AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electrical Power & Machines Department

GENERATION EXPANSION PLANNING FOR THE EGYPTIAN POWER SYSTEM CONSIDERING THE ROLE OF THE NUCLEAR ENERGY

A Thesis

Submitted in partial fulfillment of the requirements for the degree of

Master of Science in Electrical Engineering

Submitted By

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Cairo – 2012

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electrical Power & Machines Department).

The work included in this thesis was carried out by the author at the Electrical Power & Machines Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt in collaboration with the Egyptian Electricity Holding Company.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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Abstract

The Egyptian power system is facing major challenges that may limit its growth in the future and affect its important role in the Egyptian economy. Over the last years, the rapid growth in the electricity demand has forced the country to depend heavily on its fossil fuel resources to meet this growth. On the other hand, Egypt may have insufficient fuel resources to meet the future demand growth. Also, the increase in the price of fossil fuels and increasing concerns about the related environmental effects limits the usage of these fuels for power generation.

To address these challenges, this thesis reviews the historical trends of the Egyptian energy system in terms of energy supply, demand, prices and the production of green house gases. The thesis then forecasts the future values for these trends up to year 2030. For the power sector, the thesis prepares electricity demand forecast for the study period up to year 2030. The thesis proposes a wide range of advanced supply side and demand side options to mitigate the effect of the previous challenges on the power sector. The proposed supply side options include nuclear power plants and hybrid renewable & thermal technologies in addition to the traditional supply technologies such as combined cycle and steam power plants. For the demand side options, the thesis proposes the introduction of Demand Side Management (DSM) efficient lighting programs as an effective way of controlling the growth in electricity demand.

The thesis performs preliminary calculations to assess the feasibility of these options in the future electricity generation mix of Egypt. The thesis then uses a more sophisticated generation expansion planning model to prepare a Business As Usual (BAU) generation expansion scenario for the Egyptian power system. This scenario assumes that Egypt will still depend on the traditional electricity generation options to meet the future increase in the electricity demand with no introduction of advanced supply side or demand side options to its electricity generation mix during the study period.

The thesis then prepares different expansion scenarios for the proposed advanced supply and demand side options to assess its future role in the power system and also to determine the optimum share of these technologies. Another group of scenarios is prepared using the IRP methodology to integrate the previous options into an integrated supply and demand side energy mix.

All these scenarios are compared against the BAU expansion scenario in terms of system cost changes, reduction in the CO_2 emission and fuel consumption. The Enhanced energy mix

will correspond to the scenario that achieves the maximum saving in system costs, fuel consumption and emissions. Results show that, by the end of the study period, nuclear power should be expanded to generate 12.4% of the generated energy while hybrid wind technology generates 15% by the end of the study period. On the other hand, efficient lighting programs should be applied with target annual load reduction of 5% during the same period. Applying this energy mix will decrease the cost of the system by 5% from the base case, reduce the fuel consumed to operate the new units installed in the study period by about 12% and decrease GHG emissions by also 12% compared to base case.

The results of these scenarios mayn't provide a final answer to the expected challenges however, the recommended energy mix will help to decrease the effect of these challenges on the power sector. The results of these scenarios will also provide in depth assessment to the previous proposed supply and demand side options and its optimum share in the long run generation mix of Egypt up to 2030.

Contents

Chapter 6 Conclusions and Recommendations

List of Figures

Figure **Page**

Chapter 2

Chapter 3

Chapter 4

Chapter 5