


# The Optimal Egyptian Electricity Market System

BY

Mohamed Faisal Metwally Ramadan

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In partial Fulfilment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Electrical Power and Machines Engineering

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**Title of Thesis:**

The Optimal Egyptian Electricity Market System

**Key Words:**

Competitive Market, Eligible Customer, Market Operator, Market Clearing Price

**Summary:**

A model for the Egyptian electricity competitive market has been developed. The market structure and design are discussed after choosing a portion from the total power system to represent the competitive market and the other portion still operating under regulated market basis. Competitive market participant's schedules are applied through Transmission System Operator /Market Operator (TSO/MO) after considering the technical losses and all technical constraints for the entire system to assure the security of the system. On the other hand the electricity regulated market is operating base on economical dispatch. Settlements for all transactions belong to competitive market have to be defined after computing the Market Clearing Price (MCP) of the market.

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# NOMENCLATURE

## List of abbreviations

| | |
|---|---|
| **ACE** | **Area control error** |
| **AGC** | **Automatic generation control** |
| **BOOT** | **Build own operate transfer** |
| **CFC** | **Constant frequency control** |
| **CMG** | **Competitive market generators** |
| **CNIC** | **Constant net interchange control** |
| **DC** | **Distribution companies** |
| **EC** | **Eligible customer** |
| **ERA** | **Electricity regulatory authority** |
| **MCP** | **Market clearing price** |
| **MCV** | **Market clearing volume** |
| **PGC** | **Public generation companies** |
| **PLC** | **Power plant controller** |
| **PSS/E** | **Power system simulation for engineers** |
| **RES** | **Renewable energy resources** |
| **S** | **Suppliers** |
| **SCADA** | **Supervisory control and data acquisition system** |
| **SCED** | **Security constrained economic dispatch** |
| **SCUC** | **Security constrained unit commitment** |
| **TLBC** | **Tie line bias control** |
| **TSO** | **Transmission system operator** |
| **TSO/MO** | **Transmission system operator/market operator** |
| **WPT** | **Wholesale public trader** |

# List of symbols

| | |
|---|---|
| **B** | **Area frequency bias in MW/0.1 HZ for the network** |
| **CAPMAX** | **Maximum capacity limit of the unit in MW** |
| **CAPMIN** | **Minimum capacity limit of the unit in MW** |
| **Ck** | **Generation cost function of unit k in L.E** |
| **CURCAP** | **Current capacity of the unit in MW** |
| **D** | **Total demand in MW (sum of bus loads)** |
| **ECOMAX** | **Maximum economic limit of the unit in MW** |
| **ECOMIN** | **Minimum economic limit of the unit by MW** |
| **Fa** | **Actual frequency in HZ for the network** |
| **Fs** | **Target frequency in HZ for the network** |
| **Ia** | **Actual net interchange in MW for tie line** |
| **Is** | **Scheduled net interchange in MW for tie line** |
| **LFCMAX** | **Maximum load frequency control limit of the unit in MW** |
| **LFCMIN** | **Minimum load frequency control limit of the unit in MW** |
| **PGk** | **Generation output in MW from unit k** |
| **PGmax** | **Maximum generation output of the unit in MW** |
| **PGmin** | **Minimum generation output of the unit in MW** |
| **PLk** | **Load on bus k in MW** |

# ABSTRACT

Egypt is currently adopting a single buyer model for its power system. There is a need to switch to a competitive model to improve efficiency and quality of service as well as to encourage private sector to invest in generation projects to meet the rapid increase in demand. The purpose of this thesis is to develop a model for the day ahead market, which will be a part of the new wholesale market. This market belongs to "competitive market" implementation. It shall be parallel to the existing "single buyer" market, during the first phase of market transformation. Yet, as the confidence in the competitive market is developed, customers will be shifted gradually from the regulated market to the competitive market.

The developed day ahead market scheme has been simulated taking into consideration the market transformation plan as well as the characteristics of the Egyptian power system. It starts with knowing the 24-hour load forecasting, the necessary schedules for all participants of the competitive market, including both consumers and generators. In light of these schedules, the Transmission System Operator takes all technical constraints, which might require an amendment to the generation schedules to assure the security and reliability of the system. By subtracting the final schedules of the competitive market from the total load required by the system (load forecasting), the rest of the total system load (hour by hour) shall be distributed along the units of the regulated market using the economic dispatch program. The results of the competitive market as well as the regulated market are analyzed and some special issues are considered such as handling of technical losses according to system data described in the appendix. For competitive market, every certain period (1 hour) the market clearing price is defined depending on the system bids and offers. Accordingly, settlements are applied to the all participants of the competitive market during this period. The models of both markets are simulated in PSS/E 33.5 and e-terra system 2.6 to obtain the detailed results in this thesis

It has been found that applying competitive market requires availability of necessary documents to govern the operation of the market like grid code, market rules, transitional phases plan and on a top of them an electricity law supporting the unbundling process to establish the competitive market. Firewall, represented by ownership unbundling between transmission system operator and generation companies is a must. Also software to perform and handle the market operations and transactions, which takes the features of the Egyptian power system into consideration, is needed. Furthermore, it has been found that the proper grid and market management are crucial for the success of the market. These are represented by achieving maximum grid availability, minimum grid technical constraints and minimum grid losses as well as proper and efficient settlement mechanism. These can affect the benefits this market can deliver to its participants. Knowing these, this confirms the advantages of having an independent transmission system operator (TSO) over the independent system operator (ISO) model, due to interference of both technical and commercial constraints on the market performance.

This study is important for the market designers of the Egyptian electricity competitive market.

# CHAPTER1: INTRODUCTION AND VISION

## 1.1: Background

The electricity sector in Egypt was governed by several laws. These include law 12 for the year 1976, which established the Egyptian Electricity Authority (EEA). Law 12 was amended in 1996 by law 100, which allowed the private sector to participate in generation activities through concession agreements. In 2000, law 168 corporatized EEA as well as unbundled the generation and transmission activities into separate companies. Distribution activity was unbundled in 1979, yet they were re-detached to EEA by the law 18 in the year 1998. According to law 168, all the public companies including generation, transmission and distribution companies are affiliated to the Egyptian Electricity Holding Company (EEHC). Regarding electricity installations and facilities, these are governed by law 64 for the year 1973, which was later amended in 1991. Also the Egyptian Electric Utility and Consumer Protection Regulatory Agency "EgyptERA" was established according to the presidential decree 399 for the year 2001.

It was usually seen that the sector is in need for a comprehensive law, which consolidates all these laws in one legal document. As the concept of competitive market is introduced to the sector, it was necessary to provide a legal framework for this. Furthermore, to attract private investments to the sector to enable necessary finance to satisfy the fast growing demand and improve efficiency as well as quality of service to consumers. Accordingly, a new law was necessary to express this and set the necessary attractive business environment for investment. Also regardless the amendments carried out for law 64, several challenges were still facing the implementation of this law, such as the right of way and new types of terrorist actions, which may be committed against the electricity facilities. This led to an avoidable need for a new legal framework to support these targets as well as encourage free competition and support transparency and measure for protecting consumers' rights and interests. Furthermore, a new law is needed to fill the missing block regarding a legal framework for energy efficiency in Egypt. Fig1.1 shows the institutional development of the power sector in Egypt over the last 50 years.

Since the year of 2000 The Egyptian Electricity market is regulated and organized under the "single buyer" form. Accordingly the Egyptian Electricity Transmission Company (EETC) is licensed to purchase electrical energy from all generation companies and sell it to Distributors and Wholesale Consumers. Also it responsible for the national control center as well as the six regional control centers. It operates the electrical system based on economical dispatch criteria. Furthermore it is responsible for its own assets including the ultra-high and high voltage networks. It is responsible for the operation and maintenance of these networks as well as necessary expansion to improve power flow, avoid congestion and reduces transmission losses.

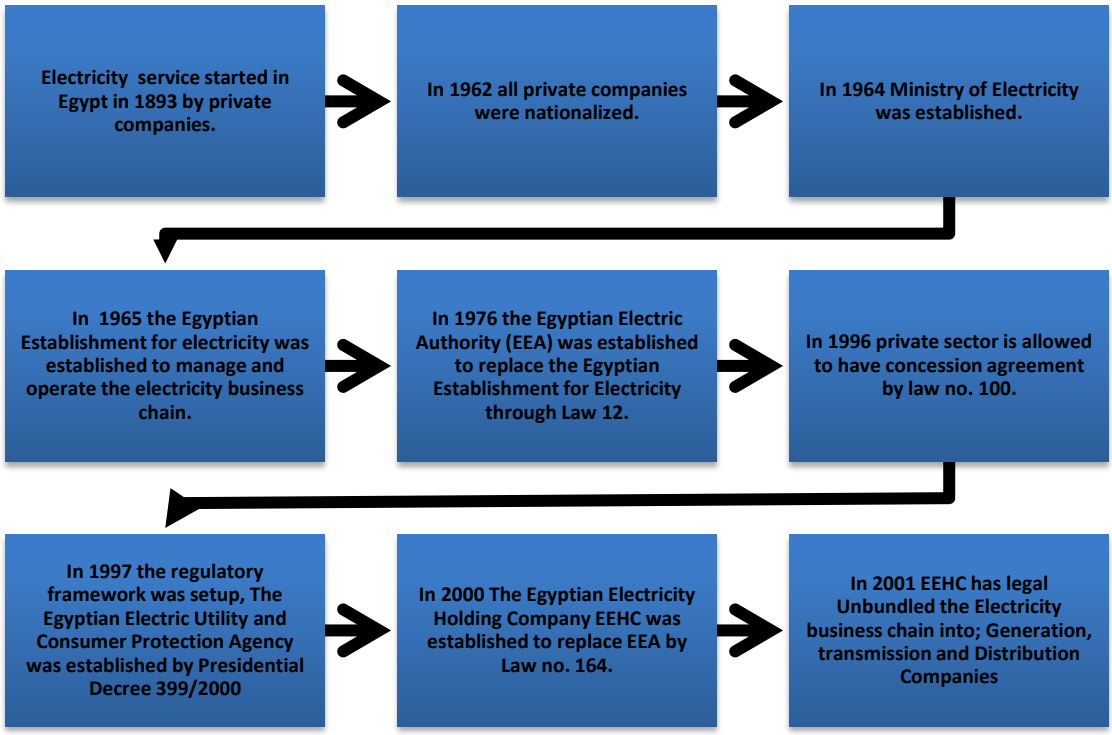


**Fig.1.1: Institutional Development of the power sector over the last 50 years**

## 1.2: Market Structure

The transitional market of Phase 1, as it will explained later, shall be composed of two submarkets working in parallel as in Fig.1.2:

i. A Competitive Market where Eligible Customers enjoy the liberty of choosing their Electricity Supplier.

ii. A Regulated Market for Non-Eligible Customers, who are subject to regulated tariffs. This Regulated Market shall gradually, in the next Phases of the market will be moved to the Competitive Electricity Market up to the point where the whole Electricity market is fully competitive.

### 1.2.1: The Competitive Market

In this market, Eligible Customers have the right to conclude direct bilateral contracts, defined as a transaction involving one buyer and one seller [8], with present/future Competitive Market Generation companies and/or Suppliers to satisfy their needs of electricity on the basis of free competition. The Transmission System Operator (TSO) shall be responsible for fulfilling these contracts for a unified Transmission access charge proposed by the TSO and approved by the regulator. The TSO purchases the

required Balancing Energy to the account of Suppliers, Eligible Customers or Generators in the case of variances between the quantities specified in the concluded contracts and actual delivery or receipt.

### 1.2.2: The Regulated Market

In this market, Non-Eligible Customers purchase their Electricity needs through regulated tariffs. The Wholesale Public Trader shall act as a Single Buyer of Public Generation operating in the regulated market. The WPT is responsible for satisfying the needs of the Non-Eligible Customers at regulated prices. Under certain conditions, the WPT may satisfy part of the Regulated Market needs through contracts with Suppliers of the Competitive Market.

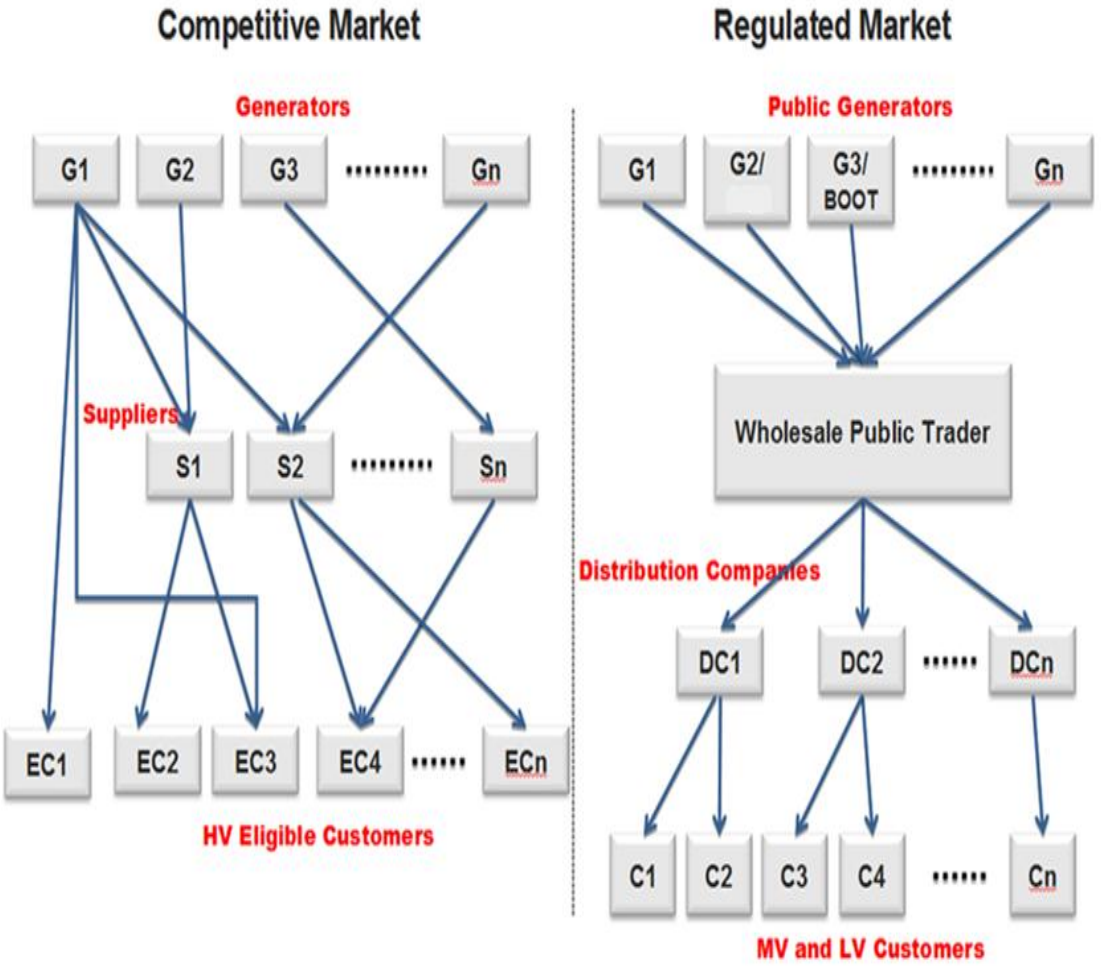


**Fig.1.2: parallel operation of the two markets [13]**