Master's Dissertation in Engineering

A Comparative Analysis on the Electricity Sector of Kazakhstan to Create a Sustainable Market Model

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Abstract

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The electricity sector deregulation process has taken place over the past three decades world-wide with the objectives of further economic development and increased social welfare. Kazakhstan also did some important steps forward deregulating its own electricity sector. But as in many countries world-wide Kazakhstan still needs to adopt more efficient model for electricity market. This research therefore aims at developing a preliminary proposal of the model based on the single-buyer model for the electricity market of Kazakhstan. In this study prior to propose new model we used the Divisia decomposition technique, Market power analysis method, with calculation of the Herfindahl – Hirschman Index (HHI), SWOT analysis and case-study analysis. Studying the market analysis and try to compare the outcomes from the existing systems we propose our own model of the electricity market for Kazakhstan.

The findings of this study are indicating some weak points, elimination of which would be most well suited for emission reduction. Analysis's result shows that there are three firms in power sector accounted for more than half of market shares, and according to the Herfindahl-Hirschman Index the power market in Kazakhstan can be classified as concentrated. At the same time there is no competition among supply companies, and the price of electricity sold in the retail market is limited by a price cap. In this case introduction of the competitive wholesale market in Kazakhstan in near future will be risky. This results show that the new model for electricity market of Kazakhstan which would be more close to single-buyer is more preferable.

Keywords: Electricity Market reform, Competition, Single-buyer, Market power, Emission coefficient

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Chapter 1. Introduction

1.1 Motivation

Electricity markets in the world have undergone a radical transformation process over the last decade. At the same time with liberalization efforts, industrialized countries have increasingly shifted their focus away from fossil fuels towards clean energy resources. Environmental impacts, escalating prices of petroleum based fuels, emission restrictions and the depletion of natural resources provides compelling impetus towards the development of more smart and flexible energy system. In addition to sustaining policy objectives “right” electricity system frameworks contribute to the concept of sustainable development.

There are still a lot of questions in the electricity sector in Kazakhstan in-spite of restructuring effort carried out by the government recent decades. The motivation for carrying out this work is that the new market structure of Kazakhstan electricity market is necessary at present. This research is motivated by the premise that well design electricity market represents an economical growth of the country and welfare of the people.

It would be interesting to see how new market model would affect the Kazakhstan electricity industry positively on whole. Work motivation of this thesis could be described as an aim to find solution in design of electricity sector of Kazakhstan to meet the needs of the present without compromising the ability of future generations. In our opinion this represents one of the greatest challenges for the future development of Kazakhstan economy.

We understand that our results could not be adopted immediately. However, the very effort to diversify a question of new electricity market design is a step forward to reach our goals. We expect to find several new ideas which will introduce progressive research contributions.

1.2 Problem description and Research question

Some experts claim that the liberalization of the power sector in Kazakhstan is often regarded as one of the most successful one in the Former Soviet countries. But in reality while there has been a substantial progress in liberalizing the market, the primary objectives so far have not been achieved. The system has remained relatively stable simply due to existence of excess capacity and the Government efforts to put the cap on the prices. At the same time the investment in new capacity is not in pace with the growth of demand.

In general everybody felt the rise of the price of electricity the recent seven years but nobody has seen real effect of sector development. The generation and transmission sectors have a lot of weak points. The major problems identified including the design of the market, lack of capacity mechanisms, lack of competition on regional level, regulatory risks. Besides that, the power and heat sector accounts for the largest share of emissions because it is mostly based on the use of fossil fuel resources. However, Kazakhstan also has plenty of potential of hydro, wind, solar, biomass, and geothermal energy. On the other hand, this potential is currently used only to a minor extent. The main reason is absence of effective mechanism of support for renewable energy.

The literature on the current situation in electricity sector of Kazakhstan is extensive. Some experts and researchers have tried to study the main problems of electricity market of Kazakhstan. In contrast, no previous study has measured major indicators of emission from power consumption of Kazakhstan, and until now nobody has done analysis on the applicability of the single-buyer model for Kazakhstan case.

Given the current data and information availability, this thesis aims to investigate the following research question:

- "Is the single-buyer model more suitable for Kazakhstan in short-run, while the competitive wholesale market model cannot be adopted in the near future?"

The following section provides an overview on how the thesis will be structured in order to answer the aforementioned research question as well as on applied methodologies.

1.3 Methodology

The research begins from the general review the relevant literature on the energy situation in Kazakhstan especially electricity sector. We focus on carbon emissions resulting from commercial energy use in thermal power generation. This work will help to find the past trajectories of emissions in electricity sector of Kazakhstan and to identify the major drivers influencing emissions in this sector of economy. The Divisia decomposition technique was applied to investigate the major indicators of emission from power consumption of Kazakhstan. The methodology follows the Simple Average Divisia Method, as simpler in implementation.

After estimating the results from decomposition method and an analysis of electricity market model in the world our focus was moved to analysis of the electricity market in Kazakhstan. Here the Market power analysis method was used, with calculation of the Herfindahl – Hirschman Index (HHI), and SWOT analysis.

After that, our research proceeds in reviewing past and current vivid experience of some countries. The case-study analysis was used to identify key-point and emphasize important lessons for own model. Review of literature was undertaken to understand the situations, challenges and capabilities arising from the experience of different electricity market in the world. The information is drawn from papers, books and reports. Based on the information from the provided sources, analysis was conducted, and the new model for electricity market of Kazakhstan was presented. Here the methodology that was used during this research has been described briefly. Further it was presented in each related chapter more detail.

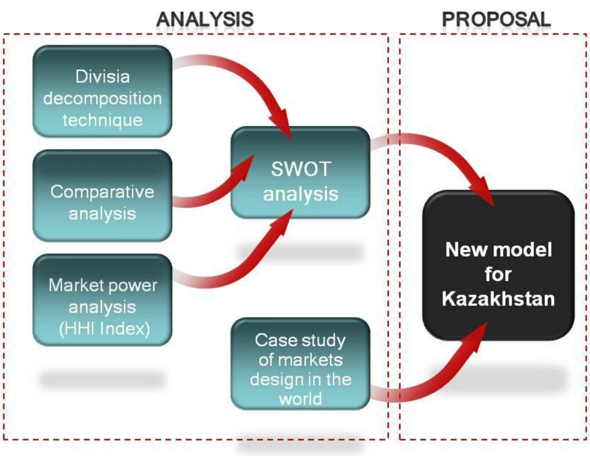


Figure 1-1: Methodologies

1.4 Structure of the thesis

This thesis is divided into eight chapters. Chapter two provides the energy situation description in such spheres as oil & gas, nuclear energy and electricity sector of Kazakhstan. Chapter three presents the approach to analyze the power sector of Kazakhstan using Divisia decomposition technique. In this chapter the basic approach and analytical framework were described. Beside that the estimation, based on available data source, was provided. Finally, in this chapter the results from the estimation were gotten and interpretation of it was given. The results from this chapter help to analyze the electricity market situation presented in Chapter five. Chapter four introduces and describes electricity market models in the world. The chapter begins with description of the differences in electricity market structures and regulatory policies around the world. Subsequently, basic types of market models are presented.

In Chapter five, the current situation in Kazakhstan electricity market was analyzed. First, description of the situation for Kazakhstan electricity sector was presented. Then, the approach to analyze Market power was presented, and using Herfindahl-Hirshman Index the market power investigation in power sector of Kazakhstan was analyzed. Based on results from Chapters three, four and first part of chapter five SWOT analysis for the electricity market of Kazakhstan was provided. Chapter six presents case-study assessment of the different electricity markets in the world. But here more concentration on the single-buyer model was done according to Brazil and Ontario cases. The summary of the lessons from international experience with sector reform was provided at the end of this chapter.

Chapter seven contains procedures and results of our experimental work. This chapter was done based on results from Chapters three, four, five and six. We try to collect main results from above mentioned chapters to create new model. The new model of the possible electricity market in Kazakhstan is presented here. Chapter eight concludes this dissertation with a general summary of the contributions.

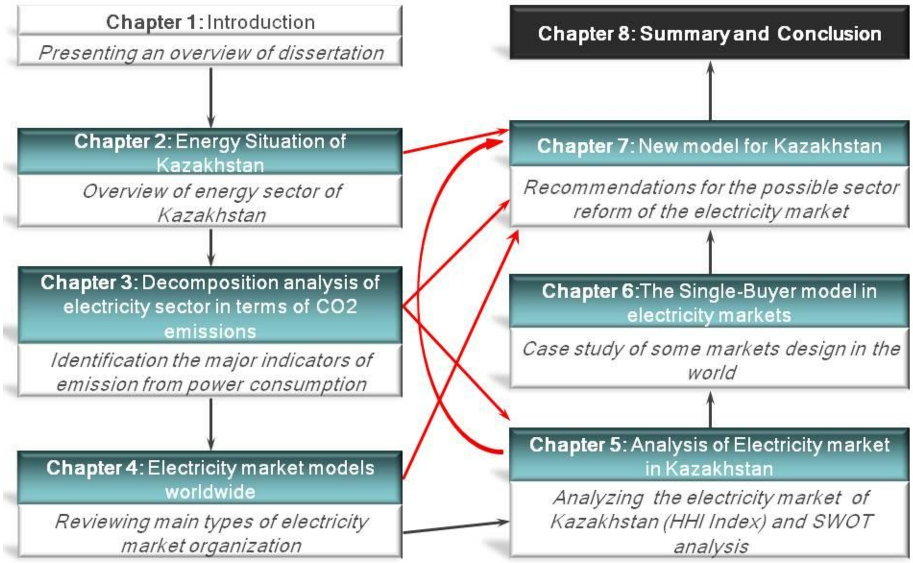


Figure 1-2: Thesis structure

Chapter 2. Energy Situation of Kazakhstan

2.1 Energy Sector of Kazakhstan

The Republic of Kazakhstan has colossal resources in fossil fuels, mainly oil, gas, nuclear and coal. These resources are also utilized to generate almost 90 % of the electricity. As a consequence of the abundance of domestic fossil resources and the centralized energy sector, the other ones have not been developed. Only recently has the Government started to initialize the utilization of renewable energy (RE) resources, namely considerable potentials of hydro power, wind and solar energy.

The legal situation in Kazakhstan favors private companies, including foreign investors, to invest into the energy sector. Therefore, the oil & gas sector has brought vast investments from abroad. Dealing with local agencies and authorities regarding licenses, permits and taxes, however, can become easy.

2.1.1 Oil & Gas Industry

The oil and gas industry of Kazakhstan performs an important role in the economic development of the republic. It is one of the main drivers of gross domestic product (GDP) growth and an important source of national budget revenue.

According to the latest GDP forecast by the Ministry of Economy and

Budget Planning of the Republic of Kazakhstan in 2013, the average annual growth from 2014 to 2018 will be 6.5%. The oil and gas industry, whose share in total GDP increased from 10.9% in 2001 to 25.2% in 2012, plays a vital role in Kazakhstan's GDP structure.[1]

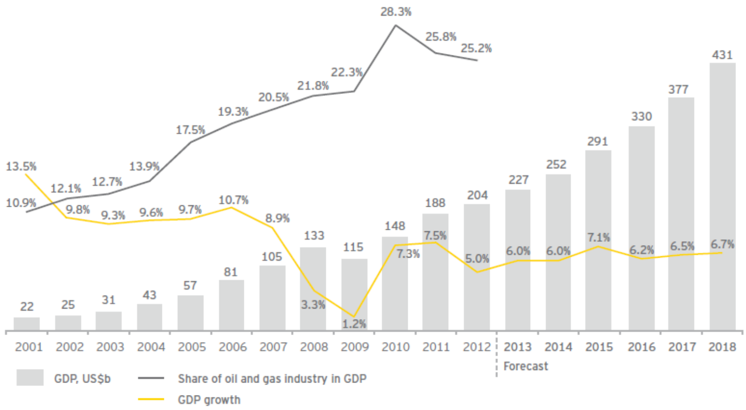


Figure 2-1: GDP of Kazakhstan 2001–2018 (Source: Agency on Statistics of Kazakhstan, the Ministry of Economy and Budget Planning of Kazakhstan)

The main oil deposits are concentrated in the western Kazakhstan areas, half of all deposits are in two large oil fields: Kashagan and Tengiz (Data of JSC NC KazMunayGas).

Currently operations in the oil and gas sectors are carried out under more than 250 contracts for subsoil use. Kazakhstan implements further modernization of the oil and gas complex of the country; it forecasts and explores promising deposits of oil and gas, and promotes the exploration, development and organization of these complexes. In 2011, production of oil and gas condensate reached 80.1 Mt, or 100.5% compared to 2010; export of oil and gas condensate

[1] The Ministry of Economy and Budget Planning of the Republic of Kazakhstan, www.minplan.gov.kz.

was 71.1 Mt, or 99.6% by 2010 in accordance with the Strategic Plan of the Ministry of Oil and Gas of the Republic of Kazakhstan for 2011–2015 (Energy Charter Secretariat, 2013).

There is over 80 subsoil users produce oil based on licenses. According to the Ministry of Oil and Gas of the Republic of Kazakhstan, around 335 companies now operate in the oil development and refining sector.

Natural gas has become an increasingly important energy source for Kazakhstan. Confirmed and estimated reserves of gas comprise approximately 3.3 trillion cubic meters, and potential reserves reach up to 6-8 trillion cubic meters. The main characteristic of the country's discovered gas reserves is that almost in all fields, including new ones, gas is extracted concurrently with oil and gas condensate. Total production of oil and gas condensate in 2013 amounted to 81.8 million tons, up 3.2% year-on-year, of which 72.1 million tons, up 5.1% year on-year, were exported. According to the International Energy Agency's World Energy Outlook 2010, by 2020 Kazakhstan will join the top 10 oil and gas exporters.[2]

2.1.2 Nuclear energy

Currently, Kazakhstan ranks second in uranium production in the world after Australia. In 2011, uranium production exceeded 19,000 tons, a 9% increase on year-on-year basis. In 2012–2015, it is planned to increase uranium production level to 25,000 tons. Kazakhstan holds about 35% of the global natural uranium market. In 2011, the National Atomic Corporation Kazatomprom only produced

[2] Data of JSC NC KazMunayGas, www.kmg.kz.

over 11,000 tons of uranium, or 20% of the global production.[3]

There are a lot of uranium deposits and ore occurrences in Kazakhstan. Commercial production of uranium in Kazakhstan is carried out in nine deposits in three uranium basins. Further development of nuclear fuel cycle activities include the production of fuel rod arrays for power reactors. To this end it is planned to establish an enterprise to adapt fuel rod array production technology and to launch a pilot fuel rod array production line at the site of Ulba Metallurgical Plant.

Currently, the country continues its efforts to increase uranium production at existing mines and has started development of new ones. Kazakhstan has established joint ventures with Russia, Japan and Canada. Within the framework of the cooperation agreement signed with Japanese companies, Kansai Electric and Sumitomo, efforts are applied to promote Kazakh nuclear fuel cycle services to the Japanese market and supply nuclear fuel components to Japanese nuclear power plants.

2.2 Characteristics of the electricity sector

The electricity sector of Kazakhstan is one of the most important sectors of the national economy. In a little more than twenty years independence this sector has changed significantly: The country has carried out restructuring and privatization of energy enterprises. The reforms included energy companies unbundling by types of activities, establishment of wholesale and retail electricity markets. Development of competition in the electricity sector caused an increase in

[3] The Ministry of Industry and New Technologies of the Republic of Kazakhstan, www.mint.kz.

tariffs and the establishment of local monopolies.

The unified power system (UPS) of Kazakhstan operates in parallel with the unified power system of Russia and Central Asia, and consist of three zones:

- Northern Zone (Akmola, Aktobe, Kostanay, Pavlodar, North Kazakhstan, East Kazakhstan, Karaganda regions);
- Southern Zone (Almaty, Zhambyl, Kyzylorda, south Kazakhstan regions);
- Western Zone (Atyrau, west Kazakhstan, Mangystau regions).

The electric power industry of Kazakhstan includes electricity production, electricity transmission, electricity supply, electricity consumption and other activities in the sphere of the electric power industry.

Peak level of electricity consumption in Kazakhstan was recorded in 1990 (104.7 billion kWh). Subsequently the level of electricity consumption was reduced to 50.7 billion kWh in 1999. During 2000 – 2008, electricity consumption steadily increased by about 5% per year on average. In 2011, electricity consumption in Kazakhstan totaled 88.11 billion kWh; electricity generation – 86.20 billion kWh (6% increase compared to 2010).[4] According to forecast of the Ministry of industry and new technologies of the Republic of Kazakhstan, in 2015 generation of electricity should reach 103.4 billion kWh, while the consumption – to 100.5 billion kWh.

A considerable part of the electricity sector’s assets is in need of modernization due to natural wear (service life from 40 to 60 years), which requires significant investment. The State undertakes proactive measures to avoid the deficiency of electricity by putting into operation new capacities and carrying

[4] The Ministry of Industry and New Technologies of the Republic of Kazakhstan, www.mint.kz.

out reconstruction and modernization of the existing power plants and grids. In October 2010, the government adopted a first stage of the new Program of the national electricity sector development for 2010 – 2014 (the Electricity Sector Development Program), which provides for an increase in electricity generation in 2014 to 97.9 billion kWh, with forecasted consumption at 96.8 billion kWh.[5] The goal of the Program is to ensure the sustainable and balanced growth of economy through the efficient development of the electric power industry.

2.2.1 Electricity generation

In Kazakhstan, electric power is produced by power plants of different forms of ownership. As of 31 December 2011, the total installed capacity of the power plants in Kazakhstan is 19 798.1 MW; available capacity is 15 765 MW.[5]

The power plants are divided into power plants of national importance, power plants within industrial complexes, and power plants of regional importance. Over 85% of all electricity is produced by thermal power plants (TPP), with about 38% of generation capacities (6,700 MW) attributed to heat and power plants (CHP). A total of 70% of TPPs use coal and only 15% use gas/mazut. In 2011, electricity generation reached the record level of over 86 billion kWh, that is, comparable with electricity generation in the early 1990s.

National power plants include the following major thermal power plants which generate and sell electricity to consumers in the wholesale electricity market of Kazakhstan. Industrial power plants include gas-turbine power plants (GTPP) of

[5] The Ministry of Industry and New Technologies of the Republic of Kazakhstan, www.mint.kz.

the oil and gas sector enterprises; these plants are adapted to covering their own demand for electricity. They are also involved in the combined generation of electricity and useful heat – cogeneration plants (CHP), which supply these forms of energy to major industrial enterprises and neighboring communities.

2.2.2 Transmission networks

Electrical networks of Kazakhstan include 0.4 – 1150 kV substations, switchgears and connecting power lines used for transmission and (or) distribution of electricity. The National Power Grid is the backbone of the Kazakhstan UPS. It provides electrical connections between the regions of the country and the energy systems of the neighboring states (Russia, Kyrgyzstan and Uzbekistan), as well as power transmission from power plants to the wholesale consumers. The system operator JCS KEGOC owns 220 kV and higher substations, switchgears, interregional and/or interstate transmission lines being a part of the National Power Grid including lines used for connection of the power plants.

Regional power networks provide electrical connections within region and power transmission to retail consumers. Regional power networks are controlled and operated by the regional network companies. A total of 21 regional power grid companies operate regional grids below 220 kV and provide dispatching services and transmission of electricity to retail consumers.[6] Transmission companies relay electricity on the basis of contracts through their own or third-party power grids to consumers in the wholesale and retail markets or to power supply companies.

[6] JSC KEGOC, www.kegoc.kz.

JSC KEGOC operates the National Power Grid of Kazakhstan and is the System Operator of the Unified Power System of the country. In accordance with the law of Kazakhstan, a joint-stock company implies private ownership. Until 2006 all KEGOC's shares were owned by the Government. In 2006 these shares (100%) were transferred to Samruk JSC (the Kazakhstan holding company for management of public assets) as a payment for the placed shares. In 2008 Samruk-Kazyna JSC (the national welfare fund) was established through merger of Kazyna JSC (the sustainable development fund) and Samruk. It became a legal successor of Samruk. Thus 100% of KEGOC's shares are currently owned by Samruk-Kazyna.[6]

Chapter 3. Decomposition analysis of electricity sector in terms of CO_2 emissions

3.1 Overview

One of the goals of this work is to ensure time series assessment of indirect carbon emissions per unit of power consumption in Kazakhstan case. In this project we paid attention to (attempted to concentrate on) carbon emissions resulting from commercial energy use in thermal power generation. This work ought to help us to comprehend and find out the past trajectories of emissions in electricity sector of Kazakhstan and to recognize the main drivers affecting emissions in this part of economy.

There are various studies on the factors affecting energy intensity in the industrial sector. However, it might be there are only several research contributions of each factor to the change in CO_2 emission intensities. Moreover, there is a possibility that B. Nag et al., (2005) are the merely studies related to carbon emission coefficient of power consumption in country level. In the meantime, as far as we know, there are not any studies in this field in Kazakhstan case.

The degree of additional consumption, transmission and distribution losses, which display the difference between power supplied and the actual power consumed, would also influence on the emissions per unit of power consumption. The emission coefficient of power consumption will be defined as influence of other factors, using decomposition analysis (B. Nag et al., 2005). Energy intensity, generation mix, net losses, auxiliary consumption of power, final consumption level are the essential key drivers of emission coefficient of power consumption in this work.

3.2 Trend of CO2 emissions in the electricity sector

The greenhouse gas inventory and National Communication are prepared in Kazakhstan according to requirements of the UNFCCC. The 2010 inventory indicates that in accordance with the drop in general economic activity in the first half of the 1990s, Kazakhstan’s emissions decreased strongly between 1990 and 1999, from 329 MtCO2e in 1990 to 133 MtCO2e in 1999, by 60 percent. Emissions have since increased, reaching 244 MtCO2e in 2008, 26 percent below the 1990 level.[7]

The power sector accounts for the largest share of emissions, with just under 90 MtCO2e from public power and heat production, and additional 18 MtCo2e in the Commercial and Residential sectors, in total close to 45 percent of emissions in 2008.[7]

[7] UNFCCC inventory.

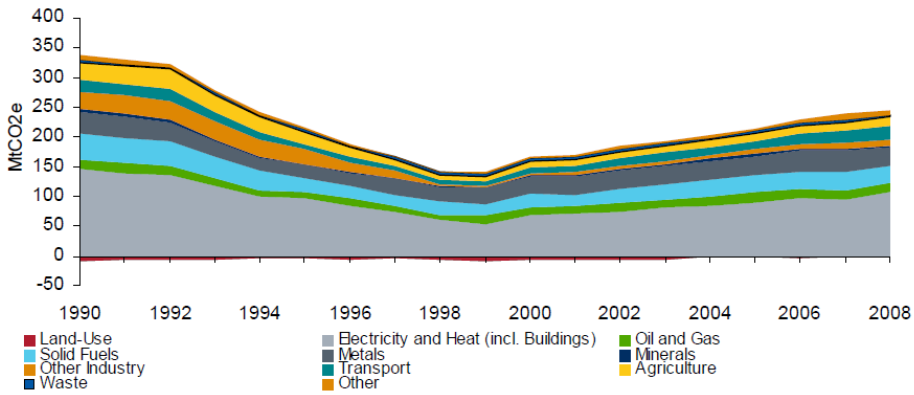


Figure 3-1: Historical Emissions Trends (Source: UNFCCC inventory)

Kazakhstan's energy intensity per unit GDP has been decreasing over the past two decades. Figures 3-2 presents the general trend, in contrast with OECD Europe. Kazakhstan's energy intensity fell from its 1992 peak of 1 toe/ 1,000 US$ GDP to 0.6 toe/ 1,000 US$ GDP in 1999 and has continued to decline much more gradually thereafter. Per capita energy intensity decreased strongly in according with overall macroeconomic output between 1992 and 1999 (from 4.8 to 2.4 toe/capita, or 50 percent), but then increased to reach 4.5 toe/capita in 2008 (only 5 percent below the 1992 level).[8]

[8] NERA Economic Consulting: The Demand for Greenhouse Gas Emissions Reduction Investments:An Investors' Marginal Abatement Cost Curve for Kazakhstan. 2011, London W1C 1BE. www.nera.com.

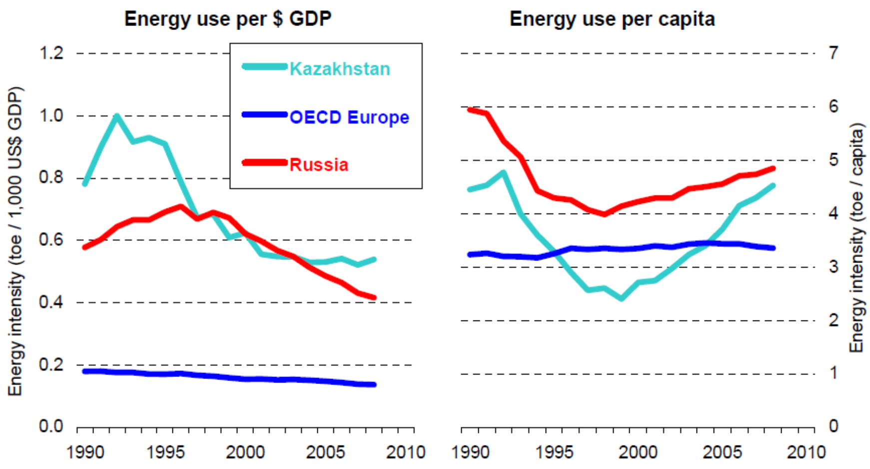


Figure 3-2: Energy Intensity in Kazakhstan (Source: IEA, UNFCCC)

Kazakhstan's emissions intensity shows trends alike to its energy intensity. Emissions per unit GDP decreased between 1992 and 1999 (by 42 percent), and continued reducing thereafter, to around 1.9 kg CO2/US$ of GDP. In per capita terms, the emissions intensity has largely followed the total emissions trends (as mentioned above, this is largely due to nearly constant population over the observed period). The emissions intensity thus fell from 20.7 to 9.4 t CO2/capita between 1990 and 1999, and then increased back to 15.6 t CO2/capita in 2008, 25 percent below the 1990 level (D. Radov et al., NERA Economic Consulting, 2011).

The illustration 3-3 indicates 20 economies that are most CO2-intensive per a unit of GDP. The purchasing power equality can be indicator for measure GDP. Reducing the CO2 intensity in countries with low-income net importers of fossil fuels could result to global and local advantages from the viewpoint of improving energy security and balance of payments (Bacon and Kojima 2008).

Reduction of emissions intensities as measured by GDP has followed in different directions in the recent years. Kazakhstan is a typical of former Soviet Union republics, where the intensity of emissions dropped abruptly in the 1990s.

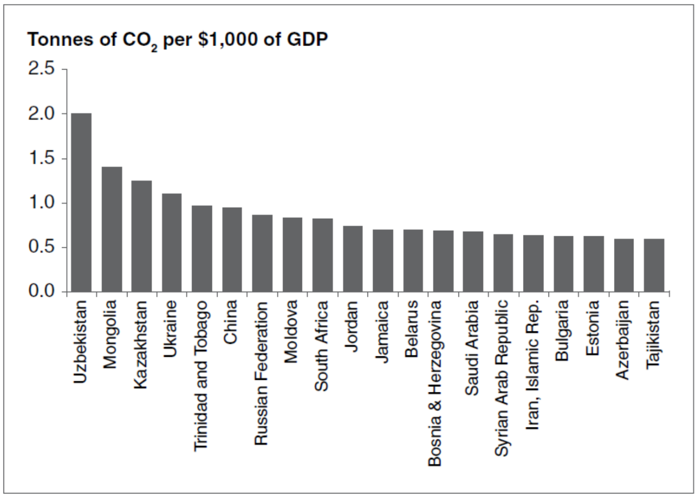


Figure 3-3: Top 20 CO2 Emitters per Unit of GDP (Sources: IEA 2009, WB 2009)

The power sector is the most major source of emissions in Kazakhstan. Not only because of electricity demand very high, at 87 TWh or 5 MWh / person, but 70 percent of this is met through highly emissions-intensive coal-fired generation. The number of emissions from the sector (including CHPs, which also serve the heat sector) was to 91 MtCO2 in 2010.[9]

Demand for electricity has grown quickly in Kazakhstan the last decade, increasing from 54 TWh in 2000 to 87 TWh in 2010. According to predictions of some experts around 144 TWh per year by 2030 can be expected. Under the current situation of era, this would develop to an estimated 178 MtCO2 by 2030 (D. Radov et al., NERA Economic Consulting, 2011).

9 UNFCCC inventory.

3.3 The Basic Approaches

Most directions of social sciences, decomposition techniques are used to help to unravel the effect of different causal factors. Any decomposition analysis begins with equation where the variable shall be analyzed and represented as the product of the factors. This equation cannot be obtained but must be provided by the analyst. The factors should be chosen depending on model and data availability (S. Seibel, 2003).

There are two essential approaches: the Structural Decomposition Analysis (SDA) and the Index Decomposition Analysis (IDA) in the literature of decomposition analysis. The collation of these two approaches is good represented by R. Hoekstra, and J. van der Bergh.

Both methods have been used to evaluate the impact of economic growth, sectoral shifts and technology changes in different environmental and socio-economic indicators. SDA uses the input-output model and data of disintegrating modifications in indicators while IDA uses the only sector level data. Consequently, SDA is capable of more refined decompositions of economic and technological effects; however, IDA is capable of more detailed time and country studies because of the availability of data. These two fields of decay literature have developed rather independently. IDA is characterized by a large variety of indicator forms, mathematical specifications and indices (R. Hoekstra et al., 2003).

The advantage of the IDA is that it can be easily applied to any available data at any level of aggregation. There are a number of different indexing methods that can be used in IDA (C. Ma et al., 2008).

As B.W. Ang stated, the popular decomposition methods among analysts can be split up into two groups: methods related to the Laspeyres index and methods linked to the Divisia index. The methods used in the late 1970s and early 1980s are like to the Laspeyres index in concept, where the effect of a factor is calculated through letting that factor to change while holding all the other factors at their respective base year values. Typical examples are the studies by Jenne and Cattell (1983) and Marlay (1984), which examined trends in energy use in industry in the UK and US, respectively. In the result, extensions and refinement of methods linked to the Laspeyres index were made. Related studies include Reitler et al., (1987), Howarth et al., (1991), Park (1992), Sun (1998) and Ang et al., (2002). Boydet al., (1987) proposed the Divisia index approach as an alternative to the Laspeyres index approach in energy decomposition analysis. Thereafter, extensions and refinement of methods linked to the Divisia index have been made. Relevant studies include Boydet al., (1988), Liu et al., (1992), Ang (1994), Ang and Choi (1997), Ang et al., (1998), and Ang and Liu (2001). As is well-known, the Laspeyres index measures the percentage change in some aspect of a group of items over time, using weights based on values in some base year. The Divisia index is a weighted sum of logarithmic growth rates, where the weights are the components' shares in total value, given in the form of a line integral. In simple terms, the building block of methods linked to the Laspeyres index is based on the familiar concept of percentage change whereas the building block of methods linked to the Divisia index is based on the concept of logarithmic change. Tornqvist et al., (1985) presented the merit of using the log change and pointed out that it is the only symmetric and additive indicator of relative change, whereas the ordinary percentages are asymmetric and non-additive.

The Divisia IDA includes the arithmetic mean Divisia index (AMDI) and the logarithmic mean Divisia index (LMDI). In their survey papers, Ang and Zhang (2000) report on 109 IDA articles and only on 15 based on SDA. Each IDA can be applied in a period-wise or time-series manner. A period-wise analysis compares indices between the first and the last year of a time period for a given country (or region, industry, etc.). A time-series analysis involves yearly decomposition using time-series data, and its results show how the impacts of predefined explanatory factors have evolved over time. Initially, the Laspeyres decomposition approach always led to a residual, which could be of a considerable size (M. Zhang et al., 2009).

To illustrate a set of recommended decomposition methods linked to the Divisia index and the Laspeyres index see the picture was used by Ang et al., presented below.

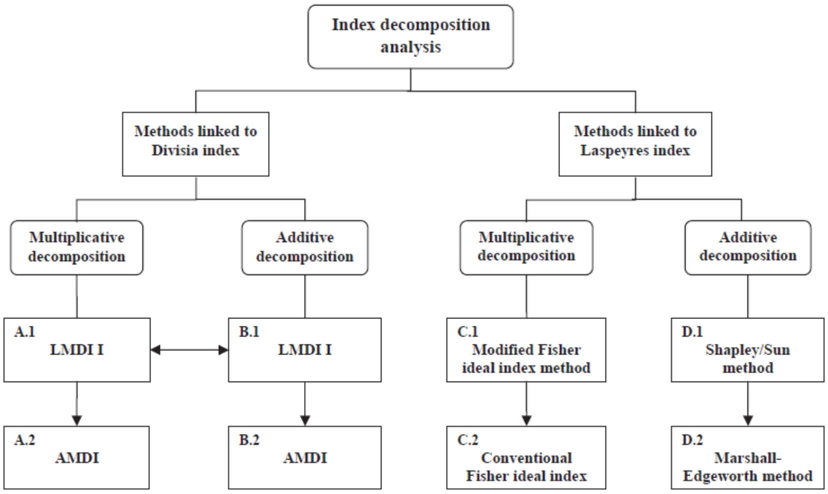


Figure 3-4: Recommended methods for energy decomposition analysis

It can be noticed that decomposition can be performed multiplicatively or additively. In multiplicative decomposition the ‘‘ratio’’ modification of an aggregate, and in the additive case its ‘‘difference’’ change is decomposed. The conventional Laspeyres index method gives a great residual term; in the case of additive decomposition the residual is about of the same size as the estimated impact for sectoral energy intensity change. In contrast, the AMDI methods present relatively small residual terms (Ang et al., 2004).

Ang et al., ended up by suggesting the multiplicative and additive LMDI I methods for their theoretical foundation, adaptability, ease of use and result interpretation, and other different desirable properties in the context of decomposition analysis. In the meantime they brought up that in some particular circumstances, other methods may be adopted in place of the LMDI I methods.

3.4 Analytical framework

3.4.1 Methodology

In this work the Divisia decomposition technique has been applied, to identify the major indicators of emission from power consumption of Kazakhstan. The methodology that was used in this work follows the Simple Average Divisia Method. As B. Nag et al., claimed this method has been preferred by a number of authors (Viguier, 1999; Shreshtha and Timilsina, 1996; Lin and Chang, 1996) for its flexibility, simplicity and the very weak weight of the residual term in the decomposition of the effects.

The arithmetic mean Divisia index method is chosen for the analysis primarily because it is simpler in implementation. As well known the most part of emissions in electricity sector come from thermal power plants, which use different types of fossil fuels. Taking into consideration auxiliary requirements in the power stations, transmission and distribution losses, not all generation electricity can be used by final consumers. In this case emission coefficient can be decomposed and expressed as:

$$\frac{E}{PC} = \frac{E}{TG} \times \frac{TG}{TOTG} \times \frac{TOTG}{NetG} \times \frac{NetG}{Avlty} \times \frac{Avlty}{PC}, \tag{3-1}$$

where E is the total emissions from power generation; PC is the total power consumed; TG is the total thermal generation; TOTG is the total power generation; NetG is the net generation which equal to total generation auxiliary consumption; Avlty is the net generation plus contribution of power from non-utilities and actual power consumption is equal Avlty minus transmission and distribution (T&D) losses.

Of the right-hand side components of (3-1), E/TG can be further decomposed as

$$\frac{E}{TG} = \sum_I ec_i \times \frac{F_I}{\sum F_i} \times \frac{\sum F_i}{TG_I}, \tag{3-2}$$

where ec_i is the emission coefficient of fuel i (in TC/GJ), which remains constant over the period of analysis.

The other two components of (3-2) are fuel mix effect, i.e. the effect of the changing share of coal, lignite, wood, diesel, furnace oil, natural gas in thermal generation and energy intensity effect. The inverse of energy intensity effect might be thought of as efficiency of power generation. The time series data of quality of each of the fuels in Kcal/physical unit of the fuel is taken into account to calculate the actual energy used in thermal generation.

By replacing E/TG in (3-2) with its components, the major indicators of emission coefficient was gotten as fuel mix effect, energy intensity effect, generation mix effect (i.e. share of thermal generation in total generation from thermal, hydro and nuclear plants), auxiliary consumption effect, the effect of changing share of power from non-utilities and transmission and distribution losses effect. Each element can be written as:

$$\frac{E}{PC} = e, \quad \frac{\sum F_i}{TG} = ei, \quad \frac{TOTG}{NetG} = aux, \quad \frac{Avlt}{PC} = td,$$

$$\frac{F_I}{\sum F_i} = fm, \quad \frac{TG}{TOTG} = gm, \quad \frac{NetG}{Avlty} = sm,$$

The final relationship between the Divisia indices of emission coefficient and its components can be written as:

$$\frac{e_1}{e_{(t-1)}} = Dfm.Dei.Daux.Dsm.Dtd.R, \qquad (3\text{-}3)$$

where Dfm is the Divisia index for fuel mix effect, Dei the Divisia index for energy intensity of power generation, Dgm the Divisia index for generation mix effect, Daux the Divisia index for auxiliary consumption effect, Dsm the Divisia index for effect of changing share of power supply from utilities and non-utilities, Dtd the Divisia index for transmission and distribution losses and R the residual term (B. Nag et al., 2005).

3.4.2 Data source

The decomposition analysis was done for the period 1990–2011 for Kazakhstan case using actual past data are annual observations of the variables. Taking into consideration the fact that Kazakhstan gained independence in 1991 in this study we considered the period 1990 – 2011, because it was the most recent period for which we had common data for all variables.

All data was collected and obtained from reports of the International Energy Agency, the World Bank (World Bank, 2013), Index Mundi, (Internet source of most complete country profiles which contains detailed country statistics, charts, and maps compiled from multiple sources), U.S. Energy Information Administration and Statistics Agency of the Republic of Kazakhstan. The specific data was adjusted for example fuel consumption in power sector information.

3.5 Analysis and outcomes

Above we already discussed which factors would be included in the analysis. In this section we tried to show our results and explain which factors contributed to changes in the emission over time for power sector of Kazakhstan. Table and Figure below show the results of the decomposition analysis of emission coefficient of power consumption in Kazakhstan.

Table 3-1: Decomposition of emission coefficient of power consumption in Kazakhstan

	1990-1995	**1995-2000**	**2000-2005**	**2005-2011**	**1990-2011**
Emission coefficient of power consumption	1.05	1.21	1.08	0.99	**1.36**
Fuel mix	0.35	0.35	0.44	0.41	**0.35**
Energy intensity	2.77	3.96	2.84	2.86	**2.37**
Generation mix	1.31	1.43	1.87	1.66	**1.35**
Auxiliary effect	1.62	1.50	1.73	1.38	**1.73**
Source mix	1.25	1.28	1.54	1.44	**1.25**
T&D	1.23	1.10	1.29	1.25	**1.15**

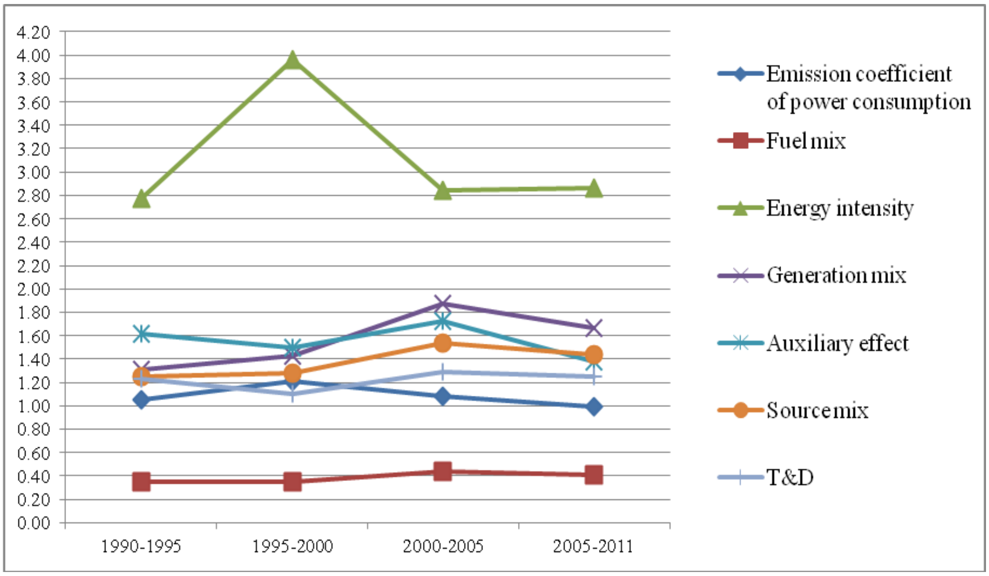


Figure 3-5: Decomposition of emission coefficient of power consumption

The power and heat sector are presenting the largest share of emissions, with just fewer than 100 $MtCO_2e$, in total close to 45 percent of emissions in 2008. The results indicate that although total emissions from power generation showed a substantial decline start from the early 90s, emission coefficient of power consumption increased significantly in the overall period of analysis, by around 33.12%. The indices for emission coefficient and the components for the entire period and the sub-periods show that the influence of Auxiliary effect, fuel mix and energy intensity have been the major indicators of emission coefficient. From 1990s to 2000s, fuel mix from one side and energy intensity effects and auxiliary from another have shown significant changes but in the opposite directions, resulting in increasing of emission coefficient.

(a) Fuel Mix effect

Fuel mix effect declined by around 65% for the period of time from 1990 to 1995, and for the same amount decrease from 1995 to 2000. After 2000 decreasing of fuel mix effect keep going respectively. Here we can say about two main reasons: first of all, start from 1990 the electricity generation on the coal-based power plants decreased. The second, as we can see that natural gas using in power stations was increasing while coal was decreasing.

We can say about increasing number of industrial power plants as gas-turbine power plants (GTPP) of the oil and gas sector enterprises. Within the framework of the State Program for Accelerated Industrial and Innovative Development for 2010–2014 in 2011, Uralskaya gas-turbine power plants was put into operation in west Kazakhstan with three gas-turbine units of total capacity 54 MW.

(b) Energy Intensity effect

High level of energy intensity is the main problem not only in power sector. Kazakhstan's total installed generating capacity is 19 GW. However, much of capacity was taken out of operation in the 1990s, and only some 15 GW of the nameplate capacity is in fact available for generation, while the remaining 4 GW would require extensive rehabilitation before it could be brought back to serviceable status. As we can see the main reasons of energy intensity component are working out of the generating equipment resource of power plants. All thermal power plants were built in 20 century. Most of the large-sized thermal generation assets have been privatized to foreign and local strategic investors, which didn't contribute any investments into the station equipments and optimization of the fuel regimen. Before 2000s, almost none of the coal-based generation companies were considering any new investment in coal-fired power stations. The situation did not change significantly, seems to be worse for some generators than others.

Above reasons give us the picture which we get from our decomposition analysis. The most significant increase was being in the period from 1995 to 2000, when it increased for almost 300%. Our results show that power sector failed to use energy efficiently.

(c) Generation mix

The Generation mix effect increased continuously in the subsequent periods, the most significant increase being in the early 2000's when it increased by 53.99%. The strong impact of generation mix on emission coefficient is caused the new power stations that were built after 1990s continuous use fossil fuel. In comparison to the change in capacity mix, the generation mix has not changed as much in relative terms since 1995. Hydro, gas and generation from renewable energy sources are steadily increasing, albeit these still account for a relatively small share of overall generation. Nowadays almost 90% of power stations of Kazakhstan use coal and gas/oil, which is causing a lack of investment in baseload generation investment. Other drivers that were raised included:

(d) Auxiliary effect

Another most significant negative impact was gotten from Auxiliary effect, which increased significantly in the overall period of analysis by 81.17%. The main reason we mention already is working out of the generating equipment resource of power plants. The equipment of the most part of power stations has outlived its designed service period. That is why we can see the picture that show the total installed capacity of the power plants in Kazakhstan is 19 798.1 MW; while available capacity is 15 765 MW. At the same time we can see that decline of Auxiliary effect has been starting in the last period (2005-2011). In our opinion the main reason that the first step in power market improvements was done. In 2009 "the tariffs in exchange for investments" were introduced for all generating companies in Kazakhstan. These tariffs were introduced to address a near term generating capacity shortages by allowing the generating companies to meet their investment commitments.

(e) Source Mix effect

In Kazakhstan, electric power is produced by power plants of national importance, power plants within industrial complexes, and power plants of regional importance. There are almost no isolated power producers in the electricity sector of Kazakhstan. And Effect of changing share of power supply from utilities and non-utilities in our analysis not largely affect to the emission coefficient.

(f) T&D effect

The transmission losses increased by 15.9% have driven to increase of emission coefficient. The main problems we are facing in electricity sector of Kazakhstan are high transmission losses and the deterioration of transmission lines cause electricity shortages in remote rural areas.

According to our results the major potential opportunities for investment to reduce greenhouse gas emissions in power generation can be emphasized:

- Improving or replacing currently operating capacity that has low thermal efficiency;
- Switching from coal to fuel sources with lower emissions intensity;
- Raising electricity prices to increasing end-user incentives to invest in electricity-saving measures; and
- Investing in grid infrastructure to reduce losses.

Our results identify current problems in power sector of Kazakhstan and substantial technical potential for emissions reduction. Significant improvements in energy efficiency are therefore technically possible. Choice of fuel in the power sector is a major determinant of carbon emissions, but the cheapest one will be still coal. Limiting the use of solid fuels would therefore substantially reduce emissions, but will increase the price for electricity in case of promotion of gas, renewable and other low carbon energy sources.

Chapter 4. Electricity market models

4.1 Introduction

The diversity of market structures emerging (exiting) from reforms to power sectors can be classified in line with increasing level of competition, as follows:[10]

Monopoly – involves no restructuring and no competition at all, since it consists of a vertically integrated monopoly at all levels of the supply chain within a country or a region in parallel to other vertically integrated regional monopolies.

Purchasing agency, also known as a single buyer – manages competition for long-term market share among generators. It generally has a monopoly for supplying distribution companies that serve customers under regulated terms and also, in some cases, large power users under regulated terms. Many types of entities in different countries, including a national vertically integrated utility, a national generation entity, a national transmission entity, a national distribution entity, a combined national generation and transmission entity, and a combined national transmission and distribution entity, carry out the functions of this agency.

Competition in the wholesale power market ("wholesale competition") – allows distributors and large users of electricity to purchase electricity directly from generators they choose either in a power exchange or bilaterally, and to transmit this electricity under open access arrangements over the power networks

[10] Hunt and Shuttleworth: "Competition & Choice in Electricity", John Wiley, 1996.

to the points of electricity consumption. Independent power suppliers (firms that specialize in energy trading, but do not own or operate distribution networks) are allowed to compete with distributors for the custom of large users.

Competition for retail customers ("retail competition") – allows end users of electricity to choose their power supplier, with open access for suppliers to the transmission and distribution systems to procure their supplies competitively at the wholesale level from generators and suppliers.

The correlation between power supply structures with these market structures is shown in figure below.

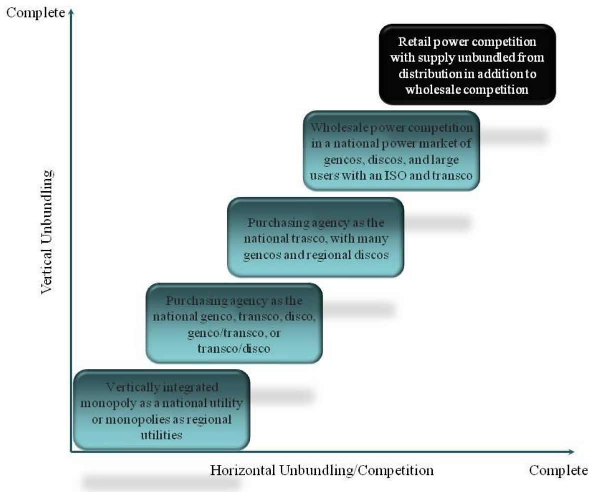


Figure 4-1: Correlation of Power Supply Structures with Power Market Structures

(Source: John E. Besant-Jones, 2006)

There is no single standard market mode seeing the differences in electricity market structures and regulatory policies around the world. Usually two main types of market organization could be distinguished from the several market models prevailing worldwide as Power Pools or centralized markets and Bilateral

Contracts Model or decentralized markets. Most electricity markets can be classified as type of one of them or its variants (Luiz Augusto Barroso et al., 2005).

IEA in its report has emphasized PJM, Australian, British and Nordic markets because of their relatively long and successful experiences. These markets are similar in the sense that they have all seriously addressed key parameters necessary to creating competition: unbundling; regulated third-party access; opening of retail markets; and establishment of comprehensive trading arrangements. But the market models in these countries vary significantly (IEA, 2005).

Amundsen et al., (2006) have mentioned that the overall design of an electricity market has three fundamental components: The regulatory framework, the trading arrangements, and the design of transmission tariffs.

IEA (2005) conclude that all markets are under continuous development. The considerations about market power, demand-side participation, intermittent resources, small distributed generation, risk management and transparency are common drivers for these changes. The appropriate market model should be design considering the specific circumstances of each electricity system and also addressing the key issues of unbundling, third-party access, cost-reflective pricing principles and transaction costs. The “one-size-fits-all” market model could not be adopted (IEA, 2005).

4.2 Market for Electrical Energy

Kirsch et al., (2004) has noted that electricity is a kind of product, which cannot be traded as other commodities. One of the essential differences is refers to the storage of the commodity, as a result, it is not efficient to store a large amount of electrical energy. Electricity must be consumed in the meantime it is produced. The other important issue is that supply and demand must be always balanced; the inability to keep them in a balance will cause the collapse of the system.

Wolak (2000) claimed that there are a lot of noticeable differences in the market structure in the various restructured electricity supply industries. These distinctions in the market structure have led to the imposition of the market rules aimed to soften the ability of firms to implement market power. There are also a plenty of differences in market rules in these electricity industries, the interaction of which with the market structure of the industry defines, whether these markets set economically efficient prices.

Hope (2005) stressed the most important market characteristics are:

- Electricity cannot be stored (except for water storage in hydro power based systems), and is a homogeneous product in market terms.
- Supply and demand of electricity have to be balanced immediately by a system operator to avoid system failures or delivery fallouts.
- Demand for electricity is quite inflexible in the short period. Demand for a feedback of consumers is limited and happens mostly with a delay, because there is limited scope for real time pricing, particularly for small consumers, at least at present. Supply of electricity is also very inelastic in the short run, especially when approaching capacity constraints in production.
- Production of electricity is capital intensive and investments in capacity augmentations are generally lumpy, irreversible, and durable. On the whole, there is a fairly long gestation period for new investment, with implications,

e.g., with regard to competitive market entry.

- Electricity transmission network is the essential importance as an instrument or mediator for decentralized market based on transactions and the efficient functioning of electricity markets. That is why; the limited capacity in transmission becomes an important factor to consider in the determination and delineation of relevant markets in competition analysis.

4.2.1 Electricity Pool

In a power pool, all generating companies offer price-quantity pairs for the supply of electricity. This forms an aggregate supply curve. The proposed prices can be based on predefined variable costs or the generators can be free to offer any price they like. At once the market operator may predict demand and dispatch generating units against this (L. Barroso, 2005).

Onaiwu (2009) separated one-side or two-sided pools. In a one-sided pool, the market operator forecasts demand and dispatches generators against this demand assumption with no input from buyers. In a two-sided pool, the market operator dispatches establishes on the quantity demanded by the buyers and the demand curve of the buyers. There will be 24 various pools per day. Using a special computer program the System operator creates a schedule of the least cost generation for the trading day. It is named the unconstrained schedule, as it implies that there will be no restrictions in the transmission of electricity.

The concept of pool emerged from the two characteristics of electricity commodity. First of all, it is not possible to store electricity and, secondly, the impossibility to track electricity from generator to customer. In concordance with the pooling arrangements generators sell electricity into a "pool" and suppliers purchase out of this pool. An electricity pool system provides a systematic mechanism and the market is hoped to end up at equilibrium price. Kirschen et al., (2004) characterized the fundamental operation of an electricity pool which is given as follows:

- Generating organizations submit offers to supply a certain quantity of electrical energy at a certain price for the period under consideration. These bids are ranked in order of growing cost. From this ranking, a curve showing the bid price as a function of the cumulative bid quantity can be built. This curve is considered to be the supply curve of the market.
- Furthermore, the demand curve of the market can be set by asking suppliers and large scale consumers to submit offers specifying quantity and price and ranking these offers in decreasing order of price. Since the demand for electricity is very inflexible, this way is sometimes left out and the demand is set at a value determined using a prediction of the load. In other words, the demand curve is assumed to be a vertical line at the value of the load forecast.
- The intersection of these “constructed” supply and demand curves symbolizes the market equilibrium. All the bids affirmed at a price lower than or equal to the market-clearing price are accepted and generators are instructed to release the amount of energy corresponding to their submitted bids. Moreover, all the offers submitted at a price bigger than or equal to the market-clearing price are accepted and the suppliers and consumers are

informed of the amount of energy that they are allowed to draw from the system.

- The market-clearing price shows the price of one extra megawatt-hour of energy and according to it is called the system marginal price or SMP. Generators are paid this SMP per every megawatt-hour that they produce, while suppliers and large scale consumers pay the SMP per every megawatt-hour that they consume, independently from the bids and offers that they submitted.

A pool can operate a day-ahead market (e.g. the former England & Wales Pool) or a close to real time market (e.g. five minutes-ahead) or a combination of several markets (day-ahead, intra-day and five minutes-ahead). One of the main advantages of a pool model is that it allows for Locational Marginal Pricing (LMP). LMP is based on the marginal cost of supplying the next addition of electric energy demand at a specific location in the electric power network including for both generation and network characteristics. There is a price per location, which can be at each node or on a wider zonal approach. A pool model with LMP specified for every node is often expressed as an ideal market model as the nodal prices perfectly reflect all costs of supplying electricity at given nodes and, manage congestion at the same time. Market players can easily catch clear signals from nodal prices regarding the location of a new generating capacity or transmission lines (L. Barroso, 2005).

4.2.2 Bilateral trading

Onaiwu (2009) has focused on that the sale of electricity in the bilateral trading model occurs through bilateral contracts between generators and buyers. Here the system operator controls the imbalances through special decisions since he does not own generating capabilities. The system operator supports the auction, which should resolve who of the users of the transmission system is and the price they should pay.

According to Kirschen et al., (2004), three forms of bilateral trading are as follows:

- Customized long-term contract – this sort of contract has pliant terms since it is negotiated privately between the participants in order to satisfy their respective requirements and objectives (It is only worthwhile to be signed at a big amount of energy since the transaction cost is relatively high).
- Trading "Over The Counter" - these operations include smaller quantity of energy to be delivered in accordance with a standard profile, in other words, a standardized definition of how much energy should be delivered during different periods of the day and week (players refine their position as delivery time approaches).
- Electronic trading – through electronic exchanging, offers to buy energy and bids to sell energy are implemented right away in a computerized market place (there is a special software).

The key issue of all forms mentioned above is the price, which is made independently between the parties involved (there is no constraint by any official price). Bilateral trading is considered to have the ability to create the electrical energy market more efficient and, therefore, decrease the energy price to the lowest possible level (Bower and Bunn, 1999).

4.2.3 Spot market

Like the electricity pool, a complementary spot market is still expected to make up any imbalances in terms of energy as well as the system. The role played by spot market or balancing mechanism will be discussed in this sub-section.

According to IEA book (2001) the physical nature of electricity does not allow for a true electricity spot market. Instead, transactions are scheduled some time in advance of physical delivery. Imbalances between scheduled and actual supply and demand that inevitably arise are handled following some predetermined procedures, which may or may not be competitive.

For this reason, a balancing mechanism is needed in order to keep the load and generation balance and this can be achieved through a managed spot market. This market also can be used when the power system is imbalanced due to technical limitations such as transmission constraint. Since the System Operator (SO) has the responsibility to maintain the balance of the system it manages a spot market as a neutral party. In maintaining the balance and stability of the system, the SO needs to match residual load and generation by adjusting the production of flexible generators and curtailing the demand of willing consumers (Kirschen et al., 2004).

Based on IEA book (2001) in an electricity market, prices are used both to co-ordinate the decisions of generators and electricity buyers, so that supply equals demand, and to ensure that these decisions are feasible given the physical constraints of the system.

Spot prices for electricity would be set for each node of the grid. A number of cases will be considered in increasing order of complexity:

- Base case: In the simplest case, when there is enough generation and transmission capacity to cover demand and transmission losses are ignored, there would be a single price for electricity for each time period: Price of energy (P1) = Marginal cost of highest cost unit in operation
- At price P1 there is a generating capacity shortage: If setting price equal to the marginal cost of the highest cost unit available would result in a generating capacity shortage, the above rule cannot be applied. The price of energy has then to be increased in order to decrease demand. The price increase S needed to make demand equal to available generation capacity is the difference between the marginal cost of generation and the marginal benefit of consumption. The price of energy is then: Price of Energy (P2)= P1 + S (S can be interpreted as the scarcity rent that covers the fixed costs of generation, therefore, S provides incentives for investment in generation).
- There are transmission losses: the price of energy (either P1 or P2, as it applies) would increase by a factor of (1 + Marginal Loss) at each node, reflecting that, in order to supply 1 kWh, it is necessary to produce (1+Marginal Loss) kWh. Thus: Price of Energy (P3) = P2 (1 + Marginal Losses).
- There are transmission constraints: the price at congested consumption nodes has to be increased so as to discourage consumption; the price at congested injection points has to be decreased so as to discourage consumption. The magnitude of the adjustment, known as the "shadow price" of the constraint is such that, at no point of the grid, supply exceeds

transmission capacity. The resulting prices include all the cases considered above as particular cases: Nodal Price = P3 + Shadow price of the constraint at that node.

Chapter 5. Analysis of Electricity market in Kazakhstan

5.1 Overview of electricity market in Kazakhstan

The electricity sector has evolved historically due to Soviet Union policy. Afterwards Soviet Union falling in 1991, the first main steps in electricity sector of independent Kazakhstan were privatization and restructuring of the electricity sector. During 1995-1996 we can see the separation of the functions was done by regional utilities for generation, transmission and distribution of electricity, all power plants were converted into joint stock companies with economic and legal independence. In transmission sector were created the Central Dispatch Service of the Unified Power System of Kazakhstan (UPS CDS), the Publicly-traded Kazakhstan Electricity Grid Operating Company KEGOC (JSC KEGOC) and joint regional power distribution companies (JSC RPDC) on the basis of 110-0.4 kV power networks.

The following steps forward to reforms were carried out in order to achieve the target of transition to market economy. Here we can indicate the-monopolization of a series of vertically integrated regional power companies, separating power transmission functions in regional power companies from sales of electricity to retail consumers.

The late performance of the electricity sector of Kazakhstan demonstrates that electricity market contains wholesale and retail electricity markets. The participants of wholesale market who can sell the electricity are pointed all power plants, which transmit electricity to their consumers though grids of JSC KEGOC. On the other hand, the buyers are performed as consumers buying electricity in excess of the settled minimum, regional power grid companies, energy supplying companies, system operators (JSC KEGOC) and operators of centralized trade in electricity.

The functional structure of the wholesale electricity market includes:

- The market for decentralized purchase and sale of electricity. Here electricity market players, through negotiations or tenders, freely go into immediate bilateral contracts for purchase and sale of electricity. These contracts indicate the capacity of electricity supplies, contract validity terms, contractual price and the payment terms for electricity. The share of the decentralized market is 88%. Power companies, power grid companies and large industrial consumers trade in a wholesale market on the basis of bilateral contracts. Consumers will have a choice of buying power from several energy supply companies or from a power generator. A consumer could be a wholesale market participant, provided that it has an access to the national and/or regional power grid, purchases at least 1 MW of the average daily base load and is equipped with automated commercial metering and telecommunication systems for communication with the System Operator.
- The market for centralized trade in electricity supplies non-discriminatory access of participants to the market where electricity purchase and sale transactions are on a short-term (spot trade), medium-term (week, month)

and long-term basis (quarter, year) basis. JSC KOREM is the operator of the centralized market. In point of fact, it is responsible for the market operation management. The share of the centralized market is about 12%.

- The balancing market in real time works for physical and the following financial settlement of hourly imbalance that emerges during an operating day between actual and contractual quantities production and consumption of the electrical energy in the power system of the Republic of Kazakhstan.
- The ancillary services that functions on the basis of electricity purchase from members of the wholesale electricity market and that uses the relevant electrical services of the wholesale market. The system operator of the Unified Electric Power System of the Republic of Kazakhstan shall provide system services and acquisition of support services from the subjects of the market of electricity of the Republic of Kazakhstan.[11]

Dispatching of day-ahead electricity load management is carried out in accordance with the schedule of electricity purchase and sale. The diurnal (everyday) schedule for participants of Kazakh's wholesale market is prepared and established on results of the trade in electricity on decentralized and centralized markets.

Start from 2015 the Government of the Republic of Kazakhstan plans to adopt capacity market, which will consist of two segments: (i) market of long-term contracts (for new power plants) and of short-term contracts (for existing power plants). In accordance with this mechanism new power plants are ensured the return on investment because the system operator warrants to procure certified

[11] INFOMINE Research Group, www.infomine.ru.

capacity volumes from them on a priority basis at prices specified by the tender, while existing plants will operate at the market without benefits and subject to confine tariffs.

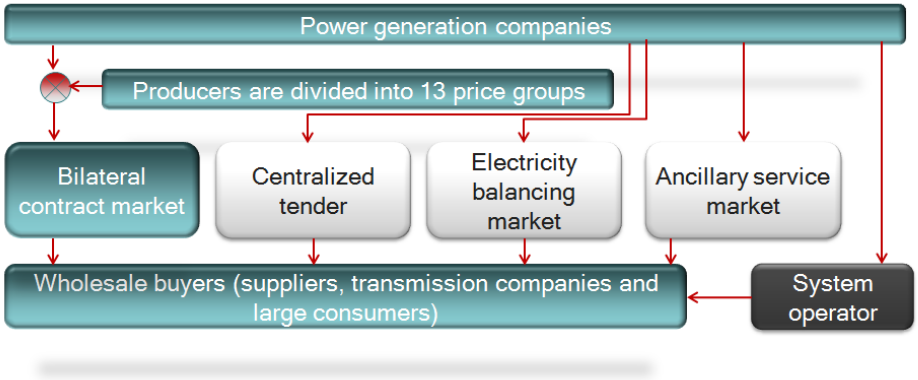


Figure 5-1: Current model of the electricity market (Source: JCS KEGOC, 2013)

Electric power supply to the Kazakh electricity market is carried out by feeding companies that purchase electricity from generating companies; or when centralized auctions sell it to retail consumers in the end-use sector. Only 45 electricity supplying companies operate in the Republic, and some of them are used as the electric power «guaranteeing suppliers». Supplying Energy Companies operate in the wholesale electricity market of the Republic of Kazakhstan only in the presence of an access to the national and (or) regional power grid, and requirements are met for the supply/consumption in the wholesale electricity market in the amount of at least 1 MW of average daily of the power.[12]

The retail electricity market participants are all consumers of electricity

[12] JCS KEGOC, www.kegoc.kz.

with a capacity of less than 1 MW and power supply organizations, exercising sales of electricity to them in a competitive environment. The power generating and distribution organisations sell electricity to retail consumers at the retail electricity market.

5.2 Market Power in Electricity Markets

5.2.1 Market Power

There are diverse definitions of market power in literature. On the whole, market power is determined as the ability of a market participant profitably to maintain the prices upward at competitive level for a considerable period of time. It is known that a company has market power if it can impact on the market equilibrium point.

Bishop and Walker (2002) gave a policy oriented definition: "Market power is defined as the ability of a firm or group of firms to raise price, through the restriction of output, above the level that would prevail under competitive conditions and thereby to enjoy increased profits from the action". Werden (1996) gives a similar definition: "Market power on the part of the sellers is the ability profitably to maintain prices above competitive levels by restricting output below competitive levels".

There are three elements or conditions to be observed in this definition of market power: a) restriction of output below which would be realized under effective competition, b) effective competition as the benchmark for the exercise of market power, c) a profitable outcome of a price increase. Every point of conditions has to be indicated forward with market power as a competition policy issue or concern (Hope, 2005).

As Kumar David et al., (2001) argued that the potential for market power abuse in the restructured power industry appears in two main forms:

1) Market dominance: if one power provider is big enough to influence on price, it has a motivation to limit output or raise its offer price up to marginal units in order to raise the market price in all units in a pool market. Market rules that regulate the activities of an electricity market and the structure of the market can have a significant affect on the ability of providers to perform horizontal market power (Wolak, 2000). For instance, there is the England and Wales (E&W) pool where a highly concentrated market may have allowed to the two dominant providers, National Power and PowerGen, selectively to withdraw capacity during peak periods and enlarge profit.

2) Transmission constraints: the existence of transmission constraints or congestion introduces local or locational market power. A provider of a region has bounded ability to import less expensive energy and will be able to affect on market power. Moreover, transmission constraints make possible to create market power in unconventional ways. A supplier can even profit from increasing, rather than decreasing, production at strategic points in the network to intentionally create congestion and limit the access of competitors. Thereby, a regional submarket will be formed, and the supplier will be at the position of monopoly.

5.2.2 Market Power Analysis Methods

The essential evidence of market power in electricity market is the fact that price rice above competitive levels, and strong price spikes during some periods. The ideal competitive equilibrium price is the baseline from which the degree of market power abuse can be evaluated. However, as Kumar David et al., (2001) argued that it is quite hard or even impossible to define the perfectly competitive price since supplier production cost information is secret.

Wang et al., (2004) has noticed that market power can be determined utilizing market power indices. The indices such as Herfindahl–Hirschman index (HHI), Lerner index (LI), and Must-run ratio (MRR) have been used in market power analysis.

Typically, the first move in evaluating a market's competitiveness is to rate the market structure, commonly market shares of providers, since market power is basically a problem closely related to structure. Having assigned market shares, it is highly helpful to summarize these shares in an index of market concentration. Knowing the degree of concentration provides useful information about where on the competitive spectrum the market lies and what other factors will have to be considered to empower a finding as to the existence or absence of main market power (Dalton, 1997).

The most widely used index for structural assessments of a market, the Herfindahl-Hirschman Index (HHI), is computed by squaring each supplier's market share, then adding the squared shares.

According to Wang et al., (2004) the HHI is defined as the sum of the squares of market shares of all participants:

$$\mathrm{HHI} = \sum_{i=1}^{N} S_i^2 \qquad (5\text{-}1)$$

where N is the number of participants and Si is the ith participants market share in percentage.

The HHI is the simplest index and has been used by FERC to evaluate the effect of mergers on system market power. Market power exists if the HHI is larger than 1000 in percentage basis. The HHI cannot reflect the impact of load variation and transmission constraints on market power.

Kumar David et al., (2001) claimed that the HHI method has the privilege of specificity with the disadvantage that it has no supporting theory and is designed simply as a rule of thumb. The HHI is used because it: 1) presents balanced greater weight to the market share of the large providers; and 2) takes account of all suppliers in the market. It was discovered that great price drop usually accompany the entry of a second or third supplier, but once there are three to five suppliers, surplus entry has little or no influence on prices. Furthermore, FERC found that an electricity market share of less than 20 percent is an indicator of lack of market power. The HHI method has taken an important role in the FERC decisions due to electricity suppliers merging.

There are also other measures of market concentration. Two other common measures of concentration are the 4-firm and 8-firm concentration ratio (defined as the fraction of the total market held by the 4 or 8 largest firms).

The Lerner Index (LI) and Price-Cost Margin Index (PCMI) are two retrospective indicators of market power.

The Lerner index is used to measure the proportional deviation of price at the firms profit-maximizing output from the firms marginal cost at that output (Landes et al., 1981). It is defined as the following:

$$\mathrm{LI_i} = \frac{p_i - mc_i}{p_i} = \frac{1}{\varepsilon_i^d} \quad (5\text{-}2)$$

where $\mathrm{LI_i}$ is the Lerner index for firm i, p_i and mc_i are price and marginal cost at the firms profit-maximizing output, respectively, and is the ε_i^d elasticity of demand seen by the firm.

The Lerner index takes into account the influence of demand elasticity on market power. The Lerner index consists the effect of other fringe firms' elasticity of supply in the form of the market-clearing price. Theoretically, if the LI of a company in a power system is large than zero it possesses the market power. The complexity to indicate the price responsiveness on demand limits the application of the LI (Stoff, 2002). Both the HHI and LI are commonly utilized to measure system market power without taking into consideration transmission constraints. Thus, geographic difference of market power is seldom counted in the HHI and LI calculation.

Zonal market power has been recognized and analyzed by Gan et al., 2002. The Must-run ratio has been proposed to consider the transmission constraints. The MRR for supplier A in a transmission zone is defined by using next formula:

$$\mathrm{MRR} = \frac{\mathrm{Pd} - \mathrm{Pl} - \left(\sum_{j=1}^{N_g} \mathrm{ed} - \sum_{j=1}^{N_{gA}} \mathrm{ed}\right)}{\sum_{j=1}^{N_{gA}} \mathrm{Pg}_{j,\max}} \quad (5\text{-}3)$$

where Pl is the import limit of the zone, $\mathrm{Pg}_{j,\max}$ is the output limit of generator in the zone, Ng is the number of generators in the zone, and NgA is the number of generators owned by supplier A in the zone and Pd be the total load of the zone.

The MMR displays the capacity that must be supplied by a generation company (Genco) to provide a given load in a congestion zone as the percentage of the maximum available capacity of the Genco. Theoretically, if the MRR of a trader is more than zero the seller is known to have market power. The MRR can give useful market power signals in a congestion zone, which relates to a simple configuration in which one transmission line can be filled to its limit by exporting generation from a low-cost region to a high-cost region (David et al., 2001).

Market focus in electricity markets is not ordinary; steady, yet quite a mutable, changing condition (Alvarado, 1998). Thus, in evaluating market concentration, possibly, it is more inherent to talk about the probability of market concentration. In this way, the use and definition of an efficient mean value for the HHI (or at least a weighted value that takes into consideration the various probabilities of market concentration) will be helpful.

5.2.3 Market Power Investigation in Power Sector of Kazakhstan

As discussed in the preceding section, the Herfindahl-Hirshman Index has been traditionally used for concentration screening for a specific market. Some of scientists argue that such concentration screening is needed because it gives early indications of the potential power in a market. The use of HHI for market power analysis is directly correlated to the market concentration.

In our study HHI was applied to Kazakhstan’s power sector. The electric power industry remains a key factor in Kazakhstan’s industrial development and economic growth. Electric power generation accounts for approximately one-tenth of Kazakhstan’s industrial output, and the thermal power stations in Central and East Kazakhstan supply almost half of the total power generation.

Many generators in Kazakhstan do not always operate at full capacity; The output may vary according to the power plant conditions. The main issue, however, is the natural wears of the power plant assets due to the difference between the installed and available plant capacities. This gap is currently not serious, but based on the growing demand for power it is expected to cause shortages in Kazakhstan's electricity sector in the near future.

The table below presents the electricity generation capacity, as well as availability to Kazakhstan's end users. Here we put plants according to Resolution of the Kazakhstan Government N.392 (dated March 25, 2009) about cap rates.

Table 5-1: Power stations of Kazakhstan (Source: Ministry of Industry and New technologies of the Republic of Kazakhstan)

N	Plant	Installed Capacity, MW	Actual capacity, MW
1	Aksu State District Power Station	2425	2304
2	Ekibastuz State District Power Station -1	4000	2246
3	Ekibastuz State District Power Station-2	1000	922
4	MAEK TPP 2-3	1342	923.6
5	Almaty Power Stations	1238.9	1036.7
6	Arselor Mittal Temirtau TPP 1,2	567	483
7	SevKazEnergo TPP	357	339
8	Astana Energy TPP 1, 2	382	357
9	Karaganda energocentr PP1, 3	472	338
10	Bukhtyrma HPP	675	675

11	Shulby HPP	702/702	702
12	AES Oskemen TPP	241,5/241,5	241.5
13	Jambyl SDPS	1230	1078
14	Shymkent TPP1-3	23	5
15	Aktobe TPP	102	83
16	Shardary HPP	100	100
17	Pavlodar Enego PP 2, 3	550	351
18	Kazakhmys SDPS	663/663	663
19	Balkhashskaya TPP Kazakhmys	155/126	126
20	Zhezkazganskaya TPP Kazakhmys	207	187
21	Alymini Kazakhstan	350	320
22	Ridder TPP	59	59
23	AES Sogrinskaya TPP	25	25
24	Karaganda State District Power-1 Station Bassel Group LLS	108	83
25	Djet-7 TPP	180	157.3
26	3-Energoortalik TPP	160	118.3
27	Atyrauskaya TPP	290	258
28	TarazenergocwntrTPP-3	60	27
29	Kizilorda TPP	113.2	91
30	Kazcink TEK	34.08	27.6
31	Shahtynskaya TPP	18	11.3
32	Pavlodar Energo ETPP	12	10
33	Arkalykskaya TPP	4	3
34	Kostanaiskaya TPP	12	11.9
35	Jaikteploenergo TPP	58.5	38.7
36	Zhanazhol GTS	104	81.2
37	Akturbo	133.8	129.8
38	Uralskaya GTS	54	45
39	Ustkamenagorskaya HPP	331.2	315

A number of authors mentioned earlier that in evaluating market concentration using HHI, if the HHI value is less than 1000, then it indicates that the market is not concentrated. If the HHI value is in between 1000 and 1800, then this shows that the market is moderately concentrated. However, if HHI value is greater than 1800, that means the market is highly concentrated.

In this study, we will calculate the HHI value according to the participants' market share. However, based on the preceding table, such will be difficult to do, because several power plants are concentrated in one hand and others are concentrated in other hands. For example, one of the branches of National Company Samruk-Kazyna is Samruk-Energy, which owns of the largest Kazakhstan hydropower plants Shardara HPP, Bukhtarma HPP, Shulbinsk HPP and Ust-Kamenogorsk HPP, and combined heat and power plants Ekibastuz GRES-2, Almaty power plants, etc. Another case shows that Kazakhmys PLC is a natural resources group that not only supplies its own business needs but also sells electricity, from its three coal-fired power and heating plants in the Central and Zhezkazgan regions.

As a first step, we want to identify the plants that belong to one or another market player. Then, we will examine such firm's market shares in 2011 according to our database. We should mention that in 2010, Kazakhmys PLC sold 50% of its stake in the Ekibastuz State District Power Station -1 to the National Welfare Fund Samruk-Kazyna. They now have a joint supervisory board, and allocated management positions. The Ekibastuz State District Power Station -2 has a similar situation, 50% of its shares are owned by Inter RAO UES, and the other 50% by Samruk-Kazyna. We reflected the two owners separately in the table.

Finally we compute the HHI index using the equation (1) that was presented above.

Table 5-2: Market shares of generating firms in Kazakhstan[13]

N	Firm	Installed Capacity, MW	Share in the market, s %	s^2
1	Samruk Energo	4 379.10	15.9	252.81
2	ENRC	2 775	19.26	370.9
3	Pavlodarenergo	562	3.33	11.08
4	Kazakhmys	1,025	4.78	22.89
5	Arselor Mittal Temirtau	567	3.82	14.59
6	Ekibastuz State District Power Station-1	4 000.00	16.21	262.76
7	Ekibastuz State District Power Station-2	1,000.00	7.22	52.13
8	MAEK	1 342.00	6.1	37.21
9	Karaganda energycenter	472.00	3.45	11.89
10	SevKazEnergo	357.00	2.76	7.61
11	Astana Energy	382.00	2.46	6.08
12	Others	1 436.58	14.71	
	Total		**100**	**2701.86**

The market shares of power generation firms in Kazakhstan's electric power market shall also be studied. According to our analysis, the top three firms (Samruk Energo, ENRC and Kazakhmys) accounted for more than half of the total market. Overall, our calculated Herfindahl-Hirschman Index was 2 701.86 (more than 1 800). Thus, using the preceding definition, the market can be described as concentrated.

At the same time, Samruk Energo, ENRC and Kazakhmys have the biggest shares which total 56%. With the transmission constraint in place, there is a good

[13] Author's own elaboration according to the data from the Ministry of Industry and New technologies of the Republic of Kazakhstan.

chance that these companies will manipulate their offer price in the spot market. This shows that such companies could exercise their market power merely by acting together to alleviate some constraints in the Kazakhstan's electricity sector. In this case, some generators can withhold all their power.

5.3 SWOT analysis of Electricity market in Kazakhstan

This section briefly analyzes the strengths, weaknesses, opportunities and threats (SWOT) of the electricity market in Kazakhstan. The main information on the electricity sector is summarized in previous sections. In this section SWOT analysis was used to show the current situation, and to define the main evidence for further research. In other words, a brief SWOT analysis was performed to develop further ideas for a new electricity market model for Kazakhstan (discussed in the next chapter). This study was also conducted to identify the positive and negative factors, as well as the internal and external factors, that might have an impact on the electricity market of Kazakhstan.

The SWOT analysis was based on the author's own experiences, information from Kazakhstan's experts, and available literature on the subject.

A. Strengths

1) High level of electricity generation in combined heat and power plants (CHP) using low-cost fossil fuel.

Seventy percent of power stations use coal. The coal sector is one of the key sectors of Kazakhstan's fuel and energy complex. Kazakhstan's primary electrical energy production relies on cheap Ekibastuz coal. Kazakhstan is among the world’s top 10 coal-rich countries. Its coal deposits are concentrated in Central and Northern Kazakhstan. Currently, the power sector of Kazakhstan can easily supply by own cheap coal.

2) Stable Kazakhstan electricity demand.

All future projects in the industrial, agricultural, and transport sector are included in the State Program for Accelerated Industrial-Innovation Development and Strategy of the Republic of Kazakhstan. We can say that Kazakhstan’s approach to forecasting future electricity demand is accurate. System operator and supply companies could make a forecast for up to five years. Practice shows that demand has been increasing gradually without any fluctuations and disturbances.

3) Well-developed transmission and distribution system.

The National Power Grid is the backbone of the Kazakhstan UPS. It provides electrical connections between the regions of the country and the energy systems of the neighboring states (Russia, Kyrgyzstan, and Uzbekistan), as well as power transmission from power plants to wholesale consumers. Regional power networks provide electrical connections within their region and power transmission to retail consumers.

4) Parallel operation of Kazakhstan power systems with power systems of the Russian Federation and Central Asia.

In its activities, the system operator interacts with the power systems of other states, such as the Russian Federation, the Kyrgyz Republic, the Republic of Uzbekistan, and the Republic of Tadzhikistan.

5) Huge potential of renewable energy sources.

Kazakhstan also has rich supplies of hydro-, wind, solar, biomass, and geothermal energy. The total potential of all types of renewable energy in Kazakhstan is estimated as 2 700 TWh (theoretical), which is over 100 TWh/year and is thus technically feasible. However, this potential is currently being used only to a minor extent. Wind, solar, and biogas energy account for less than 1% of final energy consumption. Thus, increased use of renewable energy could improve Kazakhstan's power supply security.

6) Freedom of large customers to negotiate supply with generators.

Customers consuming more than 1 MW of power are allowed to procure their electricity supply directly from generators. Here, electricity is purchased and sold through bilateral contracts, with the conditions, prices, and quantities freely negotiated between the power generator and the customer.

B. Weaknesses

1) High energy intensity.

The Kazakh power sector is generally not very efficient. According to our results, this low efficiency is due mainly to the wear-out of the existing stocks and losses in the flows. A considerable part of the electricity sector's assets is in need of modernization due to natural wear (service life: 40-60 years), which requires significant investment. The service life of the sector's electricity generation assets is close to expiring (75% – for TPP and 90% – for HPP), causing a gap between the installed capacity (19,800 MW) and the available capacity (15,700 MW) of existing power plants.

2) Inability to meet future demand.

Electricity generated today is around 90 billion kWh. According to the Kazakhstan 2030 Program, the 104.7 billion kWh level of electricity demand will be reached even in the worst-case scenario by 2030, and in the best-case scenario, by 2020. The pace of electricity production will depend on the development of the overall economy of Kazakhstan. In this case new generation capacity in the power sector is required.

3) Low competition level in the wholesale market.

According to many experts, in Kazakhstan, power generators and large industrial consumers trade in an unregulated wholesale market based on bilateral contracts. In 2009, however, “ceiling cap” tariffs were introduced for all power generation companies in Kazakhstan. The power generation companies were divided into 13 groups, and a “ceiling cap” tariff was set for each group. No payment shall be made above this tariff to the power generation companies. The “ceiling cap” tariffs were introduced to address near term power generation capacity shortages by allowing the generating companies to meet their investment commitments. Besides, as shown in the previous subchapter, during the exercise of market power ownership in the power generation sector is being concentrated. In this case, price caps may be needed to prevent excessive profits.

4) Myth of the real-time balancing market.

Pursuant to the relevant rules, an entity in the wholesale electricity market is authorized to act independently as balancer of its own imbalances in electric energy production/consumption in a balancing electricity market, or to transfer responsibility for the financial regulations pertaining to imbalance to other entities in the wholesale electricity market.

Until now, however the market is balanced in a simulation mode, without a procedure for actual settlement payments for electric energy bought or sold in the balancing market. The simulation mode of a balancing market enables the balancing market to function in accordance with the rules, including for the System Operator’s rendering of services for balancing electric energy production and-consumption, and for physically and financially regulating electric energy imbalances based of the contracts concluded between entities in the wholesale market and the System Operator and Finance Center, besides providing a procedure for actual settlement payments for electric energy bought or-sold in the balancing market.

5) Weakly developed market for centralized trade.

The centralized electricity market operator in Kazakhstan is JSC KOREM. However its share of the centralized market is only about 12%.

6) Absence of competition between energy supply companies.

The power supply sector of the electricity market of Kazakhstan consists of power supply companies (ESOs), which purchase electricity from power generation organizations or via centralized trading and sell it to end-retail customers. Some power supply companies function as “guaranteed suppliers” of electricity. Electricity retailing in Kazakhstan is carried out by around 45 supply companies, each of which has a regionally dominant position over customers consuming less than 1 MW. End-user tariffs are made up of the expenses of an energy supply company for electricity purchase, transportation, sales mark-up and profit.

7) Price disunity for customers.

Because power supply companies usually purchase energy from different power plants, regional electricity prices vary among different consumers. For example, the price is lower for consumers from North Kazakhstan than from South Kazakhstan. The main reason for this is that most of the power generation companies are located in North and East Kazakhstan. Thus, we can see that customer' tariffs are dependent on the geographical distance. Most customers are often properly indignant about this situation.

8) Low concentration level of the renewable energy industry.

The great renewable energy potential of Kazakhstan exceeds 1 trillion kWh a year (about 10 times the country's energy consumption). However, the share of renewable energy in the energy mix is below 1% (with 90% provided by small HPPs). The cost of new energy applications is higher, and the costs of solar energy and wind power are far higher than that of thermal power.

C. Opportunities

1) Energy and climate change linkage.

Energy and climate change together are among the top priorities in most countries for achieving sustainability. A strategic objective of Kazakhstan is to transition to green development, which its revenues from its sales of minerals enable it to do. Energy conservation and energy efficiency seem to be the most effective, least capital-intensive and fastest-to-implement way to solve energy problems.

2) Provision of self-sufficient domestic electric supply.

The state should undertake measures to prevent electricity shortages by growing capacities and reconstructing and modernizing existing power plants and grids. In October 2010, the government launched its National Electricity Sector Development Program for 2010 – 2014, which provided for an increase in electricity generation and electricity supply using domestic resources.

3) Payment discipline.

The power sector had been supplying electricity to users on credit because of their inability or unwillingness to pay for their consumed electricity. According to KEGOC's current policy, it terminates power supply to non-paying consumers. Not surprisingly, this policy has been very effective in ensuring payment discipline. Likewise, the percentage of non-monetary payments decreased to 5-10% of the total in 2003 from 80% in 1997.

4) Achievement of high level of additional capacity after reconstruction of the electricity sector.

This finding comes from the result of our decomposition analysis.

5) Decrease in CO2 emissions due to shift from coal to other energy sources.

As found the fuel mix effect is a major indicator of the emission coefficient.

D. Threats

1) Rise in fuel prices and capital costs.

The cost of fuel can be a significant additional risk to profitability, particularly for technologies, in which fuel cost takes up a high proportion of the total generating cost. Electricity price rise and the government's responses to it are critical to understanding the future of the use of spot prices in electricity markets to signal the need for new investment.

2) Sharp increase in electricity prices.

Price volatility also raises questions about the market's ability to ensure secure and reliable power supply.

3) Increasing gap in generation capacity.

The installed capacity and the generation capacity of Kazakhstan's power sector currently, have a huge difference. Much of its capacity was taken out of operation in the 1990s, and only some 15 GW of its nameplate capacity is available for generation, while the remaining 4 GW requires extensive rehabilitation before it could be made serviceable again. Most available plants are about 10-15 percentage points less efficient, than a new coal plant.

4) Shortage of energy at the regional level.

Thus, electrical power generation in Kazakhstan is characterized by efforts to achieve self-sufficiency in electrical power and to provide the necessary infrastructure for generating capacity with appropriate increases in reserve capacity for future needs.

5) High impact on climate change.

Despite Kazakhstan's economic success, it has not yet solved many of its serious environmental problems. Its growing desertification, 'historical' pollution, and increased volumes of waste and emissions seem to seriously threaten its economic development, environment, and health. In the country, coal is the basis of energy. Moreover, among energy products, energy and coal contribute much to carbon dioxide (greenhouse gas) emissions. Calculations show that the share of coal in emissions generation will increase dramatically.

6) Energy dependence on neighboring countries.

If we will have an electricity shortage, our electricity imports will increase. In this case, we will have to buy electricity from our neighboring countries at higher prices.

7) Potential of the several generators to exercise market power through concerned action.

Our previous result shows that some power generation companies in Kazakhstan have the potential to exercise market power to alleviate some constrains in the electricity sector merely by acting together. In this case, some power generators can withhold all their power.

The result of the SWOT analysis is summarized in Figure 5-2.

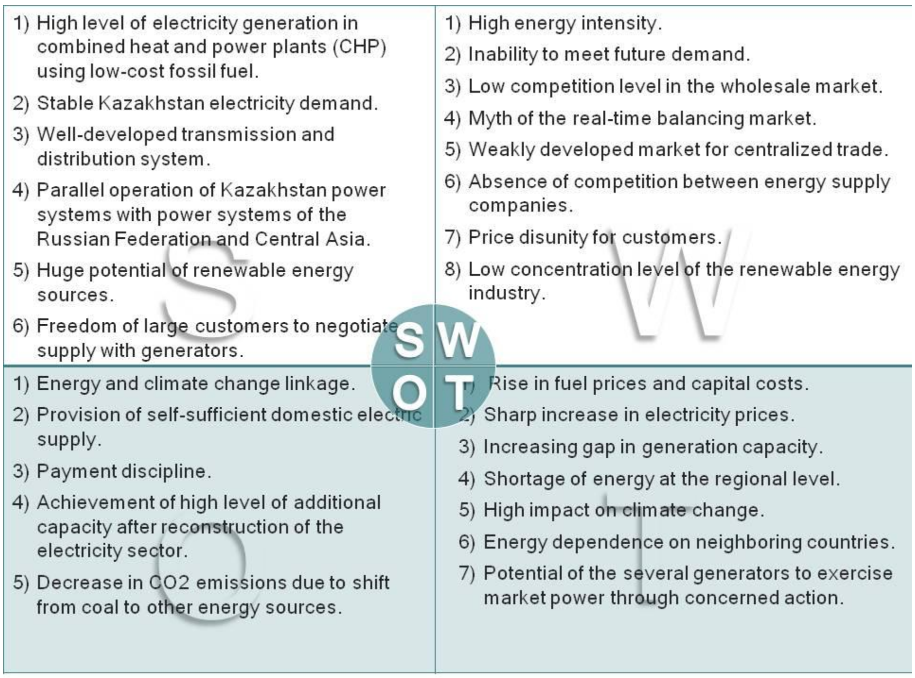


Figure 5-2: Summary of the SWOT analysis

Chapter 6. The Single-buyer model in electricity markets

6.1 Introduction

Potential industry structures can be represented on a range from a completely vertically integrated, price-regulated monopoly; to fully competitive markets. In the middle of these aspects on the spectrum, there are three principle models used all over the world:

- A vertically integrated monopoly that owns most generation yet there is some competition in generation, especially for new capacity. Depending on how roles are allocated, this structure can have features of a “single buyer” model.
- Capacity markets where there are separate markets for generation capacity (MW) and the production of energy (MWh). This industry structure could also have features of a “single buyer” model; and
- Energy only markets where generators are paid a single price for energy production (MWh), and are not explicitly compensated for providing capacity (MW). This model does not have any elements of a “single buyer” model (Castalia strategic advisors, 2013).

6.2 Single buyer market model

In economic theory, “single buyer” or “monopsony”, is a form of imperfect competition in which there is only one buyer and many sellers of a product (Noor Zafina Mohd Zamin et al., 2013).

The single-buyer model initially emerged in developing countries in the 1990s. To ease capacity shortages while keeping scarce public resources, governments in several countries allowed to private investors to build power plants – independent power producers (IPPs) – to generate electricity and sell it to the national power company. IPPs sold their output through long-term power purchase agreements that included take-or-pay quotas or fixed capacity charges to protect investors from market risks. Most resolved to keep strategically important transmission and dispatch facilities in state hands; however, awarded exclusive rights to the newly formed transmission and dispatch company – the single buyer – to buy electricity from generators and sell it to distributors (L. Lovei, 2000).

In a common single-buyer model, the IPP sells electricity to the single-buyer and the single-buyer sells the electricity to its customers. The electricity is sold to the buyer at the point of connection of the IPP to the transmission system. The electricity is transferred through the transmission system to the distributors and eventually to the end-use customers. There is no straight contractual relation between the IPP and the end-use customers. The IPP pays charges to the TC for the connection to the transmission system and for the use of the transmission system (P. Tuson, 2008).

Castalia strategic advisors stated that a single buyer – almost always a legal body and independent of generation companies – predicts the generation capacity required. This means that the degree of demanded capacity is administratively defined, and not the result of market forces. Generators are paid under long term contracts by the single buyer. The contracts are typically for the economic life of the generation plant and usually incorporate both capacity and energy payments. The single buyer dispatches all generation – usually in merit order according to the contracted energy price – but can dispatch out of merit order due to other considerations, such as optimizing use of scarce fuel resources or achieving environmental goals. The design of the dispatch arrangements determines the extent to which generators' offers determine whether their plants operate at any time. The single buyer sells all energy to one or more retailers and major customers – that is, there is no generator to retailer or customer contracting. In many jurisdictions, the single buyer sells wholesale power to regulated distribution and retail companies.

6.3. Lessons from the Reform Experience

In this part some market design was analyzed, and the significant parts in each market were depicted. We will attempt to show how some markets such as Nord Pool have been very prosperous, but others such as California market have collapsed. Thus, to be able to move to the next chapter, it is important to review the lessons learned from other markets.

Castalia Advisory Group in own report (2013) assessed some jurisdictions, as some elements of single buyer yet cannot be called as Single buyer models. Therefore, Italy electricity market was not named as a single buyer model. The terminology "Single Buyer" is the definition for a default retailer for small customers that haven't chosen a retailer. The retailer purchases both from the wholesale market and through contracts for example, Mexico, Malaysia and South Africa in retails have single integrated utility, but the type of electricity market model more related to vertically integrated monopoly with some competition for generation. In South Korea case Castalia Advisory Group has noticed that electricity market has a single vertically integrated utility with generation in six wholly owned subsidiaries. This step was considered as towards divestment which has stalled. The generators "trade" in an internal wholesale market.

Firstly, let us take into consideration some cases which show the reform experience and explain how to reform progress in the United Kingdom, Nordic countries and California.

6.3.1 UK Electricity Market Reform

The UK was one of the first nations that changed its electricity sector. From that point, a lot of countries have tried movements forward in electricity reform. After reform, the generators settled minimum prices at which they are willing to supply power on the UK wholesale spot market. The National Grid Company has the main role as coordinator and is in charge for running the transmission grid. After gather these offer prices the National Grid Company makes a least-cost plan of generating units for dispatch in the next period. This plan together with demand, defines which units will actually be dispatched. Payments to supplying sets are based on a "system marginal price" determined as the offer price of the marginal operating unit in every period. As Von der Fehr et al., (1993) argued that under the existing institutional set-up as an auction, there is possibly to be above marginal cost pricing and inefficient dispatching may result.

Prior to 1989, the British electricity supply industry (ESI) was a public monopoly consisting of the Central Electricity Generating Board (CEGB), 12 independent Area Boards, and the Electricity Council. The CEGB was divided into three generation utilities (National Power, PowerGen and Nuclear Electric) and one transmission utility – the National Grid Company (NGC). The transmission business became private and regulated natural monopoly. The commercial relations among the power generation utilities, NGC and the RECs were enforced by contracts under the Electricity Pool of England and Wales. The Pool set up a trading agreement in order to form the clearing price - calculated by balancing all traded power from generators and suppliers. Newbery (2000) presented that "the price-cost margin widened, to the advantage of producers but harming consumers". The reform seems to have functioned well just achieving the tasks at the least possible cost but at the same time there was overuse of resources within the energy sector and among economic sectors. After 1989 the operating margin per electricity unit sold increased considerably, which showed the gap between the rate and the marginal cost. This issue happens because the inefficiency of the Pool and due the market power of the incumbents. The dynamic efficiency gains of improved investment were smaller than might have been expected. The increase in the share held by renewable sources use for power generation purposes was almost insignificant (was under 2% in 1990 and remains under 3% in 2000). Reform path does not foster the development of the skills needed to deal with the problem of environmental impacts in a sustainable manner (Gorini de Oliveira et al., 2004).

In 2011 the UK Government has published proposals on Electricity market reform in a White paper. The main ideas are arising “floor carbon price”, so-called “contracts for difference” feed-in tariff for nuclear power, a “contracts for difference” feed-in tariff system for renewable and “capacity payments” to ensure there is enough power station capacity. But as D. Toke (2011) claimed that despite the bold pronouncements the impact of the Government’s Electricity Market Reform is likely to be much more incremental than revolutionary. Other words this is not greatly different from what would happen without the reform.

Next we will proceed to the description of the England and Wales electricity auction. But before, we would like briefly clear up about electricity procurement auctions. It is common for electricity market bidders privately submit their bids to the auctioneer without communicating any information to other bidders about how much they are willing to pay. In a discriminatory auction, the auctioneer purchases power from the seller(s) who submits the lowest bids and pays them their bids. Under a uniform-price auction, the auctioneer also purchases power from the seller(s) who submit the lowest bids, but he pays each successful bidder the highest accepted bid. There were bothered proponents because in a uniform price auction, it makes sense to submit very low bids to ensure that you win if you know that your bid is unlikely to set the winning price, what is impossible during a discriminatory auction (Catherine D. Wolfram, 1999).

After liberalization in UK electricity sector, trading was run through a half-hourly uniform price auction. The market operator constructed a half-hourly aggregate supply schedule and prepared demand forecasts based on price bids. According to Lízal et al., (2014) the production unit whose price bid in the aggregate supply schedule intersects price-inelastic forecasted demand is called the marginal production unit. Its price bid is called the System Marginal Price (SMP) and represents the wholesale price for electricity production during a given half-hourly trading period. In this sealed-bid uniform price auction producers don't know the bids of each other. But here as author claimed so-called capacity cutting strategy could be found. Producers could apply this strategy in order to increase the wholesale price and to enjoy higher profits on their scheduled units. Capacity cutting may be necessary to sustain tacit collusion. All of this tends to eventually decrease consumers' welfare. Le Coq (2002) and Crampes and Creti (2005) theoretically analyze a two-stage duopoly game, where producers first decide on capacity bids and then compete in a uniform price auction. The authors find that a uniform price auction creates an incentive for strategic capacity cutting when demand is known. Lízal et al., (2014) argued that in England and Wales electricity market producers apply a capacity cutting strategy to increase prices at a uniform price auction. This strategy may allow producers to artificially create deficit and drive up wholesale electricity prices and hence revenues and profits of all producers on the market.

Catherine D. Wolfram (1999) also argued that one of the principle characteristics of any efficient market, whether or not it is run as an auction, is that prices are close to the marginal cost of producing the product. On the one hand, this requires that sellers do not have unilateral incentives to raise prices. On other hand the uniform price auctions give some sellers a unilateral incentive to raise prices. The more inframarginal plants (when plants that earn the marginal price but have submitted lower bids) a firm owns the more of an incentive it has to raise the prices submitted by plants likely to be setting the marginal price. Similar incentives are not present in discriminatory auctions. While the ability to set the marginal price for all inframarginal plants may drive bids higher in uniform-price auctions, discriminatory auctions also can give incentives to submit high bids. There is a phenomenon called the "Winner's Curse" at work in markets where bidders are paid their bid and where all bidders have imperfect information about what the market clearing price is likely to be.

Catherine D. Wolfram (1999) has mentioned that there is major drawback to using a discriminatory auction. If plants that formerly submitted very low bids to ensure that they were used end up having to try to guess the marginal price in the market, they might sometimes guess too high and not end up selling while more expensive plants that make better guesses do. If that happens too frequently, there will be real inefficiencies in the market as plants with high marginal costs are being run before plants with low marginal costs. Consumers will pay too much if expensive plants are being run while less expensive plants sit idle.

6.3.2. Success of Nordic electricity market

The key trading institution in the Nordic electricity market is the Nord Pool power exchange, which is an ‘‘energy only’’ spot market at which hourly ‘‘system prices’’ are determined in single price auctions. As long as transmission capacity is sufficient the system price is equal to the wholesale trading price in all four countries. But whenever lack of transmission capacity prevents cross-border trade the ‘‘area prices’’ differ from the system price. Norway is divided into several ‘‘price areas’’, while there is only one price area in Finland, Sweden and the two parts of Denmark, respectively. The system operator in each one of the countries operates a real time market in order to continuously balance generation and load at minimum cost. Transmission tariffs are designed in largely the same way in the four countries. A key feature is that transmission prices are independent of the geographical distance between trading parties. As there are no border tariffs between the Nordic countries, the physical inter-connector capacity constraints are the only remaining barriers to trade across the national borders (Amundsen et al., 2006).

Von Der Fehr et al., (2003) believed that the establishment of Nord Pool and the elimination of border tariffs between the Nordic countries were key elements in a strategy aiming at an integrated Nordic market for electricity. There is complete market opening in all the Nordic countries. In some of the countries, such as Sweden, a household consumer may even buy electricity from suppliers in any Nordic country. Given this, the pre-tax retail prices should not differ very much between the four Nordic countries. However, there are obstacles to transactions between suppliers in one country and households and other small customers in other countries. In Sweden, legal separation between retailing and distribution is required. Thus, while all retailers may suffer from a combination of unexpectedly high area prices and consumption levels, the extra costs in the retailing business become extra revenues in the generation business for the integrated generation-retailing companies. A notable consequence of regulatory reform in the Nordic countries has been the almost complete halt to investment in generation and, to a lesser extent, in transmission and distribution. The greater emphasis on profits lead to company restructuring and mergers, as well as to increased efficiency (eg., employment in the Norwegian electricity industry fell from almost 20,000 in 1993 to below 13,000 in 2002). At the end of 2002 the impact of high prices on customer bills has occurred. Nevertheless, the market withstood the test and handled the supply shock. But this event shows that potential problems still exist.

Electricity supply systems dominated by hydropower tend to be energy-constrained rather than capacity-constrained (around 50 percent of Nordic power production is based on hydropower). Here we can speak about efficient market design (establishment of Nord pool) which not imposing price regulations or other regulations that would have increased the transaction costs or financial risks. For generators are given the possibility to compete both in the spot market and in a forward market. According to economic theory this will lead to an increase in aggregate output and a decrease in the market price (forward contracts have less incentive for generators to reduce output in order to raise the spot market price). Another aspect of market design that contributes to the mitigation of market power is the market rules of Nord Pool, according to which information about available hydro stocks and the operation plans for power nuclear plants cannot be kept as company secrets. Apart from the fact that no regulations, temporary or permanent, were imposed the no-intervention policy probably also had long-term effects. By confirming that prices will be allowed to be high in ‘‘dry’’ years the politicians in effect increased the expected rate of return on investments in new generation capacity (Amundsen et al., 2006).

6.3.3 The California Electricity Crisis

In this section we try to provide a brief overview which describes the crisis that happened in California electricity sector in 2000. Such, Frank A. Wolak (2003) argued that the California electricity crisis was fundamentally a regulatory crisis rather than an economic crisis.

James Bushnell (2004) called California's reform as an incubator of bad public policy ideas. The factors most often cited as the causes of the California crisis are the scarcity of generation capacity (combined with rapid growth in demand), a ‘‘flawed’’ market design that included a freeze on retail rates, and the venality of electricity producers.

The Californian electricity deregulation process was put into effect on April 1, 1998. In the period prior to this there was a considerable excess generation capacity (some 20 percent) and electricity prices were above normal. The deregulation process included the introduction of new institutional arrangements such as CALPEX, the power exchange that is comparable to Nord Pool, and CAISO, the independent system operator, running several markets for ancillary services and reserve capacities. Furthermore, many other measures were introduced. One of the most important measures was one of divestiture, i.e. that the three big power companies (Pacific Gas and Electric, Southern California Edison and San Diego Gas and Electric) had to sell half of their fossil based generation capacity (while for a large part retaining their delivery responsibilities). Another measure was to fix end-user prices at 1996 level until 2002 in order to protect consumers and to ease the problem of ‘‘stranded costs’’ of the power companies. Furthermore, public power companies were excluded from the deregulation process but had to continue providing cheap electricity (based on generous tax conditions). Finally, another measure was to prohibit new long-term power purchase contracts (Amundsen et al., 2006).

Chi-Keung Woo (2001) analyzed and showed that California's electric service was reliable and of good quality, even though California had the highest retail electric rates in the nation. The California electricity market generally mirrors the generic model of electricity market reform that typically creates the following markets and organizations:

- A competitive wholesale energy market in which buyers and sellers transact by making demand and supply bids.
- An independent system operator (ISO) who implements the wholesale market energy transactions by managing the high-voltage transmission owned by the newly created regulated T&D companies.
- Regulated T&D companies that descend from the formerly integrated utilities. Subject to the rate-of-return (or price cap) regulation, these companies own the T&D networks and must provide open access to all users.
- A retail market whereby retail customers can freely choose their preferred energy suppliers.

Amundsen et al., (2006) have mentioned that the summer of 1998 showed tendencies to excessive wholesale prices and there were problems on the reserve power markets (that some thought of as resulting from the exercise of market power and gaming). Otherwise there were no particular problems and the markets seemed to function fairly well until 2000. Prices on the wholesale market started to increase in the early summer of 2000 and continued to do so in the following months. Consequently, the power producing companies became sceptical to sell power on the power exchange as their contracts were not honored. Finally, the power exchange broke down and was declared bankrupt March 9, 2001.

During 1998, substantial hydro resources and abundant imports contributed to an annual average price of $26/MWh. Prices again averaged a modest $28/MWh during 1999. Beginning in May 2000, however, energy prices climbed to previously unseen levels and averaged $110/MW for the year. This was the economic phase of the crisis (James Bushnell, 2004).

Amundsen et al., (2006) investigated the Californian electricity crisis as a result of several shocks:

- A sizable increase of power demand (+14 percent as compared to the summer of 1999). This was due to a strongly rising income (+9 percent from 1999) and extremely warm weather during the summer of 2000.
- A sizable reduction of water power generation due to dry weather conditions (a reduction of 20 percent in the western part of USA).
- Breakdown and frequent excess maintenance of the aging fossil power plants due to increased power generation.
- An increase of the price of natural gas by some 70 percent from April to November 2000.
- An increase of the price of NOx permits due to increased use of natural gas.

The deregulated electricity market in California obviously could not tackle these shocks. An important reason was the cap on end-user prices that effectively hindered that rising wholesale prices transformed into rising end-user prices that would otherwise result in a reduction of consumption. Also, the restrictions on the long-term power contracts implied lacking hedging opportunities. Another factor explaining the result of the shock is that Californian companies may have been more prone to exercise market power based on extreme short-run inelasticity of demand (gaming and hockey stick bids) and structures of exchange, balance and reserve markets that made this possible. In California one of the main utilities, i.e. the Pacific Gas & Electric, went bankrupt through selling at a fixed regulated price and buying at what turned out to be much higher spot prices. Facing some regulatory restrictions, it had not participated in the (relatively ill developed) forward and futures markets for power (Amundsen et al., 2006).

Bushnell (2004) evaluated the fact that it was the lack of competitively priced capacity outside of California, in the still regulated regions of the western part of US that helped create the contrast in prices between 1998 and 2000. Even though imports were little more expensive during the summer of 2000 than earlier summers, there were no supply shortages during these high-demand months. Once market-based rate authority was granted, little additional oversight was given to pricing practices. The one remaining regulatory tool was a wholesale price-cap, which began in California at $250/MWh, but was raised to $750/MWh in October 1999.

Chi-Keung Woo (2001) cited the next circumstances about what went wrong: The California Power Exchange & Independent system operator (PX–ISO) market design was poor. The investor-owned utilities (IOUs) are required by the California Public Utilities Commission (CPUC) to buy from the PX and ISO markets. This encourages capacity withholding by the few sellers that dominate the California electricity markets. At the same time the total dependence of IOUs on the PX and ISO spot markets. They cannot enter forward contracts to ensure reliable supply at fixed prices, notwithstanding that risk hedging is common in portfolio management. The PX and ISO markets are sequential. If a seller makes a high price bid and fails to sell in the day-ahead markets, it can easily make up the lost sales and profit in the day-of and real-time markets. This encourages capacity withholding by sellers in the day a head markets. About ten sellers determine the PX market prices. This is partly due to the fact that the IOUs' plants were sold in packages to increase the auction proceeds and expedite the divestiture. The California market is inter-connected with out-of-state markets like COB and Palo Verde (PV). Market inter-connection implies that California market prices should reflect the out-of-state market prices for they measure California's in-state marginal (opportunity) cost. Virtually no new in-state capacity came on line in the last decade, despite California's robust economic growth of 3–6% per year since 1994. New plant development has also been hampered by the fact that the largest and most likely buyers (i.e. the IOUs) cannot enter long-term contracts that would reduce a developer's revenue dependence on spot market sales. Both PG&E and SCE are now financially insolvent. Though few sellers would publicize their reluctance of selling into the California markets, it is suspected that the two IOUs' default risk exacerbates the shortage problem.

6.4 Countries with jurisdiction similar to single buyer model

6.4.1 Ontario

The Ontario electricity market has many interesting features. There are three types of markets in the Ontario electricity market: the real-time market, the financial market, and the procurement market. Out of these, the real-time market affects the actual delivery and use of electricity ("IESO of Ontario Electricity Market). Ontario demand ranges from 12,000 to 25,000 MW. Total market demand could be gotten as sum of Ontario demand plus exports and losses. The bids and offers from the participants give the market clearing price for electricity (Aggarwal et al., 2009).

There are total installed generation capacity of 30,548 MW comprising 4 nuclear power stations (total 10,836 MW), 59 hydroelectric stations (total 7,615 MW), 5 coal-fired stations (total 7,546 MW), 24 oil/natural gas stations (total 4,485 MW) and 66 MW of miscellaneous capacity.[14] As noted by Zareipoura et al., (2007), coal-fired generators are the most-frequent market price setters in Ontario, while gas-fired are the price setters only during extreme demand hours in a day.

There are several main players in the electricity market of Ontario. The Ministry of Energy has overall responsibility for Ontario's energy market, including ensuring that Ontario's electricity system functions at the highest levels of reliability and productivity. The Ontario Power Authority is the organization responsible for the long-term planning and procurement of Ontario's electricity supply, as well as for facilitating achievement of the province's conservation targets. The Ontario Independent Electricity System Operator (IESO) arranges dispatch and transmission flows and manages spot markets. The Ontario Energy Board (OEB) arranges a portion of Ontario Power Generation's generation capacity. A large portion of wholesale energy costs are compensated through the Global Adjustment (GA), which is paid by consumers. Because it cannot recover through

[14] H Zareipour, CA Canizares, K Bhattacharya. An overview of the operation of Ontario's electricity market. Power Engineering Society General Meeting, 2005. IEEE. 460-467

market revenues, with the Ontario Power Authority's creation, it was included to the costs of OPA contracts (Goulding A. J., 2013).

Donald D. Dewees (2012) has mentioned that the nominal prices increased in 1993-94 and another after 2002. The government put the price-cap in 1993, causing inflation-adjusted prices to decline until the cap was removed for 6 months in 2002, and then removed permanently in 2004 when prices were regulated. As a result was discouraged investment in the province's electricity system and an increased in the debt level to be paid down by future consumers.

Residential electricity prices increased faster than inflation between 2000 and 2010, with increases including taxes averaging 4.77% per year in nominal terms, or 2.86% after adjusting for inflation. The increases were primarily from new natural gas projects and infrastructure renewal; and secondarily from changes at the wholesale and distribution level arising from the introduction of the competitive market in 2002, including higher local distribution charges.

Zareipour et al., (2005) have mentioned that the electric power sector of the province of Ontario passed through a process of transition from a government-owned vertically integrated power system to a competitive wholesale electricity market on May, 2002 (two years after the originally scheduled date).

Based on Castalia Advisory Group report (2013) there were two major flaws with the way that the wholesale electricity market in Ontario was introduced:

- Small retail customers were unprotected from spot prices without any transitional arrangements.
- There was 90 percent of the generation in the hands of one party which was always going to create difficult market dynamics.

There is a control of planning for new generation capacity in Ontario. The single buyer - the Ontario Power Authority (OPA) - is responsible for all forecasting and planning. The OPA are responsible for a 20 year plan for generation and transmission to meet those forecasts. Broader advice to the Government on energy policy also is provided by OPA.

Based on Donald D. Dewees (2012) report Ontario Power Generation (OPG) owns several power plants with different forms of production. There are also various firms operating generating facilities. The Hydro One provides transmission the electricity from generating stations to large customers and to municipal electric utilities. The Ontario Power Authority (OPA) provides system planning and enters into long-term contracts with new generators.

Zareipour et al., (2005) have mentioned that, the Ontario electricity market is divided to the real-time physical energy and operating reserves markets and a financial transmission rights (FTR) market, while a financial day-ahead forward market is under development. Furthermore, market participants have a choice to buy or sell energy through physical bilateral contracts. Physical bilateral contracts have a small share in the whole electricity trading in Ontario and are not part of the actual scheduling and dispatch of energy, while physical bilateral contracts are a part of the dispatching process in most of other markets.

Based on Castalia Advisory Group report (2013) the OPA procures capacity differently depending on whether it was before or after 2004 reforms. The OPA also uses different procurement methods depending on the type of generation.

The prices for generation owned by OPG are regulated. But for generation owned by private parties is contracted through long term PPAs. There are three mechanisms for procurement new capacity by OPA such as:

- Small scale renewable and cogeneration projects (contracts with feed-in tariffs);
- Unique situations (particularly for renegotiating contracts for OPG's large nuclear power stations);
- Large-scale new capacity (competitive tender process).

Genc et al., (2011) called the main parts of Ontario wholesale electricity market as energy market, operating reserves and financial transmission rights market. The spot market price is set by simply ranking all received energy offers in increasing price order, until the forecasted demand is satisfied. The last accepted energy offer sets the market price, which is paid to all suppliers.

The Independent Electricity System Operator arranges the wholesale market, ensures the reliability of the integrated power system, and forecasts supply requirements and demand. Suppliers submit energy offer to sell electricity and wholesale buyers submit energy bids to buy electricity. The Independent Electricity System Operator runs a uniform price auction to balance total market supply and demand and establish the Hourly Ontario Energy Price (HOEP), which is the price paid to generators that supply power. Indeed, the market clearing price (MCP) is calculated every five minutes a day and the average of these MCP prices results in the HOEP, which is also known as spot price (Genc et al., 2011).

The market clearing price is set for each five-minute interval and is based on an unconstrained dispatch algorithm. In addition to the five-minute prices, each hour, the hourly Ontario energy price (HOEP) is determined by taking the average of the 12 market clearing prices during an hour (Aggarwal et al., 2009).

Goulding A. J. (2013) has mentioned that Ontario's approach to power sector investment and planning is inefficient, expensive and arguably unsustainable. Investment decisions reflect neither market signals nor long-term, centralized, utility-style system plans has resulted in higher costs for provincial consumers. Because of Global Adjustment consumers have to pay higher prices in order to keep reserve capacity.

Goulding A. J. (2013) also argued that an energy only market in Ontario might be greeted with skepticism by investors, given the province's history of suppressing price signals. The current Ontario power sector structure is not sustainable. Repeated use of ministerial directives increases uncertainty about policy direction and durability. The Feed-in tariff program exacerbates imbalances in supply composition and increases costs. Requiring a provincially owned generator to pursue investments for other than purely commercial reasons creates additional cost challenges. Price suppression and distortion through the GA and other means produces inefficient consumption decisions. The OPA has crowded out private long-term electricity buyers: generating companies have little incentive to seek alternative purchasers and electricity buyers cannot match the credit quality and duration of OPA contracts.

Genc et al., (2011) argued that the Independent Electricity System Operator does not have a day-ahead market due to regulatory reasons. Generation dispatch and market clearing prices are set in the real-time energy market. Along with the Alberta market, Ontario market is the only market having a one settlement market which is the real-time spot market in North America.

Zareipour et al., 2007 called the next events frequently happen in Ontario:

- Demand underforecast.
- Export/import transactions failure.
- Error in non-dispatchable generators energy output forecast.

Genc et al., (2011) showed that price regulation for retail consumers and for Ontario Power Generation comes as a retroactive accounting adjustment. This dual system preserves an operating spot market with some price stability for retail consumers, but creates some additional administrative and accounting procedures to monitor and adjust prices on a regular basis (so that market and regulated prices balance with actual payments made by consumers).

Currently, residential and small business consumers who buy their electricity directly from their local utility (instead of from retailers) pay either a tiered or time-of-use (TOU) rate according to the Regulated Price Plan (RPP), depending on whether they have smart meters. RPP prices are set by the OEB and reviewed twice per year. To calculate RPP prices, the OEB forecasts the cost to supply electricity to RPP consumers for the next 12 months, taking into account factors such as forecast prices for coal and natural gas, supply-fuel mix, contracts with generators and demand forecast. While all Ontario electricity consumers are required to pay their share of the GA, a forecast of the GA is also included in the RPP prices and, therefore, is not shown separately on the bill (Goulding A. J., 2013).

Ontario's electricity demand is falling and electricity generation capacity is rising. But that has not led to lower electricity prices in the province, and with current plans to increase the use of costly and inflexible nuclear power, prices will continue to rise.

Falling electricity demand in Ontario is due to a combination of factors as:

• Capital equipment replacement cycles.

• Direct efforts to incent efficiency improvements and reduced peak period demand.

• Structural changes in the Ontario economy.

• Greater use of self-generated power in power hungry industries.

On the supply side, Ontario's electricity generation capacity has increased by 13% since September 2003. However, Ontario’s electricity consumers have not benefited from the falling market price for electricity since the Government of Ontario has imposed a special charge on all electricity consumers (the Global Adjustment Charge) to provide a supplementary “out-of-market” revenue stream for Ontario’s electricity generators (Ontario Clean Air Alliance Research Inc., 2012).

6.4.2 Brazil

The Brazilian electricity system is based on hydropower. More than 80% of the country’s electricity comes from state hydroelectric dams in years of normal precipitation. A few coal plants exist near coal reserves in the South, but thermal power mainly supply isolated markets. Power costs in Brazil are low, which reflects the historical reliance on cheap hydropower. Nevertheless, tariffs are relatively high as result of system charges and taxation (Adilson de Oliveira et al., 2005).

In 2004, the initial model of the Brazilian Electrical Sector reform

(RESEB) developed along the 90s was revised. Although the RESEB's initial model has implemented risk management tools intended to attract private investments, the reform was not as straightforward as firstly envisaged. Several factors contributed to this situation. One of these factors – and perhaps the most important – was the vast complexity of the Brazilian Electrical Sector. Other factors were an incompletely defined regulatory structure; a lack of effective planning; and an unstable economy. Together, these factors hindered the flow of investments necessary to guarantee the system's expansion. As a result, the Brazilian society experienced a rationing of electrical energy that lasted from June 2001 to February 2002. Indeed, the rationing (caused by a misbalance between supply and demand) was the major motivation for the 2004 revision of the initial model (De Souza et al., 2010).

Brazilian Government created a new regulatory framework for electricity sector. The main objectives included: creation an efficient mechanism for the contracting of electricity on behalf of captive consumers; establishing security of supply at the lowest possible prices; universal access to electricity around the country (Dutra et al., 2005).

The current industry model is a result of crisis. After investigation of international experience with single buyer model, the current structure was presented in 2004 where the single buyer acts as a broker between the distribution companies and the generators. There is a difference in procurement between existing and new generation.

The new model for the wholesale power market consists of regulated markets for captive consumers and free markets for large consumers. In the regulated market, distribution companies pool their purchase of power to supply their captive consumers in annual auctions. Generators may sell to either market and for regulated market through competitive regulated auctions. To induce greenfield power plants, the new model distinguishes between old capacity and new capacity to which larger power purchase agreements (PPAs) (15 to 35 years) are offered in the regulated market auctions.

Demand in the regulated market comes from captive and potentially free (over 3 MW demand) consumers while demand in the free market comes from large consumers that decided to leave the regulated market already. For the time being, the free market is relatively small as yet but there is a strong movement of potentially free consumers towards the free market. Distribution companies and free consumers are required to contract up to 100% of their 5 years future demand. A spot market provides system balancing for differences between power consumed and contracted (Adilson de Oliveira et al., 2005).

Within the ACR, a distinction is made between ‘‘new’’ and ‘‘existing’’ electricity. The aim is for final consumers to pay a combination of a higher price associated with new plants and a lower price associated with existing, partially, or fully depreciated plants. In this contracting environment, distributors are required to contract their entire forecast demand for captive consumers. Contracts will be auctioned off over time with different auctions for new and existing electricity. For existing electricity auctions, distributors have to provide, prior to the auctions, their forecast demand for the next five years. The government then collects the information from all distributors to determine the forecast system demand for the next five years. Distributors do not participate in the auctions. Generators, on the other hand, submit bids indicating their willingness to supply. These supply contracts, CCEAR are denominated by the year in which supply begins. The unit in the auction is a lot: defined as the amount of electric energy equal to 1 average MW. At the end of the auction, suppliers sign contracts for MWh. Contracts specify an amount of electricity (the number of lots won, multiplied by the number of hours in the year and by the number of years) and the price. Both quantity and price are determined by the auction mechanism, as explained below. Three types of products are auctioned off: A-1 contracts for supply beginning in 2005, A-1 contracts for supply beginning in 2006, and A-1 contracts for supply beginning in 2007. The auction proceeds in two stages. Bids in the first stage take the form of numbers of lots at the standing price. Each lot corresponds to the guarantee of supply of 1 MW for a period of eight years. After the conclusion of the auction, distributors and generators sign the supply contracts. In particular, each generator signs contracts with each distributor. All distributors then have access to a common price that is an average price with the weights determined by their share of total forecast demand as illustrated below.

For example, suppose there are two distributors – D1 and D2 – who have reported forecast demands (say, for the first year after signing the contract) of, respectively, 100 and 200 MW. Recall that this is secret information and only known by the auctioneer. Assume further that there are three generators – G1, G2 and G3 – and that the auction results are such that G1 sold 50 MW at $75, G2 sold 150 MW at $80 and G3 sold 100 MW at $100. That is, G1's share is 50/300 = 0.16666. Similarly, G2 and G3's shares are, respectively, 0.5 and 0.3333. Each distributor then pays an average price of $85.83. For new electricity, the contracts to be auctioned off are longer (more than 15 years) than the contracts for existing electricity (eight years) and supply will start three years ahead (A-3 contracts) and five years ahead (A-5 contracts). The assumption is that the first market will attract mostly yet-to-be-built thermoelectric power plants whereas the second market will attract yet-to-be-built hydroelectric power plants. For the new electricity, a government-owned firm, EPE, identifies potential hydro and thermal projects and auctions them off. In the case of thermal projects, the project is subject to the assurance of fuel availability. In the case of hydro projects (to be sold in A-5 auctions), the project will already have received environmental clearances. A winner in either an A-3 or A-5 auction will sign long term contracts that will allow it to recover its costs though consumer charges. Cost recovery via consumer charges is also a feature of the A-1 auctions. Finally, the new model consolidates the vertical separation of the industry (with the elimination of self-dealing) and a trend towards centralization of decisions within the Ministry of Mines and Energy (MME). Table 14 summarizes the main characteristics of the electricity regulatory framework in Brazil (Dutra et al., 2005).

Based on Castalia Advisory Group report (2013) there are also "adjustment" auctions for 1 to 2 year contracts with delivery 4 months ahead. These auctions allow distributors to revise their contracted positions. This adjustment process only allows distributors to adjust their positions if their forecasts are wrong. The other mechanism for rebalancing distributor supply and demand is the weekly balancing market, which is more costly and risky because prices are more volatile.

Old capacity is never eligible to participate in new energy auctions.

However, if owners of old capacity do not sell their capacity in the old energy auctions, they are allowed to sell to large customers on the free market. New capacity can participate in the old capacity auctions after the expiry of their initial 15 year contracts (or can choose to sell their energy to large customers on the free market).

6.5 Lessons for Kazakhstan from International Experience with sector reform

A very important issue is that electricity deregulation reforms do not always succeed. The success of the “model” in the electricity market does not mean it could be adopted all over the world.

As many scholars have mentioned, electricity market reform in the UK did not present new ideas. The inefficiency of the pool and the existing market power of the incumbents show the advantage of producers, but there are no benefits for consumers. UK’s reform did not show a sufficient increase in investment in the electricity sector. We can also say that the reform did not solve the problem of its environmental impacts (the RES share was under 2% in 1990 and remained under 3% in 2000).

Many authors have argued that an efficient market is characterized by an auction, where in the prices are close to the marginal cost of producing the product. In a uniform price auction, the producers are assured of success by submitting low bids, which is impossible in a discriminatory auction. Also, during a uniform price auction, a producer does not know the bids of the other producers. In this case, however, producers could use a capacity-cutting strategy, which may allow them to artificially create a deficit and drive up wholesale electricity prices. In discriminatory auctions, sellers do not have unilateral incentives to raise prices, and in most cases, the prices are close to the marginal cost of producing the product. At the same time, however, there is one major weakness of a discriminatory auction: high-cost plants make better guesses too frequently and are run before plants with low marginal costs. Consumers will pay too much if high-cost plants are run while low-cost plants sit idle. In a discriminatory auction, firms that are good at guessing bids may try to increase their capacity, while smaller firms may consider the market too risky. This could eventually lead to less competition and higher prices. In a discriminatory auction, the price a firm is likely to receive depends on how good it is at forecasting the market-clearing price. In the uniform price setting approach, profits for inframarginal plants do not depend on accurate forecasting of the market price.

In the Nordic market, we note a simple but sound market design and a significant share of hydropower. Market power was successfully diluted by integrating the four national markets into a single Nordic market. The coordinated work of the governments of the Nordic countries show strong political support for the electricity sector. To mitigate market power special market rules were adopted, according to which most information cannot be kept as company secrets. After reform, transmission prices became independent of the geographical distance between trading parties. At the same time, we observed an almost complete halt in generation investment. Companies emphasize profits that induced restructuring. As a result employment in the Norwegian electricity industry fell from almost 20,000 in 1993 to below 13,000 in 2002. An important lesson from this case is that one of the most effective ways to keep prices down is to ensure that entrants are not prevented or inhibited from building economic electricity generation plants. An important idea is that the presence of forward contracts can promote competitive pricing in the spot market.

The California electricity crisis was a result of several shocks. Aging fossil power plants were excessively maintained due to increased power generation. Also the price of natural gas significantly increased in 2000. The most important issue, however, was the cap on end-user prices. The PX-and ISO markets were poorly designed. Their sequence allows recovery of lost sales in real-time markets that failed during the day-ahead markets. It is easy to see that only about 10 sellers determine the PX market prices. In the last decade, there was no new in-state capacity. In the current market model investors cannot enter long-term contracts. A number of factors can influence a firm’s decision to build or not to build a power plant, including the costs of building the plant, the prices the firm expects to pay for fuel and the likely price of its generated power.

The single-buyer model was selected for Ontario’s case due to the wholesale market failure. In Ontario’s electricity sector, the highest generation share is concentrated in the hands of the dominant player. As a result, the wholesale market was closed after six months. A new model was introduced: that of a single buyer as the procurement agency accountable to the government under the Ministry of Energy. We emphasize that the electricity prices increased due to new natural gas projects and infrastructure renewal, and secondarily, due to changes at the wholesale and distribution levels, which include higher local distribution charges.

A very important issue is the question related to the Independent Electricity System Operator. As mentioned in previous chapters the system operator (KEGOC) of Kazakhstan also operates the National Power Grid of Kazakhstan. However Ontario’s system operator is a non-profit company that is mainly responsible for ensuring fair competition among market participants and for maintaining the reliability and security of the power grid.

An important issue in electricity procurement is that the market participants were given a choice to buy electricity through physical bilateral contracts. This causes some worry that the bilateral contracts are not part of the actual scheduling and dispatch of energy, despite their small share in the total electricity trading.

We also emphasize two important facts pertaining to different types of procurement methods from OPA. In the first type of procurement method, the time dependent method (since or after the 2004 reforms) will provide a comfortable environment for developers; and the method that depends on the type of generation should attract new investors in the power sector. In our opinion, complementing this method with procurement through a competitive tender process that uses long-term contracts would reduce costs. The second type of procurement method would make it possible to reach the Government’s targeted in generation capacity level, including the development of renewable energy.

Some experts have concluded that Ontario’s approach to investment questions and planning is inefficient. The investment approach is not connected to market signals and system plans. Here, however, we saw that Ontario’s installed capacity has grown after it started using the single-buyer model. At the same time, the development of the power sector has resulted in higher costs for consumers. This failure has been connected to the GA approach. As shown GA reduces transparency in the electricity market.

As shown in the preceding paragraph, one of the main problems in Ontario’s electricity market is forecasting and dispatch failure. In this case, the system operator has to dispatch some of the more expensive units that may cause high market prices. The main obligations of the OPA will expand the generation capacity volume, which should cause over-capacity. At the same time, however, we could not see that a single buyer should execute this plan at the least cost. Such situation may lead to a price increase.

The important lesson mentioned earlier was that Ontario’s single-buyer planning system has a lot of weak points. First, while demand has been falling the generation capacity continued to expand in the electricity market. As a consequence of the rising supply and falling demand, the market price of electricity in Ontario has declined, but the consumer price has risen. This situation happened when the Government of Ontario imposed the Global Adjustment Charge, which gives, besides energy, reserve benefits for Ontario’s electricity generators and consumers in Manitoba, Quebec, and the U.S.

The key lesson is to create a mechanism for reliable supply at the least cost. From Ontario’s single-buyer model, we emphasize that competition between retailers is limited by the fact that they all get the same wholesale price.

As in the Brazil case, one of the significant arguments for the decision to adopt the single-buyer model in Kazakhstan’s electricity sector is that the current market design and reforms did not create incentives for the private sector to invest in new generation capacity. At the same time, we saw that Brazil's model for the electricity sector (the single-buyer model) is difficult and has many potential unforeseen and unintended consequences.

There are some facets of the Brazilian model that could be used for the Kazakhstan case. For example, the single buyer does not actually buy and sell electricity, but acts as a broker. We saw that the single buyer plays no role in dispatch: there is a spot market for dispatch with all generators participating.

In Brazil distribution companies are heavily incentivized to make their demand forecasts as accurate as possible because they have to contract for generation capacity based on their forecasts. Otherwise, in case of over- or under-forecasting, they are imposed some penalties. In this situation, distributors directly suffer the consequences of forecast error, and this approach overcomes the usual problem of correct planning. As we know, inaccurate forecasts in many countries, including Kazakhstan, put additional costs on customers. Therefore, the Brazilian approach to managing forecasting risks could be applied to the Kazakhstan case by providing adequate changes in legislation.

Similar to Kazakhstan in the power market of Brazil, electricity is purchased and sold through bilateral contracts, with the conditions, prices, and quantities freely negotiated between the generators, traders, and customers (who consume more than 3 MW of electricity). The Brazilian approach to correct contracting for free market customers could be applied to the Kazakhstan case.

The critically important issue involves the process of procuring electricity in Brazil's "regulated auctions". This approach could also be adopted for our new electricity sector model, considering the uniqueness of Kazakhstan's situation. Let us consider and describe it in greater detail in the next chapter. In this chapter, we discuss some positive and negative features of the Brazilian auction market. First, to reduce prices, a reverse price auction for the MW is used. Second, the price differentiation between "old" and "new" assets is a very important lesson for Kazakhstan. In this model, however some problems can appear, such as: the ability of existing generators that did not sell through the regulated auction to contract with customers on the free market. These customers were willing to pay the generators higher prices than those achieved through the auction. As a result, existing generators had less interest in participating in the next auction for "old" energy, which raised the prices. Subsequent auctions for old energy, have accentuated this trend with more energy sold in the free market, and less competitive tension in the regulated auction. The key issue with the Brazilian single-buyer model is that all loads and generation are fully contracted. Moreover, the spot market here merely balances differences between fixed contract levels and actual consumption. As Dutra et al., (2005) argued, bidders not only lack information on auction parameters but also do not know the criteria adopted by the government for setting such parameters. This lack of information increases uncertainty, which affects the bidding behavior and might yield an inefficient outcome. As new model is founded in long-term contracts, mitigates investment risks. Still, it is uncertain if acceptable prices will induce investment in new power auctions.

Our case studies in this chapter provide some useful lessons for understanding the main issues in the development of an effective model for

Kazakhstan's electricity sector. The summary of the main lessons is given in Table 6.1.

Table 6-1: The summary of the main lessons from international experience

Jurisdiction	Type of Model	Lessons learned	
		Positive	**Negative**
Brazil	Single buyer	• Single-buyer does not actually buy and sell electricity, and acts as a broker. • Single-buyer plays no role in dispatch: there is a spot market. • Usually there is correct planning, that help to avoid additional costs on customers. Distribution companies are heavily incentivized to make their demand forecasts. • The purchases and sale of electricity through bilateral contracts is undertaken with conditions, prices and quantities freely negotiated between generators, traders and customers. • There is approach about correct contracting for free market customers. • The process for electricity procurement in Brazil "regulated auctions": the reverse price auction for a total	• Brazil's model is not easy, and there are many potential unforeseen and unintended consequences. • Existing generators will try to contract with customers on the free market through the higher prices than the auction. • Bidders not only lack the information about auction parameters but also do not know the criteria adopted by the government to set them that increases uncertainty and might result in an inefficient outcome.

		number of MW; the price differentiation for “old” and “new”. • All loads and generation is fully contracted. The spot market only provides balance out. • In long term contracts, the single-buyer model mitigates risks for investments.	
Ontario	Single-buyer	• The selection of single-buyer model was done as a result of the wholesale market failure. • Ontario's system operator is a nonprofit company that is mainly responsible for ensuring fair competition for market participants and maintaining the power grid reliability and security. • The market participants were given a choice to buy electricity through physical bilateral contracts. • Two different procurement methods from OPA provide easy way to reach the Government's objectives in generation capacity level including development of renewable energy: procurement differentiation such as depending the time will provide	• The bilateral contracts are not part of the actual scheduling and dispatch of energy, despite they have a small share in the whole electricity trading. • The Global Adjustment Charge (GA) brings lack of transparency in electricity market and this approach became a result of higher costs for consumers. • Ontario's electricity market main problem is forecast and dispatch failure. System operator provides dispatch services does not think and care to do it with least cost that may lead to increase the prices.

		comfort environment for developers; procurement methods depending on the type of generation should attract new investors in power sector. • Ontario's installed capacity has grown after started to using single-buyer model. • Competition between retailers is limited by the fact they all get the same wholesale price.	• Weak points: First, while demand has been falling additional generation capacity continued to involve in electricity market. Because of the GA as a consequence of rising supply and falling demand, the market price of electricity in Ontario has declined but the prices for consumers have risen.
UK	Pool market	• Efficient market is characterised by an auction with prices are close to the marginal cost of producing the product.	• The inefficiency of the Pool and existing market power of the incumbents show the advantage of producers, but there are no any benefits for consumers. • Reform did not show sufficient increase in investment in electricity sector. • Reform's path did not solve the problem of environmental impacts. • The share of the RE almost did not change (under 2% in 1990 and remains under 3% in 2000).

			• The existing auction system in UK could induce the above marginal cost pricing and inefficient dispatching. • In a uniform price auction, the producers are sure of success by submitting low bids, that impossible in a discriminatory auction. • During a uniform price auction producers could apply capacity cutting strategy,
Nordpool (Sweden, Norway, Finland, Denmark and some part of Germany)	Pool market	• Simple but sound market design and significant share of hydropower. • The integration of the four national markets into a single Nordic market. • Coordinated work of the governments of the Nordic countries, which show strong political support for electricity sector. • Special market rules in order to mitigate market power. Most information cannot be kept as company secrets. • Transmission prices became	• Almost complete halt to investment in generation. Employment in the electricity industry fell.

		independent of the geographical distance between trading parties. • Presence of forward contracts can promote competitive pricing in the spot market.	
California	Wholesale market with regulated retail supply		• There were no steps to prevent excess of the aging fossil power plants and significant increase of the price of fossil fuel. • There was the cap on end-user prices. • The poor PX–ISO markets designs. • There was no new in-state capacity in the last decade. In current market model investors cannot enter long-term contracts.

Chapter 7. New model for Kazakhstan

7.1 Rational for Restructuring

The single-buyer model is usually defined as a transitional model arrangement before the transfer to a competitive wholesale market. In reality, however, especially in the Brazil and Ontario cases, the competitive wholesale market model has been replaced by the single-buyer model, because of the failure of the former model. As discussed in previous chapters, the main reason for the competitive wholesale market failure was market power. In the California case, about 10 sellers determine the PX market prices that far exceed the competitive levels. In our analysis in Chapter 5, we found that the top three firms (Samruk Energo, ENRC and Kazakhmys) accounted for more than half of the total market, and the Herfindahl-Hirschman Index showed that the power market in Kazakhstan can be classified as concentrated. At the same time, we found no competition among supply companies in Kazakhstan, and the presence of a price cap to protect consumers. The price of electricity sold in the retail market is limited by the price cap, which is based on the recoverable costs and the minimum rate of return. In this case, the introduction of the competitive wholesale market in Kazakhstan in the near future will be risky.

The ultimate objective of this chapter is to provide recommendations for the possible reform of the electricity market in the Republic of Kazakhstan through the single-buyer model. The single-buyer model is proposed as the new model for the electricity market in Kazakhstan, based on both international experience and the characteristics of the Kazakh electricity market.

Many scholars claimed that if electricity market reform is not done in an environment of surplus capacity, many sellers and easy market entry, it will not yield the desired outcome of reliable service at low and stable prices. Such L. Lovei (2000) evaluated some factors of popularity of the single-buyer model:

- By giving the entity responsible for real-time dispatch the exclusive right to buy electricity from generators and sell it to distributors, the single-buyer model greatly facilitates this balancing.
- Network electricity flows follow the laws of physics with no regard for contractual arrangements – a major problem for market models with multiple buyers and sellers. The single-buyer model solves this problem without requiring a regime for third-party access to transmission, which can be costly and institutionally demanding to establish.
- The single-buyer model preserves a key role for the sector ministry in decisions on investments in generation capacity and for the state-owned electricity company in the sector's day-to-day financial affairs – and thus tends to be favored by these influential players.
- The single-buyer model helps to maintain a unified wholesale electricity price, simplifying price regulation.
- The single-buyer model makes it possible to shield financiers of generation projects from market risk and retail-level regulatory risk, reducing financing costs or making the investment commercially bankable.
- The single-buyer model appeals to the populist instincts of politicians

reluctant to support the state's complete withdrawal from wholesale electricity trading.

As shown earlier, the total electricity consumption in Kazakhstan started to increase in 2000. In 2010, began to rise again and in 2011, power generation increased by 5.2% while consumption also jumped. The Government has forecast the average annual growth in electricity consumption in 2011-2020 as around 4.5%. It has developed an action plan for electric power development through 2015, which includes a list of power plants for reconstruction and modernization as well as the construction of new power plants. The total capacity of Kazakhstan's power generation sector is expected to reach 124.5 billion kWh by 2015. However, equipment in existing electric power plants will only allow an increase in energy production to only 93 billion kWh. Therefore, the country plans to modernize existing facilities and construct new power plants to meet consumer demand and increase its export potential and reserve capacity (U.S. Commercial Service, 2011). However, financing for new generation facilities remains questionable. The Law introduced "ceiling cap" tariffs for all generation companies in Kazakhstan. No payment is to be made above this tariff to generation companies. At the same time, another amendment, to the law requires generators to have an investment agreement with the Government and to reinvest all their profit into either new infrastructure development or upgrades. Many experts believe these issues are not effective enough. Hence, the construction of new power plants and the expansion of power distribution networks are still being discussed. In summary the current market structure in Kazakhstan cannot meet the main goals of government policy.

To relieve capacity shortages while conserving scarce public resources, the single-buyer model should attract private investors to construct power plants. Independent power producers will sell their output through long-term power purchase agreements with the state agency to protect investors from the highest market risks.

Another question that could be answered by introduction the single-buyer model involves price disunity for customers. The wholesale prices of different generation companies vary, and the tariffs for end-users are dependent on the geographical distance. In this case, the single-buyer model could also help maintain a unified wholesale price for all customers.

Besides L. Lovei (2000) denoted some important disadvantages of the single-buyer model:

- The single-buyer model responds poorly when electricity demand falls short of projections. Under the single-buyer model, however, wholesale electricity prices rise because take-or-pay quotas must be spread over a shrinking volume of electricity purchases. When these high prices cannot be passed on to final consumers, taxpayers must bear the losses.
- The single-buyer model hampers the development of cross-border electricity trade by leaving it to the single buyer, a state-owned company without a strong profit motive.
- The single-buyer model weakens the incentives for distributors to collect payments from customers. The state-owned single buyer is often reluctant to take politically unpopular action against a delinquent distributor, and its aggregation of cash proceeds from distributors allows it to spread the shortfall caused by a poorly performing distributor among all generators.

- The single-buyer model makes it so easy for governments to intervene in the dispatch of generators and the allocation of cash proceeds among them that few are able to resist the temptation.
- The single-buyer model increases the likelihood that, under pressure from vested interests, governments will indefinitely delay the next step toward fully liberalized electricity markets.

According to above given information we can see that the single-buyer model is more reliable these days for Kazakhstan electricity market. But we understood that it will be not pure single-buyer model as it usually presents in some countries. We see our future model as a hybrid approach that combines some aspects of different electricity market structures. We also understood that there is no perfect structure that provides achieving all objectives and goals. In this case creation of our own model poses difficult challenges that must be tackled in the next chapter.

7.2 New Market Design for Kazakhstan

The Single buyer body should be established as an Agency or a Center under the Ministry of Energy. This Agency shall be established to act as a single broker of electricity. It shall link generators to the electricity market. In principle, a state-owned company participated in by the Ministry of Energy would represent the best option for ensuring full independence, and would help to prevent conflicts of interest.

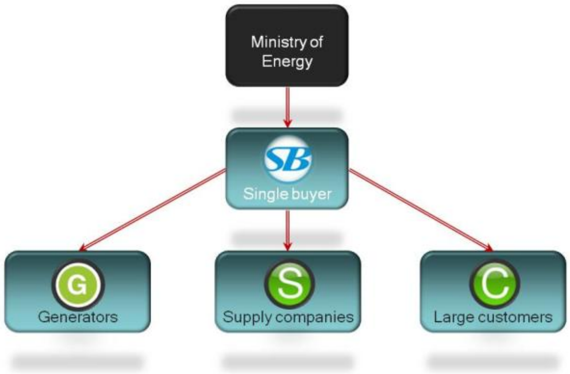


Figure 7-1: Structure of single-buyer model (Source: author's own elaboration)

The mission of the Single buyer can be defined as ensuring that the transactions required for implementing policy targets are performed effectively and efficiently, and ensuring fair allocation of the cost of electricity to consumers, irrespective of their point of connection to the electricity grid. The activities carried out by the Single buyer must be based on the principles of independence, neutrality, and confidentiality.

In our model, we suggest that the Single buyer refrain from acting as a buyer, but as in the Brazilian model, as a broker. The Single buyer will not actually buy and sell electricity, but should act as a coordinate body. All energy that passes through the Single buyer should be pooled. Moreover, each supplier contracts with each generator in proportion to the generator’s share of the pool, which the Single buyer must calculate and announce. The Single buyer should collect information on demand; and after getting the results of the auctions with respect to the supply volume of each generator at a given price, should calculate the average weighted tariff for consumers. We also suggest integrating a separate procurement mechanism between the existing generation and the new generation.

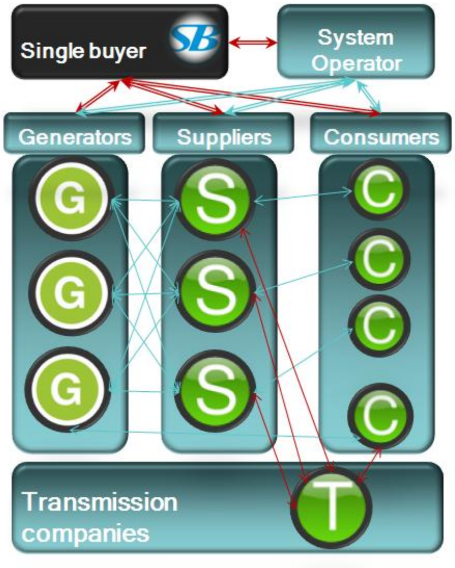


Figure 7-2: The single-buyer model for electricity market of Kazakhstan (Source: author's own elaboration)

The Ministry of Energy will control the planning of new generation capacity. The Single buyer will be responsible for all forecasting and planning. It should provide proposals for the Ministry to develop an energy plan. The Single buyer will be accountable to the Government for ensuring adequate, reliable, and secure electricity supply. These obligations should be completed and provided at the least cost to consumers. We understand that the current situation, wherein the system operator owns transmission lines and at the same time acts as the transmission company, is inefficient. In this case, the system operator tries to use its position as a natural monopoly to maximize its profit. This shows the need to split the function of the system operator into transmission and dispatch.

Supply companies and customers with a greater that 1 MW demand are required to make their demand forecast and submit it to the Single buyer and the system operator. There should be penalties for over- or under-forecasting. No more than 5% over- or under-forecasting should be allowed. In other words, the aforementioned customers should be responsible for inaccurate forecast. The supply companies, not customers, should pay the penalties from their profit. This approach would not be difficult to apply in Kazakhstan because the country has no competitive retail market.

In our model, there is only one type of procurement method: the purchase and the sale of electricity will be run through the Single buyer. Here procurement of electricity is conducted through "regulated by single buyer auctions".

Electricity procurement can be differed depending on the type of capacity, as follows:

- "Old" capacity – is energy generated from existing generators.
- "New" capacity – is energy from large-scale new projects.
- "Old-to-new" capacity – is for new capacity from old power plants. The Government should provide possibilities for existing power plants to expand their capacity. Newly generated energy from "old" stations is procured regularly at known intervals, through annual public auctions, for electricity to be delivered three years and five years later. Each auction may offer long-term energy contracts.
- "Green" capacity – is energy from renewable projects. According to the law, the Single buyer should obligate suppliers to purchase electricity from renewable energy through the feed-in tariffs. This will occur through

long-term bilateral power purchase agreements between each supplier and "green capacity".

When new generation capacity is required, the Government should announce it publicly and determine the date of the future auction. New generation projects will be procured regularly, through public auctions, for electricity to be delivered three and five years later. Auctions will be run for a set number of MW in a certain location. Potential generators will bid in this auction and compete on the price. Each auction will offer long-term energy contracts (15- to 20 year contracts for power plants). These can be standard financial contracts, wherein the procurement price for the next 15-20 years is fixed. One exception is for the future price of fuel for a thermal power station. The procurement price should be changed if the price of fuel will change in the future. Figure 7-3 shows the general energy contract auction scheme.

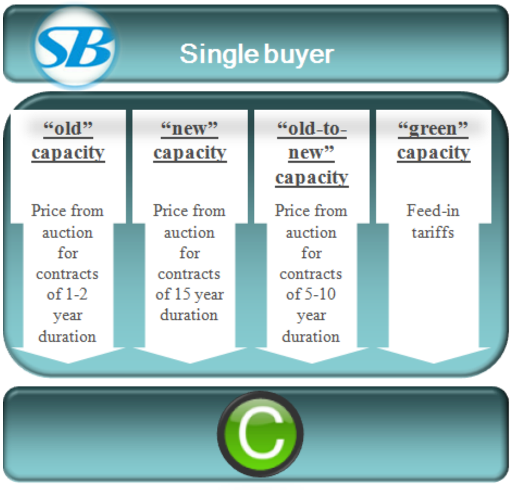


Figure 7-3: Characteristics of Auctions (Source: author's own elaboration)

Existing capacity should never be entered in new energy auctions. In the case of "new" capacity, however, including "new" renewable energy, after the expiry of their initial 15- to 20 year contracts, they should be entered in the old capacity auctions.

In our model, we suggest that the procurement process for both “old” and “new” energy start with a reverse price auction. The Single buyer sets a starting price that will produce excess supply. Generators will bid in the quantities that they are willing to supply at the stated price. Then the Single buyer will reduce the price, and the generators will bid in the quantity they are willing to supply at the lower price. The Single buyer will continue to drop the price until there is equal demand and no more excess supply. The important thing is the use of a reverse price auction for the total number of megawatt (for the procurement of the generation capacity “portfolio”, instead of procuring all the capacity from a single plant). The auction process ranks projects according to cost and selects the portfolio needed to meet the capacity requirement. The following figures illustrate the auction mechanism through a hypothetical example.

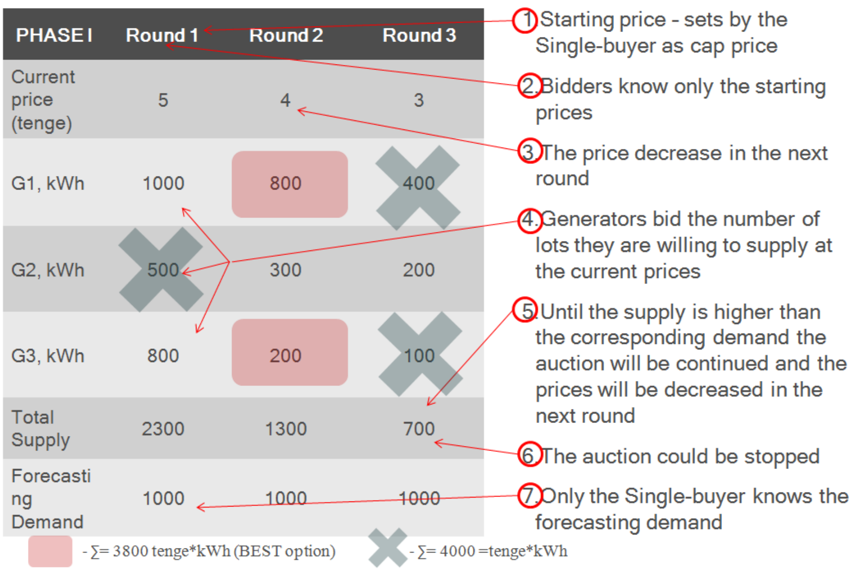


Figure 7-4: Bids in the First phase (Source: author's own elaboration)

PHASE II	Quantity, kWh	Price, tenge	Electricity cost, tenge*kWh
G1	800	4	3200
G2	200	3	600
Total Supply	1000		3800
Forecasting Demand	1000		

Figure 7-5: Bids in the Second (final) phase (Source: author's own elaboration)

As in the Brazilian approach, we also suggest involvement in "adjustment" auctions with delivery four months ahead. This approach allows players, especially supply companies, to revise their contracted positions, only if their forecasts are wrong. However, the main mechanism for rebalancing supply and demand is the balancing market, which is currently not operational in Kazakhstan. The balancing market should help forecast future demand and supply as accurately as possible, because any imbalance is costly and risky as prices are more volatile.

In our model, a real-time balancing market for regulating hourly imbalances occurred in the operational days between the actual and agreed delivery quantities in a physical and prospectively financial way. All wholesale electricity market operators must participate in the balancing market, organized by the system operator, and in which balance providers (regional distribution companies) act on behalf of (retail and wholesale) consumers.

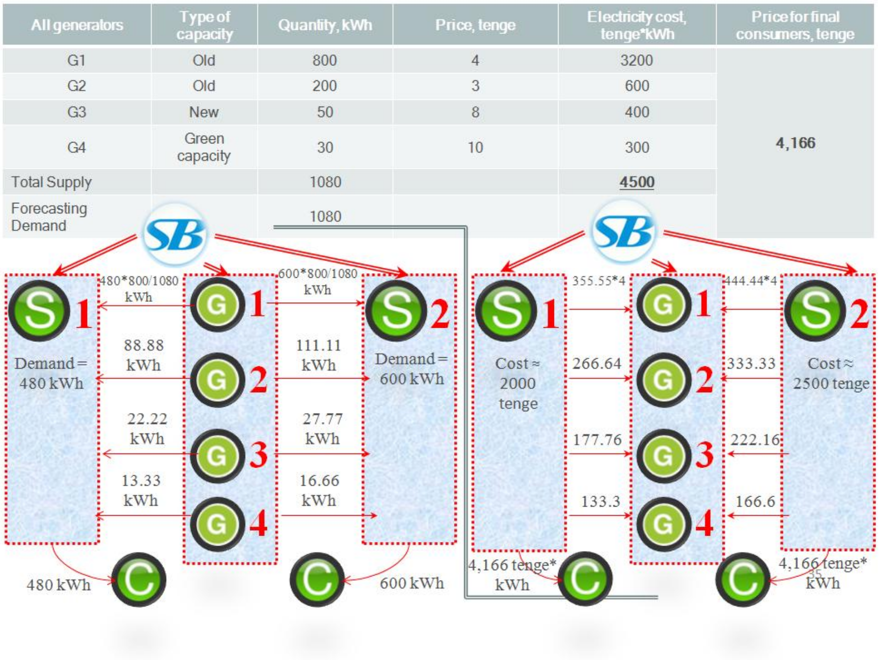
Kazakhstan could use a spot price market to balance any power that is not dispatched under long-term contracts. In such market, a generator, that had produced more electricity than contracted, can sell it to suppliers that presumably consume more energy than provided under their long-term contract. The spot market should operate daily. Having a daily average price will clearly show price signals. If a generator has extra capacity at peak times, its price will differ from that of a generator with extra capacity at lean times, because extra generation at peak times is more valuable. Therefore, the main role of the spot market is, only to balance any differences between the fixed contract levels and actual consumption.

In our model, the retail market will be divided into two sections:

- small customers (who consume less than 1 MW, including all residential customers and small business customers) served by supply companies; and
- large customers (who consume more than 1 MW, including all commercial and industrial consumers and large business customers) who will buy directly and not from a supply company.

The tariff that single buyer will set for these customers be equal to the average price of the total amount of electricity of each supply company or large customer, which is bought from all generators. There are currently around 45 electricity supply companies in Kazakhstan. Half of them have a regionally dominant position. In our model we suggest that electricity should be supplied to the Kazakh electricity market by supply companies, which purchase electricity only passing through the Single buyer. There is no competition between retailers, and competition is limited only to the payment of the same wholesale price. In this case it will be better to reduce the number of supply companies. Besides, we think the Government should set a cap on a special levy for supply companies (for example 10% of the Single buyer’s tariff), but not on end-user prices. Here, special rules should be adopted with important criteria for electricity procurement.

The following figure presents the continuation of preceding example of the procurement mechanism in the new model for Kazakhstan. For simplicity, four system generators and only two suppliers were assumed.



All generators	Type of capacity	Quantity, kWh	Price, tenge	Electricity cost, tenge*kWh	Price for final consumers, tenge
G1	Old	800	4	3200	4,166
G2	Old	200	3	600	
G3	New	50	8	400	
G4	Green capacity	30	10	300	
Total Supply		1080		**4500**	
Forecasting Demand		1080			

Figure 7-6: Procurement in the single-buyer model

Another issue is that transmission companies today have different tariff levels. This is one of the reasons why customers in South Kazakhstan pay a different price for electricity than customers in North Kazakhstan. In this case we suggest that transmission prices be independent of the geographical distance. Regulators should adopt a single transmission tariff for all transmission customers.

As seen, the proposed model of the potential electricity market of Kazakhstan relies on a combination of competition and planning to guarantee supply adequacy and to provide a relatively predictable environment for attracting new investors.

7.3 Comparison between the existing system and the proposed market model

As a conclusion of this chapter we provide brief comparison of the existing electricity system in Kazakhstan and our model that was developed here. This comparison is given in Table 7.1.

Table 7-1: The comparison of the existing electricity system and new model

	Existing system	**New market model**
Planning	National electricity balance. According to the forecast from the System operator.	There is an energy plan. For new generation capacity will be centrally controlled Ministry of energy. The Single buyer will be responsible for all forecasting and planning. Retailers are required to make their demand forecast.
Wholesale market price	There are cap-prices for all generators, which were divided into 13 groups. There is no competition among generators.	The reverse price auction for "old" and "new" capacity, which should provide competition. Feed-in tariffs for renewable energy.
Procurement	Electricity market players, through negotiations or tenders, independently enter into direct bilateral contracts for purchase and sale of electricity (not clear mechanism). Consumers buying power from energy supply companies or from a power generator	The Single buyer acts as a broker. All energy which passes through single buyer should be pooled. Each supplier contracts with each generator in proportion to their share of the pool, which the Single buyer must calculate and announce. Separate procurement mechanism

	(dependent on capacity).	between existing and new generation.
Dispatch	Dispatching of day-ahead electricity load management is performed according to the schedule of electricity purchase and sale. The daily schedule by participants of Kazakh's wholesale market is prepared, based on results of the trade in electricity on decentralized and centralized markets (not clear scheme).	Real-time balancing market to regulate hourly imbalances All wholesale electricity market operators must participate in the balancing market The spot price market could be used to balance any power that is not dispatched under long term contracts. The spot market should run on a day basis.
Retail	Supply companies purchase electricity from generating companies; or during centralized auctions sell it to retail consumers in the end-use sector. A total of 45 electricity supplying companies operate, and some of them function as the electric power «guaranteeing suppliers».	The tariff that will be set for the customers by the Single buyer should be equal to average price of the total amount of electricity of each supply company or large customer, which is bought from all generators. Supply companies should purchase electricity only passing through the Single buyer. The number of the supply companies should be reduced. There is a cap on a special levy for supply companies, but not on end-user prices.

7.4 Barriers to Successful Implementation of the new model

Finally, we want to discuss the main barriers, which can appear before or during the creation of the new model for the electricity market in Kazakhstan. We will not consider the ability of policymakers to rebut the offer pertaining to the new model structure, which was presented in this thesis. Furthermore, we tried to briefly consider the possibility that the limits could come from other players and cases.

First, some government ministries, such as the Ministry of Economy and Budget Planning and the Ministry of Justice, can show some disagreement on the new electricity model. Also, the important question is on the opening of a new budget for the single buyer, which should be established as a non-profit organization. Here, some questions are expected to be raised by the Ministry of Finance.

During the creation of the new model strong protests can come from large generators and electricity supply companies operating in the Republic of Kazakhstan. As in the Brazil case, existing generators will be interested to contract with customers in the free market at higher prices than at the auction.

Supply companies are expected to ask about the reduction of their number, and to launch a huge protest, if the Government will try to set a cap on a special levy for supply companies.

The current system operator would not like to split its function and transfer the dispatching to the Government. To continue maximizing its profit, it will try to hold its high position and may dispute the new model.

In our model, a real-time balancing market should be created. Until now, this market could not be established. This is one of the main limitations, of our model, which should be addressed in the near future. All wholesale electricity market operators must participate in the balancing market.

The Customs Union of Belarus, Kazakhstan, and Russia was launched in July 2010, and the Common Economic Space between these countries started functioning on January 1, 2012. In this case, change drivers may be included to align national regulations with Custom Union standards.

Among the common barriers to the development of the new model are an unstable regulatory environment; the maintenance of regulated retail prices for households; and low consumer activity in the energy market.

Chapter 8. Conclusion and Policy Implications

8.1 Conclusion

The main objectives of this thesis were to evaluate the current situation in the electricity sector of Kazakhstan and to develop the new electricity market model. This thesis found the single-buyer model more suitable for Kazakhstan in the short-run. By answering the research question, the thesis intendeds to expand existing research on the electricity market of Kazakhstan and especially to better understand the impact of the power sector on the environment.

The electricity sector evaluation was started using the Divisia decomposition technique. This method was chosen because of its easy, flexible, and clear framework, which incorporates the major structural parameters that might directly or indirectly affect emissions over time. The emission coefficient of power consumption was studied using past data to decompose the emission coefficient into meaningful indicators. The findings of this study indicate the high level of energy intensity in the power sector, mainly due to the generation equipment of power plants and transmission lines. Therefore, it should be noted that significant improvements in energy efficiency are technically possible. The major determinant of carbon emissions is the choice of fuel in the power sector, but the cheapest fuel is still coal.

Investigation of market power in power sector focused on concentration measure suggests that Kazakhstan electricity market is highly concentrated. The model-based analysis of competition in the Kazakhstan electricity market show that the three dominant producers have the potential to exercise market power. At the same time, to date, there is no evidence that the generators have exercised market power. Considering the almost zero competition among power companies because of the price cap, it is difficult to analyze if any participant has exercised market power by withholding capacity. However, there is a high chance that these three companies will manipulate their offer price merely by acting together in the future in case the competitive wholesale market will be introduced.

From the analysis of the strengths, weaknesses, opportunities, and threats of the Kazakhstan's electricity sector a portfolio of actions could be inferred. We considered our findings from this part of the thesis while we were constructing the new electricity market model for Kazakhstan.

Before we created the model, we studied the deregulation process and situation of electricity markets in different parts of the world. It was evident that deregulation of the electricity market has become a global trend. The deregulation was very successful and exemplary in Nordic countries, and the power crisis in California in 2000 highlighted the need to have strong regulatory bodies and a flexible market structure in place before opening a competitive market or it will lead to abuse of market power. This issue shows a good example for Kazakhstan, based on our findings that high concentration in the power market and, introduction of a competitive wholesale market in Kazakhstan in the near future will be risky. Without a deep analysis, the introduction of competition in the electricity market will be risky and disruptive, as seen in Ontario's and Brazil's failed market reforms that led them toward the single-buyer model.

According to our illustrated analysis of the Kazakhstan electricity market and our case studies of electricity markets in the world, the framework of an effective electricity market should be simple and flexible and should appeal to all stakeholders, including the government and policy-makers. It is clear that restructuring of the electricity sector in the future will make, the single-buyer model, presented in the last chapter, more appropriate, as new capacity can be added with more efficient generation units. It was shown that the single-buyer model would offer advantages in terms of simplicity and low cost of capital, while maintaining a competitive environment for investment.

At the same time, the developed model is not claim to be hundred percent accurate and perfect and so it could not be adopted immediately. However, it can serve as the basis for the establishment of an electricity market model in Kazakhstan to achieve the country's main goals. Thus, future work and improvement of this model has a wide scope. The findings from this thesis can be used to analyze the electricity market to create the single-buyer model. Our analysis of international experience clearly showed that the reform process is too risky. In this case, we suggest that reform of the electricity market should only be considered if a clear-cut and obviously better market model is proposed.

8.2 Policy Implications

This dissertation has generated a number of implications, the main ones of which are discussed follows. At the same time the presented ideas are not exhaustive and can be further developed. From our results, it could be stressed that:

- the electricity sector has a high level of energy intensity;
- there is a huge gap between the installed capacity and the actual capacity;
- Kazakhstan's electricity market is highly concentrated; and
- The current market structure in Kazakhstan may not enable the achievement of the main goals of the government policy (to increase investment in the electricity sector, increase power capacity, address environmental impacts, meet future demand, create a mechanism for reliable supply at the least cost etc.).

In this case we suggest that with the correct framework, the electricity market model presented in this thesis will be able to answer the aforementioned questions. At the same time, more efforts are needed before, or in some cases during the creation of the new electricity market model, such as the following:

- The Government should design and adopt an energy plan that will, reflect the need for new capacities. This plan will help create conditions for future auctions to prevent insufficient demand for new connections and insufficient supply from new generation sources.
- Revision of the current legal framework and adoption of new legislation will be required. This legislation would establish not only the power of the single buyer, but also its independence, neutrality, and confidentiality. The

legal framework should show the clear and, transparent mechanism of the new system as well as prevent overlapping of responsibilities and conflicts of interest. Cooperation between market players and the single buyer should be strengthened by means of coordination mechanisms.

- The issue on the financing of the single buyer should be resolved before its creation, to prevent problems and sidestep barriers.
- The absence of a wholesale competitive market in the near future suggests that regulation would still be needed in Kazakhstan for a long time. Thus, the regulator must focus on providing:
  - a single transmission tariff, which should be independent of the geographical distance;
  - control of supply companies' passing through the single buyer by paying the same wholesale price; and
  - inspection of the management and trading of the single buyer.
- Creation of an independent system operator. It is necessary to split the functions of the system operator into from transmission and dispatch. This would ensure that the dispatching of plants is always undertaken based on fair principles.
- A real-time balancing market should be created as soon as possible. All wholesale electricity market operators must participate in the balancing market. Transforming the energy system into a system wherein electricity is mainly generated from fluctuating energy sources such as renewables has very extensive implications. Step-by-step fundamental restructuring of the entire electricity system is required.

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Appendix A

Table A-1: Fuel mix - Coal

ton/ktoe

	1990	1995	2000	2005	2011
Total	3.15	3.23	3.11	3.22	3.40

Table A-2: Fuel mix - Oil

ton/ktoe

	1990	1995	2000	2005	2011
Total	0.33	0.23	0.12	0.10	0.02

Table A-3: Fuel mix - Gas

ton/ktoe

	1990	1995	2000	2005	2011
Total	0.11	0.14	0.28	0.24	0.19

Appendix B

Table B-1: the Divisia Index of emission coefficient

	1990	**1995**	**2000**	**2005**	**2011**
Total	0.0012	0.0012	0.0015	0.0016	0.0016

Table B-2: the Divisia Index for generation mix effect

	1990	**1995**	**2000**	**2005**	**2011**
Total	0.92	0.88	0.85	0.88	0.90

Table B-3: the Divisia Index for auxiliary consumption effect

	1990	**1995**	**2000**	**2005**	**2011**
Total	0.83	0.90	0.94	1.00	0.96

Table B-4: the Divisia Index for effect of changing share of power supply from utilities and non-utilities

	1990	**1995**	**2000**	**2005**	**2011**
Total	1.00	1.00	1.00	1.00	1.00

Table B-5: the Divisia Index for transmission and distribution losses

	1990	**1995**	**2000**	**2005**	**2011**
Total	1.08	1.16	1.15	1.11	1.08

Table B-6: the Divisia Index for energy intensity of power generation

	1990	1995	2000	2005	2011
Total	0.42	0.39	0.47	0.41	0.33

Table B-7: the Divisia Index for fuel mix effect

	1990	1995	2000	2005	2011
Total	3.59	3.60	3.52	3.56	3.62

발췌문

지속 가능한 시장 모델 창출을 위한 카자흐스탄 전기분야에 대한 비교분석

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지난 30 년 동안 미래 경제의 발전과 증가된 사회복지를 목적으로 전기분야에서의 전 세계적인 규제 완화 과정이 진행되어 왔다. 카자흐스탄도 자국 전기분야에 대한 규제 완화를 위해 일련의 중요한 조치를 취했다. 그러나 전 세계의 많은 국가들과 같이 카자흐스탄도 전기시장을 위한 보다 더 효율적인 모델을 적용할 필요가 있다. 그러므로 이 논문은 카자흐스탄 전기시장을 위한 단일구매자(single-buyer) 모델을 기초로 하는 모델의 예비제안 개발을 목적으로 한다. 본 논문에서 새로운 모델을 제안하기 전에 “디비시아 분해 기법”, “시장 지배력 분석 방법”, “허핀달 허쉬만 지수 계산법”, SWOT 분석 및 사례 연구 분석 방법을 사용했다. 시장분석 연구와 현존 시스템들의 결과를

비교하는 노력을 통해 우리는 우리가 자체 고안한 카자흐스탄 전기시장의 모델을 제안한다.

본 연구과정에서 몇몇 약점들을 발견했으며 이 문제들이 해결된다면 배기저감에 기여할 수 있을 것이다. 분석 결과에 의하면 3 개 회사가 에너지 분야 시장의 반 이상을 점유하고 있으며, 따라서 허핀달 허쉬만 지수에 따라 카자흐스탄 에너지 시장은 집중화 시장으로 분류될 수 있을 것이다. 동시에 전기 공급 회사들 사이에 경쟁이 없고 소매시장에서 거래되는 전기가격이 상한가격제로 한정되어 있다. 이런 경우 가까운 장래에 카자흐스탄에서 경쟁력 있는 도매시장을 도입하는 것은 위험할 것이다. 이러한 결론은 카자흐스탄 전기시장의 새로운 모델이 단일구매자 형태에 가까울수록 더 나을 것이라는 것을 보여준다.

키워드: 전기시장 개혁, 경쟁력, 단일구매자, 시장 지배력, 배출 계수

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