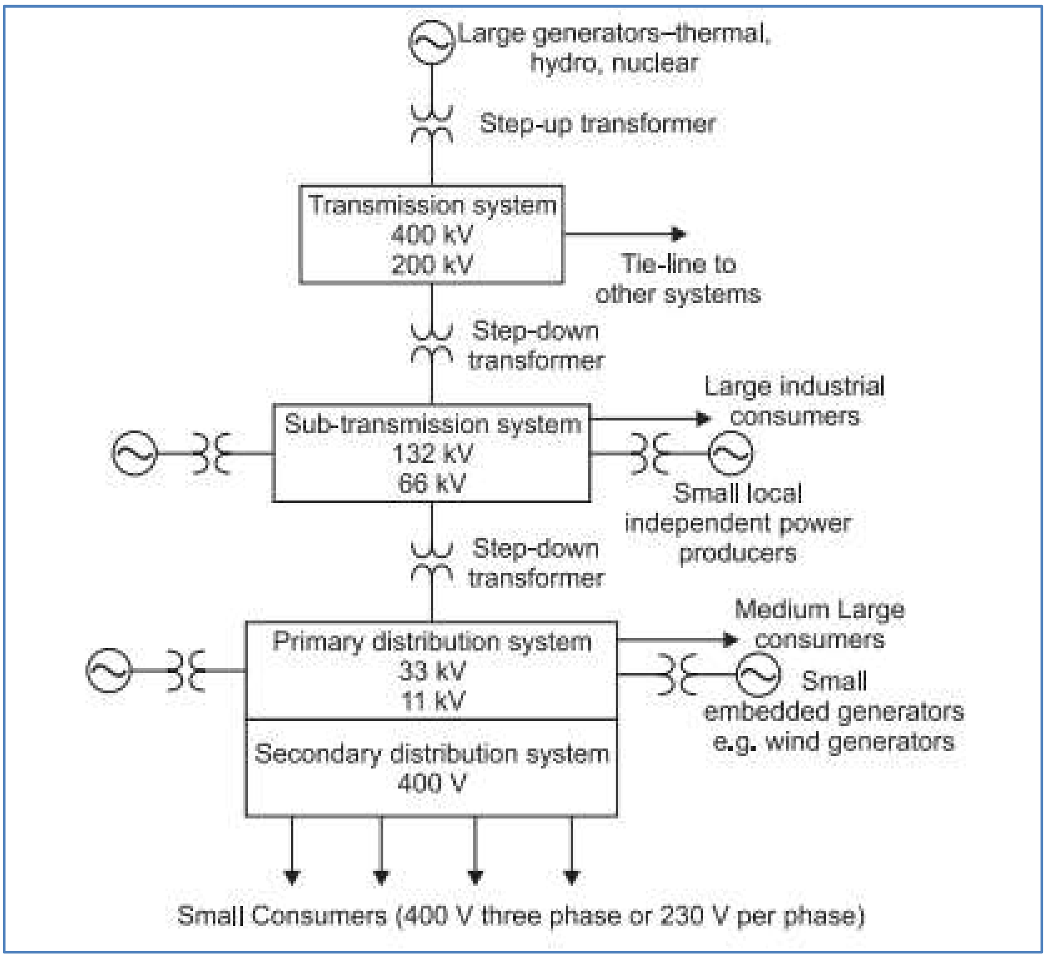

Figure 1.3 Schematic Diagram of a power supply system [2]

1.2 Problem Statement

With the high penetration of renewable energy source in the power system, the system operator has to be able to react to the high variability and unpredictability of the wind power plant in matching the load demand, while minimizing the total production cost of the generators [3]. A common measure to counter the problem of the wind power generation is to provide the spinning reserve form the online committed generation. There are several recommendation and suggest from the researcher on the quantity of reserve. Some system operator require the capacity of the largest generating units at all time, while J.Wang et al [4] suggested the 10 percentage of the real time load demand.

The prediction of the wind power generation also is a big challenge in order to determine the reserve required and also to solve the economic dispatch problem. R.A. Abarghoose et al use Roulette Wheel Mechanism (RWM) along with Probability Distribution Function (PDF) to model the wind forecast error [5], while Chenghui Tang et al proposed Versatile Mixture Distribution (VMD) to represent the wind power in his study with multiple wind farms [6]. In this context, the ability to get the global minimum total cost with high penetration of wind power in power system is important for power system security, emission control and also the long term sustainable and more economical operation cost.

1.3 Objectives and Scope of the Study

Followings are the objectives proposed for this study: -

(1) To solve the economic load dispatch with cost minimization function while meet the equality and inequality constraints.

(2) To investigate the effect of wind power plant on total operating cost in economic load dispatch problem.

1.4 Organization

This thesis report has been presented in five chapters. Chapter one introduces the background of the project study, the problem statement and enlists the objective and scope of the study. Chapter two discusses in more details on the literature review, the type of ELD and also the algorithm used to solve the problem. Chapter three explains the methodology approaches and assumption used in this thesis to achieve the objective. Chapter four reports the numerical simulation results of several cases and discuss the analysis of the cases. Finally a conclusion of the work done and suggestion of the future work are presented in last chapter.

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