DEVELOPMENT OF UNIT COMMITMENT ASSESSMENT TECHNIQUE BASED ON MALAYSIA GRID CODE REQUIREMENT

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

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

MAY 2007

DEDICATION

To my beloved wife, sons, daughters, mother & parents in law.

Al-Fatihah to my late father.

ACKNOWLEDGEMENTS

I first wish to express my sincere appreciation and gratitude to my thesis supervisor, Dr. Azhar bin Khairuddin, for his invaluable ideas, support, critics and encouragement guidance since the first beginning of this project. He has far exceeded the expectations of a great supervision and provided means for the establishment of the grounds of a good friendship.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Master study.

At last, but not least, I am extremely grateful to my beloved wife Nor Mastika bt. Mohammed, my sons, my daughters, my mum Timah bt. Abd. Rahman and my parent in-law Mohammed bin Yusoff and Che Naemah bt. Che Daud. I am grateful to all my family members. Without their unlimited dedication, support and love throughout so many years, I would never have got this far. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space.

ABSTRAK

Komitmen Unit adalah satu kaedah analisis yang diperlukan di dalam sistem kuasa untuk merencanakan dan menghantar kuasa elektrik. Berbagai teknik matematik telah dihasilkan bagi memenuhi keperluan untuk menyelesaikan masalah komitmen unit di dalam sistem kuasa. Dalam merencanakan penjanaan kuasa, pelbagai syarat telah diperincikan oleh setiap negara di dalam bentuk kod dan piawaian. Dalam sektor elektrik di Malaysia, proses perencanaan dan penghantaran kuasa elektrik ditentukan oleh syarat khusus di dalam Kod Grid Malaysia 2006. Kod edisi baru telah memperincikan syarat dan aturcara yang diperlukan untuk proses unit komitmen bagi industri tenaga elektrik Malaysia. Tujuan utama projek ini adalah untuk membina cara sistematik bagi menyelesaikan masalah komitmen unit secara amnya dan untuk sektor elektrik Malaysia secara khususnya. Tujuan kedua adalah untuk memanfaatkan cara ini bagi meminimumkan kos penjanaan dan pada masa yang sama dapat menyelesaikan semua had berhubung dengan penghantaran tenaga elektrik daripada syarikat penjanaan kepada penguna. Syarat-syarat Kod Grid Malaysia adalah dipertimbangkan di dalam memenuhi skop projek ini. Kaedah yang dihasilkan deprogram dengan aturcara Turbo Pascal dan diuji dengan beberapa system ujian. Kaedah Pemprograman Dinamik telah dipilih untuk menyelesaikan proses komitmen unit. Atucara yang dihasilkan telah berjaya menganalisa sistem kuasa berdasarkan Kid Grid Malaysia. Operasi penjanaan juga dapat dioptimakan berpandukan pada permintaan beban harian. Kos penjanaan juga dapat diminimumkan disamping memenuhi permintaan beban. Akhirnya aturcara yang dihasilkan dapat digunakan untuk menganalisis sistem kuasa di Malaysia.

ABSTRACT

Unit commitment is one of the pertinent analyses required in the scheduling and dispatch of power system. Various mathematical techniques have been developed to cater for the requirements of solving the unit commitment problems in power system. In scheduling of power generation, various requirements have been detailed out by countries in the forms of standards and codes. For Malaysian electricity sector, the process of scheduling and dispatch is governed by the requirements specified in the established Malaysia Grid Code 2006. This newly revised Code has detailed out the requirements and necessary procedure for the Unit Commitment process for the Malaysia electrical energy environment. The main objective of the project is to develop a systematic method in solving unit commitment problem in general and for Malaysia electricity sector in particular. The second objective is to utilize the method in order to minimize generating cost and at the same time fulfilling all the constraints related to the delivery of electrical energy from the generating companies to the consumers. The specific considerations to the requirements of the Malaysian Grid Code are fulfilling the scope of the project. The method has been programmed using Turbo Pascal language and tested on several test systems. The Dynamic Programming method has been chosen to solve the unit commitment process. The program has been successful applied to run the system base on Malaysia Grid Code requirement. The generations have been able to be optimized the operation of the system base on the load demand for the given day. The generating costs of the generation have been minimized besides fulfilling the load demands. Eventually, the program is capable to be used to analyze the Malaysia power system.

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LIST OF ABBREVIATIONS

AFLC	-	Average Full Load Cost
B&B	-	Branch and Bound
UC	-	Unit Commitment
CC	-	Combine Cycle
CPU	-	Control Processor Unit
CUF	-	Commitment Utilization Factor
DP	-	Dynamic Programming
DP-TC	-	Dynamic Programming Truncated Combination
DP-SC	-	Dynamic Programming Strict Combination
DP-STC	-	Dynamic Programming Sequential / Truncated Combination
DP-VW	-	Variable Window Dynamic Program
DP-ANN	-	Dynamic Programming – Artificial Neural Network
DISCO	-	Distribution Company
EC	-	Energy Commission
ESCO	-	Electricity Supply Company
FDP	-	Fuzzy Dynamic Programming
GENCO	-	Generating Companies
GSO	-	Grid System Operator
GT	-	Gas Turbine
IEEE	-	Institute of Electrical and Electronic Engineer
MGC	-	Malaysia Grid Code
MW	-	Mega Watt
MWh	-	Mega Watt hour
NLDC	-	National Load Dispatch Centre
QS	-	Qualifying Facility
SA	-	Simulated Annealing

SESCO	-	Sarawak Electricity Supply Corporation
SESB	-	Sabah Electricity Sdn Bhd
ST	-	Steam Turbine
TNB	-	Tenaga Nasional Berhad
Users	-	Power Generating Company

CHAPTER 1

INTRODUCTION

1.1 Introduction

A great problem developed from the industrial era is the dilemma of the increasing demands for energy. As the electric power industry assumes an ever increasing commitment to resolve the energy supply problem, it is subjected to escalating societal pressure to:

i. Generate reliably a sufficient amount of electricity to meet any demands.
ii. Retain or decrease its price rates.
iii. Minimize the impact of its generation efforts upon the ecosphere.

Therefore, unit commitment is one of the pertinent analyses required in the scheduling and dispatch of the power system. It is the process of deciding in advance whether to turn on or off each generator on the power grid at a given hour. It becomes an intricate mathematical decision process because the hourly decisions are interdependent. Various mathematical techniques have been developed to cater for the requirements of solving the unit commitment problems in power system.

Many utilities have daily load patterns which exhibit extreme variation between peak and off-peak hours because people use less electricity on Saturday than on weekdays, less on Sundays than on Saturdays, and at a lower rate between midnight and early morning than during day. If sufficient generation to meet the peak is kept on line throughout the day, it is possible that some of the units will be operating near their minimum generating limit during the off-peak period. The problem confronting the system operator is to determine which units should be taken offline and for how long.

In most of the interconnected power system, the power requirement is principally met by thermal power generation. Several operating strategies are possible to meet the required power demand, which varies from hour to hour over the day. It is preferable to use an optimum or suboptimum operating strategy based on economic criteria. In other words, an important criterion in power system operation is to meet the power demand at minimum fuel cost using an optimal mix of different power plants. Moreover, in order to supply high quality electric power to customers in a secured and economic manner, thermal unit commitment (UC) is considered to be one of the best available options.

With the advent of global crisis and the complication of energy resource structure, the power system production simulation has become a major problem to match effectively the various generating units in power systems and cut down the fuel consumption. Therefore more demands are placed on the probabilistic production simulation. An engineer is always concern with the costs of product and efficiency. For a power system to return a profit on the capital invested, a proper planning and scheduling on operation is very important.

In scheduling and planning of power generation, various requirements have been detailed out by countries in the forms of standards and codes. For Malaysia electricity sector, the process of scheduling and dispatch is governed by the requirements specified in the established Malaysia Grid Code 2006. This grid code requirement must be meet and in the scope of work for developing the unit commitment program.

1.2 Project Objective

The principle aims of this project are:-

i. To develop a systematic method in solving a unit commitment problem in general and for National Electricity sector in particular.

ii. To utilize the method in order to minimize the generating cost and at the same time fulfilling all the related to the delivery constrain of electrical energy from the generating companies to the consumers.

1.3 Scope of Work

The project scope covers the following requirement;

i. Development the program to solve the unit commitment that fulfills the Malaysian Grid Code requirements.

ii. Application of Dynamic Programming (DP) method by using Turbo Pascal programming for solving the unit commitment problem.

iii. Verification of the program to solve the unit commitment problem for power system in general and for Malaysia system in particular.

1.4 Background on the Unit Commitment Analysis

Many strategies have already been developed to tackle the unit commitment economic optimization. In this work, only Dynamic Programming Method is chosen.

Dynamic Programming (DP) is a name used for the methods in which a priori impossible or improbable possibilities are left out. The dynamic programming algorithm (DP) has proven to be one of the successful approaches to unit commitment. This algorithm would systematically evaluate a large number of possible decisions in terms of minimizing the overall cost in multistage scheduling problem. Due to the enumerative nature of the method, dynamic programming suffers from a long processing time that expands exponentially with the size of the problem. Therefore a lot of algorithms have been developed to improve the DP method problem in unit commitment. This development is not only scientifically clumsy but will also amount in the largest possible calculation time.

Lowery [3] introduced the first algorithm on dynamic programming. In the proposed method, the search of dynamic programming can proceed in a forward or backward direction. The forward dynamic programming finds the most economical schedule by starting at the initial stage accumulating total costs, then backtracking from the combination of least accumulated cost starting at the stage and ending at the initial stage. However, the disadvantage of the method is that the combinations of units within a time period (the states) made the process problem. Typically each stage represents one hour of operation. The time periods are longer.

C.K. Pang and H.C. Chen [4] have proposed a truncated dynamic programming (DP-TC) method for the commitment of thermal units over periods of up to 48 hours. With the truncated of potential uneconomical commitment schedules at each time step, it is possible to use a dynamic programming method to find the schedule having the least total cost. This DP-TC method is a fixed search window to truncate the priority list in which only the truncated combination are evaluated. However, the disadvantage of the method is that it requires a much longer processing time to complete the process. The method had been developed when C.K. Pang, G.B. Sheble and F. Albuyeh [5] proposed the Search Sequence Dynamic Programming (DP-SC). This method uses a strict priority list search sequence to reduce the possible combinations at every stage. However, the disadvantage of this method that it requires a much longer processing time to complete the process. Fred N. Lee [7] had improved the two methods [4] and [5] by proposed the dynamic programming – sequential / truncated combination (DP-STC). It approach sequentially determines the optimal commitment order for the available generating units over a short-term operation horizon. The evaluation of a short-term unit commitment method is based upon its solution quality and computational requirement. The method proposed still had been faced the heavy dependence of its computational requirement upon the demand variation in the studied system. If the system hourly load exhibits large variations, it needs to use a large state space truncation window to assure solution feasibility.

W.L.Snyder, H.D.Powell and J.C.Rayburn [6] had introduced the units with similar characteristics such as minimum up/down times; generation capacity, start up cost etc are classified into the same groups. Within each group, windows as well as their positions on priority lists are defined and units follow the strict priority list commitment and de-commitment order. Combinations are made of candidates from different groups in a pre-defined order and economical evaluations are made subsequently. The method has a disadvantage which is; the system will be failed if the distinctions between different types of units in the system do not hold. Walter J. Hobbs, Gary Hermon, Stephen Warner and Gerald B. Sheble [8] had found the new method creates several states from each unique combination and links each state to one of the possible paths to that combination. By preserving many predecessor options, infeasibility may be avoided and more practical and economic solutions may be reaches. However, the disadvantage was the increasing a minimum run time by several hours. It might bring the unit on-line several hours earlier so that it could be at full capacity during its true minimum run time.

The technology has been changed time to time, Chung Ching Su and Yuan Yih Hsu [9] has developed a new approach using fuzzy dynamic programming (FDP). A characteristic feature of this approach is that the errors in the forecasted hourly loads can be taken into account by using fuzzy set notations, making the approach superior to the conventional dynamic programming method which assumes that the hourly loads are exactly known and there exist no errors in the forecasted loads. However, the disadvantage of the approach that it requires more computer time compare to the conventional dynamic programming method. Therefore, it required the CPU time higher for solving this problem.

Z. Ouyang and S. M. Shahidehpour [10] and [11] had proposed two methods. First method knows as variable window dynamic program (DP-VW). It is a heuristic improvement of the truncated window dynamic program. The proposed method employs a variable window size according to load demand increments, and corresponding experimental results indicate a substantial saving in the computation time without sacrificing the quality of the solution. An iterative process for the number of strategies saved in every stage to fine tune the optimal solution. Disadvantage of this method was the probability of running DP-VW without achieving a feasible solution becomes very low by incorporating no valid combination and flow control mechanism. The second known as hybrid dynamic programming – artificial neural network algorithm (DP-ANN). The proposed two step process uses an artificial neural network (ANN) to generate a pre-schedule according to the input load profile. Then the dynamic search is performed at those stages where the commitment states of some of the units are not certain. It is based on truncated window dynamic programming (DP-TC). However, the disadvantage of this method that DP-ANN requires longer time to prepare the program for the application because firstly, it should have training patterns developed for cases in which a different number of units are in service.

1.5 Problem Statement

The methods proposed earlier in section (1.4) by the experts still facing with many problems. In this project, some limitation and advantages of each methodology has been considered to solve the unit commitment problem based on the Malaysian Grid Code requirement.

Scheduling the operation of the generating units involves the selection of the units to be placed in operation and the allocation of the load among them. These two points have been taken to minimize the sum of the startup, banking and expected running costs subject to the demand, spinning reserve, minimum down time and up time constraints. Another additional limitations have been considered in the project was; a unit should not be started up more than once a day and no more than two units of the same plant should be started up simultaneously.

In Malaysia, the demand for the electricity exhibits such large variations between weekdays and weekends, and between peak and off-peak hours that it is usually not economical to continuously keep on line all available generating units. However, to determine which units should be kept on line and which ones should not constitutes a difficult problem for the operator who seeks to minimize the system production cost. This optimization problem has been formulated in each method of unit commitment. Based on the accuracy, simplicity and computational time for the nonlinear situation; the Dynamic Programming combination with priority list and complete enumeration approaches have been selected to develop the suitable program for solving the UC problem and in the same time fulfilling the Malaysian Grid Code requirement.

1.6 Project Report Outline

This project report is divided into six chapters.

Chapter 2 presents the theory of the Unit Commitment and will explain detail on the factor to consider for the UC. Several solution methods are discussed to show that the different between each method terminology. Lastly, the method that is used in this project is elaborated.

The unit project background is explained in Chapter 3. Load demand cycle, modeling of the MGC system for UC solution and implementation of the method are presented. Description of the Malaysia Grid Code requirement has also been discussed detail.

In Chapter 4, the step of implementation for the project and the method for UC problem solution chosen are expressed in detail. Flow chart of the program is shown based on the topology applied in the project. The method for the topology is categorized based on the most successful algorithm. The dynamic programming (DP) approach is used to obtain the model developed for the analysis. Detail explanation on the application with example is included.

Chapter 5 presents the analysis on IEEE test system and Tenaga Nasional Berhad (TNB) system. The results of this analysis are elaborated in detail.

Chapter 6 draws conclusion and proposes future work for this project.

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