# THERMAL GENERATING UNIT COMMITMENT BY DYNAMIC PROGRAMMING

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Submitted in partial fulfillment for the requirements of the Degree of Master of Science in Mechanical Engineering

at the

Faculty of Engineering

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### SUMMARY


Saving foreign currency spent on fuel oil is one of the targets of the utmost importance in Egypt, due to the great amounts of fuel consumed in the large number of thermal generating units connected to the national grid.

This thesis is concerned with the short term thermal generation scheduling in which the thermal units are scheduled on an hourly basis to minimize the total fuel cost in a day-to-day system operation while satisfying some of the important operational constraints.

The purpose was to provide a flexible operational method, that is, an analytical model which, given the continuous changes in the system and its demands, could be applied by the Egyptian Electricity Authority ( EEA ) to schedule the thermal units in a flexible manner while maintaining a maximum saving in the foreign currency spent on the consumed fuel oil.

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## GLOSSARY OF TERMS

| SYMBOL | DESIGNATION | UNITS |
|---|---|---|
| A(I),B(I), C(I) | The coefficients of the unit's input-output equation. | |
| CSTF(I) | Cold start up factor of unit I. | Gcal |
| D(L1),E(L1) | Constants used in determining Y. | |
| ECFC(I) | Unit economic fuel cost. | LE |
| ECLP(I) | Unit economic low power output. | MW |
| ECHP(I) | Unit economic high power output. | MW |
| FC(L1,T) | Fuel cost of running the sorted units at state L1 and time T. | LE |
| FC1(I) | Fuel cost of running unit I. | LE |
| I | A counter referring to the unit's number. | |
| L1 | A counter referring to the state of units at stage T. | |
| L2 | A counter referring to the state of units at stage (T-1). | |
| LOPT(T) | The optimum state at stage T. | |
| M(T) | The optimum number of units at optimum state LOPT(T). | |
| MNTC | Minimum total cost. | LE |
| MNTC1(L1,L2) | Minimum subtotal cost between points (L2,T-1) and (L1,T) | LE |
| MXPD | Maximum power demand. | MW |
| N | Total number of available units. | |
| NM1(T) | Number of units scheduled to run | |

| | | |
|---|---|---|
| | at time T to meet the load. | |
| P(I) | Power output of unit I. | MW |
| PD(T) | Power demand at time T. | MW |
| STC(I) | Start up cost of unit I. | LE |
| STM(I) | Station code of unit I. | |
| T | A counter referring to the hour under study. | |
| TC(L1,T) | The total cost at state L1 and stage T. | LE |
| TC1(L1,L2) | The subtotal cost between the states L2 and L1. | LE |
| TCP1A | The new total power capacity of the units. | MW |
| TCP(I) | Total capacity for a certain group of units. | MW |
| TSTC(L1,L2) | Total start up cost required to move from state L2 in stage (T-1) to state L1 in stage T. | LE |
| TT | Total time period under study. | hrs. |
| UAFC(I) | Unit average fuel cost. | LE/MW |
| UFCF(I) | Unit fuel cost factor. | LE/Gcal |
| UMNP(I) | Unit minimum power output. | MW |
| UMXP(I) | Unit maximum power output. | MW |
| UNM(I) | Name of unit I(either GT or ST). | |
| Y | A symbol referring to incremental fuel cost instead of $\lambda$ . | |

# CHAPTER ONE

# INTRODUCTION

## 1.1- Scope of the Thesis :

The past few decades have seen a vastly rising demand on electric energy allover the world. Heavy usage of steam and gas turbine units in electricity generation to meet the rising demand has in turn increased extremely the consumption of petroleum products.

Due to limited resources of fossil fuels, research is now directed towards the usage of renewable energy resources on one hand and the minimization of the consumption of classical fuels on the other.

In the latter direction, efforts are being made to increase the thermal efficiency of the generating units and to achieve reasonable results in the field of optimum generating unit commitment scheduling. The economic load sharing ( the subject of this thesis) has become particularly important in the last 30 years.

Previous research and studies have shown the dependance of the fuel costs minimization problem upon both the different mathematical approaches, such as integer programming and dynamic programming, and the old methods, such as heuristic approach and priority lists.

Some of the research, which have considered the mathematical approaches, have only mentioned in general the ability of applying these approaches, but they did not show any application for these methods. Another group of research have shown a limited and restricted applications for it. A third group of research, which have dealt with the heuristic approaches and priority lists, showed that these methods when applied gave considerable results.

This study presents a program for the thermal generating unit commitment problem in Egypt applying the dynamic programming as a preferred solution technique for this problem.
The study considered the actual data for the existing thermal generating units in the Egyptian power system.

## 1.2- Outline of the Thesis :

The thesis presented here consists of six chapters and five appendices.
After this chapter which presents a brief introduction and description for the thesis, comes chapter two which comprises a detailed surveying study indicating the progress of work in the unit commitment field since 1958 and till the time of preparing this thesis.
Following this, chapter three gives an illustrative discussion for all the features, factors and constraints affecting the commitment problem.
Chapter four gives an idea about the dynamic programming approach viewing its history from its first begining in addition to its main types of applications.
In chapter five a detailed description supported by the flow

charts of the program is presented.

Then we arrive to the last chapter which introduces an illustrative discussion for all the results obtained by the program, giving the conclusions obtained by these results and pointing out some recommendations for future studies.

The thesis includes also five appendices. The first presents the economic dispatch problem and its features.

The second appendix gives the different approaches for the start up costs that have been applied in previous research.

The third one presents the input data of the available units on the national grid. Appendix number four lists the programmes and their subroutines. Finally, the results of the third trial are tabulated within appendix five.