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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

AN IMPACT ASESSMENT OF ELECTRICITY GENERATION AND CONSUMPTION ON THE ECONOMY OF THE COUNTRY

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OVERVIEW

Actuality of the subject and review of literature. Sustainable electricity supply and efficient use of energy resources are the areas given importance by the Government of Azerbaijan recently. Fluctuations in the prices of hydrocarbon resources in the domestic and international markets makes the comprehensive study of opportunities necessary for economic generation and consumption of the electricity as being secondary type of energy in the local market. So that, recent increases in the tariffs of electricity and natural fuels in the local market requires efficient consumption of electricity and natural fuels as well as brings up the optimal use of electricity generation capacities.

Along with said issues, the actuality of the research work stipulates the following factors.

Although huge investment is made for creating new electricity generation capacities in Azerbaijan, operation of existing capacities require high costs. On the other hand, there is a need for different assessment of electricity supply and demand of Azerbaijan population and its economy. The optimal use of existing electricity generation capacities and creation of new capacities to meet electricity demand are to be paid attention. It should be noted that the determination and application of the tariffs (prices), that would ensure the economic balance of producers and consumers in the electricity market, can lead to economic efficiency in the power sector.

In this regard, the achievement in efficient use of electricity generation capacities and efficient consumption remains pivotal issues considering the requirements of strategical state documents, including Azerbaijan 2020: “Conception of Future Outlook” and “Strategical Roadmaps for National Economy and main sectors of the economy”.

The assessments made based on the Tariff Differentiation Model, Equilibrium Prices Model and short term forecast of electricity supply and demand developed within the research work and achieved results allow to judge about their actuality from the existing stand of local electricity market in Azerbaijan.

The study of electricity generation and consumption impacts on the country`s economy has theoretical and practical importance for all world countries. The key approaches are reflected in the existing literatures which were referenced in the course of assessment and forecast of electricity supply and demand.

The factors considered in the supply and demand assessment models of the US and Europe include consumer groups of electricity consumption, technological novation, trends in the consumption, social issues, substitutes to electricity, economic growth and electricity generation capacities. Similar systemized ready-made models were widely interpreted in the works of the US and European researchers such as A. Kann, J. Weyant, J. Karjalainen, M. Käkönen, J. Luukkanen, J. Vehmas, T. O'Mahony, P. Hofman, B. Elzen, F. Geels, A. Lipinski, L. Mantzos, P. Capros P., G. Bord, S. Parikh S, B. Chateau, N. Quercia, K. Chen, S. Kung, K. Anderson, M. Plachkov, G. Pollitt, E.Mearns, T. Sorasalmi and etc.

The factors taken in the models for estimating electricity supply and demand in the Asian and former Soviet Union countries were determined to be electricity prices, changes in the number of populations, consumption costs of population, climatic indicators, number of consumers, electricity losses, electricity consumption in the economic sectors and GDP. Similar approaches are met in the works of Russian researchers such as Q. Starkova and Y. Kononov, Turkey researcher Z. Dilaver, Kazakh researcher Z. Atakhanova, Moldov researcher B. Sheet, Iranian researchers R. Nourpanah, N. Ansary and S. Amini.

Governmental and non-governmental institutions are engaged in estimation of supply and demand in the Republic of Azerbaijan, and the factors considered in the estimations are number of population, non-oil GDP, revenues and costs of households, electricity production, consumption indicators, and climatic indicators. In the early 2000s, when reforms were commenced in the Azerbaijan's power sector, most international organizations, particularly World Bank, Asian Development Bank, BP company and USAID carried out comprehensive works related to electricity demand-supply projections. The first steps in the projection of electricity demand by international organizations were taken in the Heating Strategy of Azerbaijan Republic developed within the framework of Azerbaijan Energy Assistance Project funded by USAID. The countrywide heat energy demand was projected in the report, and the demand for electricity was also estimated as an alternate energy used for heating purposes. The suggested explanatory variables in the electricity demand model included the national electricity generation and the number of population, while dependent variable was the national electricity consumption.

The forecast of electricity demand in the state organizations was implemented in the fuel and energy balances of the country being developed annual basis, development programs of fuel and energy complexes, Strategic Roadmap for development of utility services (electricity, heat, water and gas) in the Republic of Azerbaijan.

Serious research work on forecasting of electricity demand in Azerbaijan were carried out by F.Hasanov and J.Mikayilov. The authors built nonlinear econometric model expressing dependency of per capita electricity demand, per capita actual electricity consumption, prices for electricity, real GDP for the non-oil sector, per capita GDP on the number of heating season and use of air conditioning systems.

A number of models were elaborated and the relevant analysis were conducted in terms of demand & supply equilibrium, assessment of spatial spillover impacts and development of projections with various terms, both during the project-specific researches and during the preparation of various state programs, as well as individual researches. Azerbaijani scholars Y.Hasanli, V.Valiyev, M.Mehdiyev, K.Ramazanov, E.Hajizade, I.Mirzaliyev, F.Hasanov and J.Mikayilov carried out researches in this field accordingly.

Key approaches for the market models and market equilibrium of electricity in the existing literature are as follows:

- General equilibrium theory by Leon Walras causes more interest from the objectives of this research work. According to the theory, monetary value of all demand for commodities is equal to monetary value of all supply in the market;

- Practical application of general equilibrium model by Leon Walras was carried out with the use of hypothetical values in the works of Russian researchers L.Tarasevich, P.Grebennikov and A.Leusskinin. Along with equilibrium, differentiation of electricity prices was considered which were studied in the researches of R. Tabors and S. Adamson.

From the point of inter-industry relations of the economy, the following key approaches in the existing literatures with regard to the impact of the changes in the electricity tariffs on the other sectors were reviewed in the research work:

- Equilibrium Tariff Model being a modification of Inter-Industry Balance developed by Vasiliy Leontief is of great importance from the point of objectives of the research work;
- We can refer to the following authors as well who carried out researches in the mentioned areas D. Hooks, K. Reinert, D. Roland-Holst, S. Robinson, A. Cattaneo Taylor, L. Thorbecke, J. Blonigen, A. Bruce, J. Flynn and K. Reinert;

The objective and tasks of the research. The objective of the research work is to build Tariff Differential Model based on the general equilibrium which would allow optimal deployment of existing generation capacities and efficient consumption of electricity in Azerbaijan, impact assessment of electricity tariffs on the economic sectors, development of short term forecasting models of electricity supply and demand. The objective of the research work, is to analyze the economic equilibrium of electricity demand and supply in Azerbaijan considering inter-industry relations of the electricity sector, as well as to assess the electricity demand and supply in the short-run perspective. The following tasks were implemented with the aim to achieve objective of the research work:

- Assessment of electricity supply and demand and to study practices on the market models;
- Analysis of the structure of electricity generations costs;
- Analysis of consumption as per the consumer groups;

- Analysis of the current capacity utilization level at power plants;
- Analysis of demand and supply equilibrium in the electricity sector, and determination of prices that would enable equilibrium between generation and consumption in terms of day and night time;
- Assess the spatial impact of the electricity sector to other industrial sectors;
- Develop a methodology for short-term demand and supply projection for electricity

Theory of Utilitarianism, General Equilibrium and Input-Output models and econometrical techniques were applied as the research methods in the dissertation work.

Research techniques such as mathematical modelling, comparative analysis, synthesis, analysis, graphical descriptions, and functional analysis were applied in the research work.

The main provisions that are presented for defense are:

- Analysis of electricity consumption in Azerbaijan by residential and non-residential consumers and by time of day (day and night).
- Analysis of fixed and variable costs at various types of power plants in Azerbaijan, and assessment of the capacity utilization ratios at these power plants.
- Researches on theoretical and methodological basis of electricity markets, as well as on the current state of Azerbaijan's electricity sector.
- Study the contemporary approaches on electricity demand and supply projections.
- Identification of the factors that affect the electricity demand and supply in Azerbaijan in the short-run.
- Examine the impact of price changes in the electricity sector of Azerbaijan to other industrial sectors.
- Econometric assessment of demand and supply equilibrium matters in the electricity sector of Azerbaijan.

Scientific novelty of research. Following results having scientific novelty were reached in the research work:

- Tariff Differentiation Model was developed for the first time which would equal economic interests of electricity producers and consumers, be based on general economic equilibrium, estimate the electricity generation capacities pertinent to existing demand, calculate the differentiated electricity day and night tariffs, and enable to analyze the efficiency of required investments for new generation capacities;
- Analytical approach based on the Equilibrium Price Model was developed for impact assessment of changes in the electricity tariffs on the price levels in economic activities considering inter-industry relationships and the overall inflation level in the country;
- Short term forecasting models of electricity supply and demand for Azerbaijan were developed.

Theoretical and practical importance of the research.

Theoretical importance of research work ensures provision of new methodological approach for electricity tariff discrimination that would enable optimal use of existing generation capacities based on the economic equilibrium, and impact assessment of changes in the electricity tariffs on economic activities and forecasting of electricity supply and demand.

Practical importance of research work is application of its results in adoption of tariff policy, especially in differentiation of tariffs, its wide scale application in adoption of policy decisions towards the optimization of existing production costs on the electricity generation, and identification of amount of investment in creation of new generation capacities, and forecasting of electricity.

The outcomes of the research work achieved in the course of its development were deployed in the studies related with electricity performed by Scientific Research Institute for Economic Reforms under Ministry of Economy.

Methodological approaches proposed within the research work could be deployed by specialists carrying out the researches in the electricity market of Azerbaijan and by the respective state institutions for taking policy decisions on electricity supply, demand and tariffs.

Approbation and application of the research work. The outcomes of the research works were reported in the following conferences:

- Azərbaycan Texniki Universitetinin 70 illik yubileyinə həsr olunmuş "Dördüncü sənaye inqilabının texnoloji perspektivləri: sənaye interneti, kiberfiziki sistemləri və intellektual texnologiyalar" mövzusunda keçirilən Respublika elmi-texniki konfransı, 24-26 noyabr, 2020, Bakı, Azərbaycan
- 5th International Conference on "Lifelong Education and Leadership for All", July 9-11, 2019, Baku, Azerbaijan
- 4th Eurasian Conference of the International Association for Energy Economics on "Energy Resources of the Caspian and Central Asia: Regional and Global Outlook", 17-19 October 2019, Nur-Sultan, Kazakhstan
- 3rd Eurasian Conference of the International Association for Energy Economics on "Implications of Global Developments within the Energy Industry in the Caspian and Central Asian Region", October 18-20, 2018, Baku, Azerbaijan
- Экономика и Управление: Проблемы, Тенденции, Перспективы Развития, Сборник материалов V Международной научно-практической конференции, Центр научного сотрудни-чества «Интерактив плюс», 2017, г. Чебоксары
- Экономическая Наука Сегодня: Теория и Практика, Сборник материалов
- V Международной научно-практической конференции, Центр научного сотрудничества «Интерактив плюс», 2016, г. Чебоксары.

Ten articles and tow theses encompassing the content of the dissertation work were published, including four articles published in the foreign countries.

Organization where the dissertation work was implemented. The Scientific Research Institute for Economic Reforms under Ministry of Economy of Azerbaijan Republic.

Scope of the dissertation paper. The dissertation work consists of 172 pages, including Introduction (15988 characters), three chapters (Chapter I – 50572 characters, Chapter II – 65511 characters, Chapter III – 30533 characters), Conclusion (2643 characters), 10 figures, 14 charts and the bibliography with 102 references. The total volume of the dissertation paper is 167243 characters.

The content of Dissertation paper

OVERVIEW OF CONTENT OF DISSERTATION PAPER

Actuality of the topic is justified, the level of study of the issue, objectives and tasks, key provisions presented for defend, theoretical and methodological basis and techniques, scientific novelty and practical importance are provided in the **Introduction chapter**.

The market models for electricity supply and demand and theoretical and methodological basis for forecast of electricity supply and demand were studied in the first chapter of dissertation work with the title of **"THEORETICAL AND METHODOLOGICAL BASIS OF REGULATION OF ELECTRICITY SUPPLY AND DEMAND"**.

Theoretical basis existing in the scientific literature related with modelling of the electricity markets were studied, as well as factors stipulating the equilibrium were reviewed. From the objective of the dissertation work, empirical application of "General Equilibrium" theory by Sweden economist Leon Walras, being the head of Lausanne school of marginalism, at the same time, Theory of Utilitarianism and Production Functions were proposed be deployed in the sample of electricity market.

Theoretical and methodological basis of forecasting electricity supply and demand were studied. Various scenario approaches being applied in forecasting of electricity supply and demand, factors to be taken in forecasting of the electricity supply and demand, as well as peculiarities of the ready-made models that were deployed in forecast of electricity demand were reviewed. Typical peculiarities of forecasting electricity demand applied in the US, Europe, Turkey, former USSRs, as well as Azerbaijan, and key influencing factors applied in prognoses were studied accordingly.

The first chapter also reviews the current situation of electricity market in the Republic of Azerbaijan and peculiarities of the market regulation. Regulation of electricity markets was explained in terms of their understanding in one European, one Asian and in one former USSR countries as samples.

Appropriate factors causing electricity supply and demand equilibrium in Azerbaijan were analyzed in the second chapter of the dissertation work with the title of **“DEVELOPMENT OF TARIFF DIFFERENTIATION MODEL OF ELECTRICTY”**, first of all, including:

- There is a payback issues with regards to investments made on creation of new generation capacities.
- The fuel supplied to electric power engineering sector for electricity generation purposes is discounted in comparison with world fuel prices listed in the world markets, thus, meaning that the sector still receives state subsidies.
- Use of subsidized fuel in electricity generation does not generate incentives for saving.
- Although improvements in the metering systems of the residential customers lead to efficient use of electricity in last ten years, energy efficiency potential in the non-residential consumers remain huge.

Thus, the development of Tariff Differentiation Model based on the general equilibrium on the electricity was proved to be important on the point of equilibrium of supply and demand in the electricity market, optimization of electricity production costs, efficient use of production capacities, and estimating maximum beneficial utilization of opportunities by all the categories of customers.

The following methodological provisions was mainly referred in the course of development of Equilibrium Tariff Differentiation Model:

- There is one electricity generation field and this field is engaged in generation of electricity for residential and non-residential customer groups. In other words, this field has two products: electricity that is produced and consumed during a daytime, and electricity that is produced and consumed during a night time.

- There are two customer groups –residential and non-residential. Each of these groups purchases electricity with specific tariffs designated to them. The amount of fixed and variable costs and values of fixed and variable costs per one kilowatt hour electricity are predetermined.

Pursuing the methodological provisions enables to achieve the below mentioned goals – Which tariffs should be assigned to electricity being produced during daytime and nighttime in order electricity generation site could obtain maximum profit with minimum costs and accordingly, customers could consume more electricity with the least costs. Here, the main task is to find values for the resources (expenditures) consumed for the electricity being produced during daytimes and night times, and to find the values of electricity tariffs consumed during the daytime and night-time that would yield equilibrium.

Appropriate mathematical model was developed for resolution of mentioned question within the research work and as there were discrimination in the tariffs and the models to be built would define different tariffs, the model was named as "Tariff Differentiation Model", conditionally. Various scalers, parameters, variables and equations were used in the mentioned model. As the form of mathematical operations to be carried out in the process of identifying dependencies for the night and day stages have similar character, the following symbols and vector notations were accepted:
d – day; n – night; r – residential; u – non-residential; V – variable costs; F – fixed costs
In this case, conditional vector notations for the production of electricity and residential and non-residential consumer (usefulness) functions were as follows: $Q = (Q_d, Q_n), a = (a_d, a_n), \alpha = (\alpha_d, \alpha_n), \beta = (\beta_d, \beta_n), V = (V_d, V_n), F = (F_d, F_n),\ U = (U_r, U_u), b = (b_r, b_u), \gamma_d = (\gamma_{dr}, \gamma_{du}), \gamma_n = (\gamma_{nr}, \gamma_{nu}), Q_d = (Q_{dr}, Q_{du}), Q_n = (Q_{nr}, Q_{nu}), c = (c_r, c_u), e = (e_r, e_u)$

Where Q is the value of production, U is the value of consumption (utility). The scalers, parameters and variables used in the developed equilibrium model are the followings: V_0- total variable costs incurred in electricity production (in AZN); F_0- total fixed costs incurred in electricity production (in AZN); V_d- variable costs incurred during daytime in electricity production (in AZN); V_n- variable costs incurred during night-time in electricity production (in AZN); F_d- fixed costs incurred during daytime in electricity production (in AZN); F_n- fixed costs incurred during night-time in electricity production (in AZN); v – price level of variable costs per one kilowatt hour electricity; f – price level of fixed costs per one kilowatt hour electricity; p_d – price level of 1 kWh electricity sold during the daytime of a day; p_n- price level of 1 kWh electricity sold during the night time of a day; α_d- power of daytime variable costs relevant to daytime electricity production function (elasticity factor); β_d- power of daytime fixed costs relevant to daytime production function (elasticity factor); a_d- efficiency factor in daytime production function; α_n- power of night-time variable costs relevant to night-time production function (elasticity factor); β_n- power of night-time fixed costs spent relevant to night-time production function (elasticity factor); a_n- efficiency factor in night-time production function; γ_{nr} – power of night-time consumption in the utility function for the residential consumers (elasticity factor); γ_{dr} – power of daytime consumption in the utility function for the residential consumers (elasticity factor); γ_{nu} – power of night-time consumption in the utility function for the non-residential consumers (elasticity factor); γ_{du} – power of daytime consumption in the utility function for the non-residential consumers (elasticity factor); b_u – efficiency factor in the utility function for non-residential consumers; b_r – efficiency factor in the utility function for the residential consumers; δ_r –weight of profit obtained from the sales of electricity to residential consumers; δ_u – weight of profit obtained from the electricity sales to non-residential consumers; c_r – variable costs per the residential consumers; c_u – variable costs per the non-residential consumers; e_r – fixed costs per the residential consumers; e_u – fixed costs per the non-residential consumers.

V_0 and F_0 are scaler values, v, f, p_d, p_n are unknowns to be determined through the deployment of the model, the remaining is the factors and parameters to be calculated empirically among the above mentioned.

As a first step, Cobb–Douglas General Production Function (Producer Behavior Function) was compiled for the electricity generation:

$$Q = a \cdot V^{\alpha} \cdot F^{\beta}$$

General Consumption or Utility Function of consumers (both residential and non-residential) were established as followings:

$$U = b \cdot \bar{Q}_d^{\gamma_d} \cdot \bar{Q}_n^{\gamma_n}$$

Total fixed and total variable costs are known in advance and denote general electricity production costs. As the electricity is the commodity being produced uninterruptedly during a day, subdividing the costs into night and day times from the equilibrium model point of view is possible. As the objective of the research work was to find equilibrium point that would ensure maximum profitability of the electricity generation sector and consumers maximum benefitting from the consumption of electricity and to find day and night production prices (tariffs) that would yield equilibrium position, electricity production was assumed to be equal to consumption and the following system of equations is achieved. In other word, the condition for assumed equilibrium should be as followings, i.e. production of electricity is taken equal to consumption:

$$\begin{cases} V_d + V_n = V_0 \\ F_d + F_n = F_0 \\ \breve{Q}_{dr} + \breve{Q}_{du} = \breve{Q}_d = Q_d \\ \breve{Q}_{nr} + \breve{Q}_{nu} = \breve{Q}_n = Q_n \end{cases}$$

Where,

$\breve{Q}_d$- value of electricity consumed during the daytime of a day;

$\breve{Q}_n$- value of the electricity consumed during the night-time of a day;

$\breve{Q}_{dr}$- value of the electricity consumed by the residential consumers during daytime;

$\breve{Q}_{nr}$- value of the electricity consumed by the residential consumers during the night-time;

$\breve{Q}_{du}$- value of the electricity consumed by the non-residential consumers during the daytime;

$\breve{Q}_{nu}$- value of the electricity consumed by the non-residential consumers during the night time.

Furthermore, each parameter indicated in the system of equations is denoted with variables through the use of appropriate conversions. The scaler values in the system of equations is derived from the existing data, the variables p_d, p_n, v, and f is attempted to be found with resolution of the question. The parameters were calculated through the realization in `Eviews 7` software package by using respective database based on the data in 2018 year.

The system of equation developed with the use of Tariff Differentiation Model, as well as collected and calculated parameters were included into GAMS program package and is attempted to resolve the equation. The task was to find values of the variables which would ensure difference between right and left sides of the equation to minimum, close to 0. But resolution of the equation system was failed to find. Lack of resolution of the system of equation established for the electricity market in Azerbaijan for the Tariff Differentiation Model implies lack of equilibrium in this market within the existing conditions. As a result, certain points were brought to attention for the electricity market of the country.

- Huge amount of fixed costs in the electricity production of Azerbaijan implies that investment in the power generation capacities made last 15 years were not fully studied for meeting future electricity demand in Azerbaijan;
- With existence of single electricity tariffs which put preference for the consumers to consume electricity mostly during the daytime, fixed costs of the power plants prevails in the

production costs. In the night-time when the demand is low, the fixed costs are the only costs for maintaining capacities in the power plants. In other words, with the lack of night tariffs, with no incentives to consume electricity during the night-time, there is no incentives for optimal exploitation of generation capacities in the power plants.

Other analysis related to the costs were made by the author for empirical verification of the mentioned points. The aim of the analysis was to identify how well the costs were covered with the state regulated tariffs and to identify the level of tariffs that would ensure normal level of profitability for the generation companies.

Marginal analysis were performed for the power plants. The source of information was database compiled for the Tariff Differentiation Model. It was concluded based on the results of the analysis that the installed capacity for the system was much higher than the electricity demand. The perspective of increasing the capacities do not seem real and there is no need for additional capacities for meeting the forecasted volume of demand, i.e., it is possible to meet demand for the near future with the efficient use of existing capacities by avoiding creating new capacities. In general, realization of the proposed model is attempted in Azerbaijan market condition with lack of free competition. Although the model has no resolution for Azerbaijan market, it could be applied to any electricity market as a universal analytical tool.

Impacts of electricity tariff changes on the price changes in other sectors of the economy in Azerbaijan were studied in the third chapter of the dissertation work with the title of **IMPACT ASSESSMENT OF ELECTRICITY TARIFFS ON COUNTRY ECONOMY AND FORECASTING SUPPLY AND DEMAND**.

Equilibrium Prices Model is the attachment of the Input-Output and or Inter-Industry Balance Model by Leontief. The following denominations is accepted in the Input-output model as it is:

A – direct costs matrix,

$\bar{x} = (x_1, x_2, ..., x_n)$ - general output vector,

$\bar{p} = (p_1, p_2, ..., p_n)$ - prices vector,

P_i- i-ci price for a single product of the sector and or price index,

$p_i x_1$- i-ci output of the sector as value.

It is possible to forecast the prices of the products for each sector by knowing the value added norm in the equilibrium prices model. The model allows to identify impact of price changes in one sector on the prices of other sectors, as well as inflation.

$$\bar{p} = (I - A^T)^{-1}\bar{v}$$

Where, $(I - A^T)^{-1}$ – is the transposed matrix of complete costs.

Equilibrium prices model equations has three resolution options in resolution of practical questions:

1. Direct cost factors, thus, $(I - A^T)^{-1}$ inverse matrix is known, added value norms of the sector $V = (V_1, V_2, ..., V_n)$ is known. Equilibrium prices of the sector $P = (P_1, P_2, ..., P_n)$ is found.
2. $(I - A^T)^{-1}$ matrix and $P = (P_1, P_2, ..., P_n)$ is known. Added values norms for the sectors are found: $P = (P_1, P_2, ..., P_n)$
3. $(I - A^T)^{-1}$ matrix and added value norms of some sectors $V = (V_1, V_2, ..., V_k)$ (k<n), prices of products of the remaining parts $P = (P_1, P_2, ..., P_n)$ (k<n) is known. Unknown parts of added value norms and prices of products are found, i.e., V_{k+1}, V_{k+2},...., V_m and $P_1, P_2, ..., P_k$ variables are found.

Tariff changes in the sectors were assessed based on the third option by building the respective simulation model.

However, as it was uncertain how the economic agents will behave while deploying the model, the following assumptions were accepted while reviewing the tariffs:

1. Economic agents agree to work with new electricity tariffs for the intermediate products while reviewing the tariffs.
2. Changes in the prices of the other intermediate products are conditioned only by the changes in indicated tariffs.
3. Changes in the norms of the value added are conditioned by only changes in revised tariffs.

4. All the other behaviors of the economic agents are stable, they adjust their prices only as per the changes in the tariffs to maintain their previous economic positions and new incomes.

In the following phase, impacts of price changes in 96 economic sectors with respective 10%, 20% and 30% electricity tariff increases was assessed with deployment of Equilibrium Prices Model based on real indicators of the Inter-Industry Balance. In each scenario of changes in electricity tariffs, the ten areas with the highest price changes are ranked. The results of the compiled ranking are given in Table 1.

Table 1

The ranking of ten economic fields mostly exposed to price changes in the 10, 20 and 30 percent increase scenario of electricity tariffs using Equilibrium Price Model

10 economic fields mostly exposed to tariff increase	Electricity tariffs increase scenarios		
	10%	20%	30%
Metal ores	2.77%	5.54%	8.31%
Paper and paper products	2.07%	4.17%	6.27%
Rubber and plastic products	1.07%	2.16%	3.24%
Glass and glass products	0.94%	1.88%	2.82%
Refractory products	0.90%	1.80%	2.70%
Other porcelain and pottery	0.73%	1.46%	2.18%
Other pre-processed steel products	0.68%	1.36%	2.04%
Metal casting services	0.61%	1.22%	1.83%
Electric equipment and other spare parts	0.59%	1.18%	1.77%
Payment for natural water, water treatment and supply	0.57%	1.15%	1.73%
Genera inflation level	0.20%	0.42%	0.64%

As can be seen, the 10% increase in electricity tariffs leads to almost insignificant changes in other areas, and a 0.2% increase in the overall inflation rate in the country. In other simulation cases, when electricity tariffs are increased by 20% and 30%, the level of price increase in these 10 economic activities increases, and the overall inflation rate in the country increases by 0.42% and 0.64%, respectively. This indicates the high share of electricity costs in production and services in these areas and the sensitivity to significant increases in electricity tariffs. Of course, the 20% and 30% increase in electricity tariffs for economic activities is considered serious, and ultimately increases the value of products and services. This is due to the introduction of only one type of electricity tariff in economic activities. On the other hand, this raises the issue of efficient use of electricity. Stimulation of efficient use of electricity, in turn, can be provided mainly through price measures. The application of different tariff levels per day in economic activities (day and night tariffs) or tariff levels based on the amount of consumption (increase in tariffs as consumption increases) can stimulate savings in electricity consumption.

In this context, it is important to calculate the reasonable forecast prices of supply and demand for electricity for the implementation of the Tariff Differentiation Model in the electricity sector in Azerbaijan. Electricity supply and demand in Azerbaijan during 2020-2023 was forecasted in this regard.

Consumption of residential and non-residential sectors was reviewed as a factors of impact on electricity demand, first of all. The changes in the number of Population was referred as indicator of residential sector, and General Output in the National Accounts Systems was referred as indicator of the non-residential sector. Furthermore, dependence of electricity demand on the number of population and general output was evaluated econometrically in the `Eviews 7` software package. During the evaluation process, the cost of electricity, gas and steam`s generation, distribution and supply is subtracted from the general output. Time span is taken as 2009-2019 years. The following model is reached in evaluation of dependency of electricity consumption (demand) on the number of population and general output:

*LOG(ELEKTR_OLKE_TEL)=3.7*LOG(EHALİ_SAY)+0.02*LOG(UB_ENERJİSİZ) – 36.19*

R-squared: 0.873154
Adjusted R-squared: 0.836912
Durbin-Watson stat.: 0.780798

Generally, following the estimation of “Durbin-Watson” criteria, d_l and d_u are identified based on “Durbin-Watson” significance table. In the case of above model, d_l and d_u are 0.466 and 1.333 accordingly. With these values, it is hard to make a decision on autocorrelation among variables, however, high value of R-squared implies the adequacy of the model.

Here, as could be seen, electricity consumption is mostly dependent on the number of population. In other words, 1 % increase in the number of population causes 3.7% increase in electricity demand. Therefore, the most influencing factor on the demand is change in the number of population.

The data on General Output of for Azerbaijan was compiled based on the Resource Use Tables of Products and Services of the State Statistics Committee and on the inter-industry balance tables of the products and services.

As the mentioned model indicates dependency of electricity demand on the number of population and general output only for the given time period, forecast of independent variables need to be provided for the purpose of its forecasting. To this end, dynamics of the number of population and value of general output covering 2009-2019 years in Eviews software package was identified to be linear dependency.

Number of population for 2020, 2021, 2022 and 2023 is forecasted to be 10.13, 10.24, 10.35 and 10.47 million respectively through the application of linear dependency formula obtained for the number of population $y = 111806 * x + 8789398$.

General Output for 2020, 2021, 2022 and 2023 is forecasted to be 116857, 122790, 128723 and 134656 million Manats respectively through the application of linear dependency obtained for the value of general output $y = 5933 * x + 45661$.

In the following stage, forecasted values for the number of population and value of General Output for 2020 and 2023 years were inserted into the columns of the database used in the Eviews 7 program package. Electricity consumption as being the dependent variable based on the forecast values of independent variables for 2020-2023 was forecasted in the Eviews software package through logarithmic dependency mentioned above for the respective years.

Based on the forecast results, electricity demand for 2020, 2021, 2022 and 2023 years is expected to be 20.6, 21.4, 22.3 and 23.3 gigawatt-hours, respectively.

Since the electric power sector was in close relationship with other economic sectors, impact of other economic sectors on the output of power sector was studied. To this end, dependency of electricity production on the Intermediate Consumption and Final Consumption Costs of the other economic sectors was reviewed and this dependency is evaluated in Eviews 7 software package.

*LOG(ELEKTRİK_İSTEHSAL) = 0.71*LOG(ARALIQ_ISTEHLAK) – 0.28*LOG(SON_ISTEHLAK) + 19.55*

R-squared: 0.905339
Adjusted R-squared: 0.878293
Durbin-Watson stat.: 1.532867

Similar to above case, d_l and d_u are the same, i.e. 466 and 1.333. The derived “Durbin-Watson” criteria value (1.532867) indicates that there are no autocorrelation among and together with high R-squared it implies the adequacy of the model.

As seen from the model, electricity production is mostly dependent on Intermediate Consumption, i.e., 1% increase in Intermediate Consumption increases electricity production in 0.71%.

As in estimation of electricity demand, as the given model shows only dependency of the demand on the intermediate consumption and final consumption for the period of 2009-2019, forecast of independent variables need to be predefined, firstly for performing its forecasting. Trend for the Intermediate Consumption and Final Consumption during 2009-2019 years was defined to be as linear dependent, as in estimation of demand.

Intermediate consumption costs was forecasted to be 41430, 43758, 46086 and 48414 million Manats for 2020, 2021, 2022 and 2023 years respectively based on the linear dependency $y = 2328 * x + 13494$ obtained for the intermediate consumption costs.

Final Consumption costs was forecasted to be 58142, 61887, 65632 and 69337 million Manats for 2020, 2021, 2022 and 2023 respectively based on the linear dependency $y = 3745 * x + 13202$obtained on the final consumption costs.

2020-2023 years forecast indicators for the Intermediate Consumption and Final Consumption cost was inserted in the columns of the database used in Eviews 7 software packages. Electricity production as being dependent variable was forecasted for the respective years through the use of logarithmic dependency mentioned above in Eviews software package based on forecast values of independent variables for 2020-2023 years.

According to the results of the forecast, electricity supply (production) for 2020, 2021, 2022 and 2023 is expected to be 27.2, 27.8, 28.3 and 28.9, respectively. As could be seen, supply exceeds the demand by 32% in 2020, 30% in 20201, 27% in 2022 and 24% in 2022.

Main conclusions and recommendations are the followings:

1. Tariff Differentiation Model was developed based on the equilibrium of supply and demand in electricity market which enables the (i) calculation of differentiated daytime and night-time electricity tariffs in the electricity market, (ii) determination of optimal electricity generation capacities relevant to the existing consumption level (iii) optimization of existing electricity production costs and estimation of investment required for creating new generation capacities and resolution of other questions. The Model was resolved using complex equation system. Despite the

lack of solution for the Azerbaijani case, model can be applied to electricity market of any country as a common analytical tool [5, 7, 12].

2. An impact assessment of electricity tariff changes on the other sectors of the economy and impact assessment on inflation level for the whole country was conducted based on the Equilibrium Prices Model of Inter-Industry Balance. Impact analysis proves that increase in electricity tariffs has insignificant impact on the non-oil sector, especially on food and process industry The introduction of night and day tariffs for all areas of economic activity or a flexible tariff system based on the amount of consumption can prevent sharp fluctuations in the prices of products and services produced by enterprises. the proposed Tariff Differentiation Model can be used in this direction from this point of view of reducing the impact of the increase in electricity tariffs on the country's economy as a whole [1, 4, 8, 10].
3. An econometric forecast model of electricity supply and demand was developed by analyzing the factors affecting the production and consumption of electricity. These models allow for short- and medium-term forecast assessments of the electricity market. Forecast estimates for the country show that supply exceeds demand by 2023 [2, 3, 6, 8, 11].
4. A methodological approach was developed for efficient use of existing capacities, system development, tariff regulation by consumer groups, electricity in general and for to the formation of a regulatory environment in the electricity sector, on the basis of econometric analysis of the structure of fixed and variable costs of electricity generation at power plants, as well as night and day consumption of population and non-population consumers [9]. The proposed approach could be applied by Azerenerji JSC, engaged in electricity generation and wholesales, and for Azerishiq JSC, engaged in retail sales of electricity from the point of optimization of the costs of the state enterprises.
5. The proposed analytical tool related with impact assessment of changes in electricity tariffs on other economic sectors through

Tariff Differentiation Model and Equilibrium Prices Model of Inter-Industry Balance could be applied by Tariff Council of Azerbaijan Republic and Azerbaijan Energy Regulatory Agency which carry out regulation of market and tariffs in the electricity sector.

The following scientific articles and thesis were published dedicated on the key scientific outcomes of the dissertation work:

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