# Simulation and Economic Impact Evaluation of Ukrainian Electricity Market Tariff Policy Shift

*Maksym Chepeliev*
*Institute for Economics and Forecasting, Ukrainian National Academy of Sciences*

## Summary

Among all types of economic activities in Ukraine the power industry is the only one that utilizes cross subsidization mechanisms. Electricity tariffs for the residential consumers are set far below the estimated retail level, while industrial consumers have to pay higher prices in order to compensate for these costs. In 2012 electricity consumption subsidies exceeded 31 billion UAH, which is over 8,7% of Central government budget and 2,3% of Ukraine's GDP.

In this study a static computable general equilibrium model with heterogeneous households is applied to investigate distributional and poverty-related effects of price reform in the electricity sector of Ukraine, considering 30%, 50% and 100% subsidies elimination. In addition, different compensating mechanisms for various households' groups are studied. In particular, direct transfers from Central government budget, partial preservation of cross-subsidization and compensation through increase of taxes on production and import of goods and services.

The results indicate that essential positive effects from subsidies elimination – lower production costs, output gain and investment intensification are seen, mostly by industrial activities. The highest growth rates are observed for those industries that not only actively consume electricity but also energy intensive goods and services. Regardless of the nature of implemented compensation mechanisms, the decrease in cross-subsidization leads to investments growth: for some scenarios up to 18 billion UAH. At the same time, residential consumers suffer with poor households loosing relatively more than rich.

In this context, according to the investigated scenarios, the most appropriate compensatory option is partial preservation of cross subsidization. This approach bears no additional burden on the Government budget and does not require

significant regulatory changes. However, given the specific nature of this concept, it should be used only in the case of 30% subsidies reduction.

In general, key positive effects of cross-subsidization reduction come from the production costs decrease, manufacturing capacity rise and investments volumes increase in the real sector of Ukrainian economy.

**Key words:** electricity subsidies, reforming, socio-economic consequences, compensating mechanisms, computable general equilibrium model.

**JEL classification:** D58, Q43, Q48.

## Introduction

In the process of subsidization[1] the government has to coordinate a wide variety of criterions and performance targets, considering social, economic and environmental issues. As a result, authorities often face difficult and ambiguous choices with uncertain consequences.

The situation is complicated even more by the fact that some questions on micro and macro level do not have unique "right" answers. For example, whether government should partially neglect income distribution issue in order to maximize economic growth rate? Or what is the balance between environmental and economic components: health care, emission reduction, green energy promotion, cost reduction, competitiveness, energy independence and domestic producers support? Answers probably depend more on the individual value system than on the pure economic principles.

Often, the situation is further complicated by disaggregation issue. While in many cases estimated aggregate monetary loss, resulting from subsidization, may exceed profit (IEA, 1999), evaluation of expected utility shifts distribution among economic agents remains the most challenging task. In this sense, a misleading assessment may lead to the unexpected social reaction. As an example, two recent cases can be considered: resign of Bulgarian government, induced by 18% electricity price increase, and paralyzing streets protests in Brazil due to the bus fare increase by 7 eurocents, which continued even after the fare increase was revoked (The Economist, 2013a, 2013b; Bloomberg, 2013).

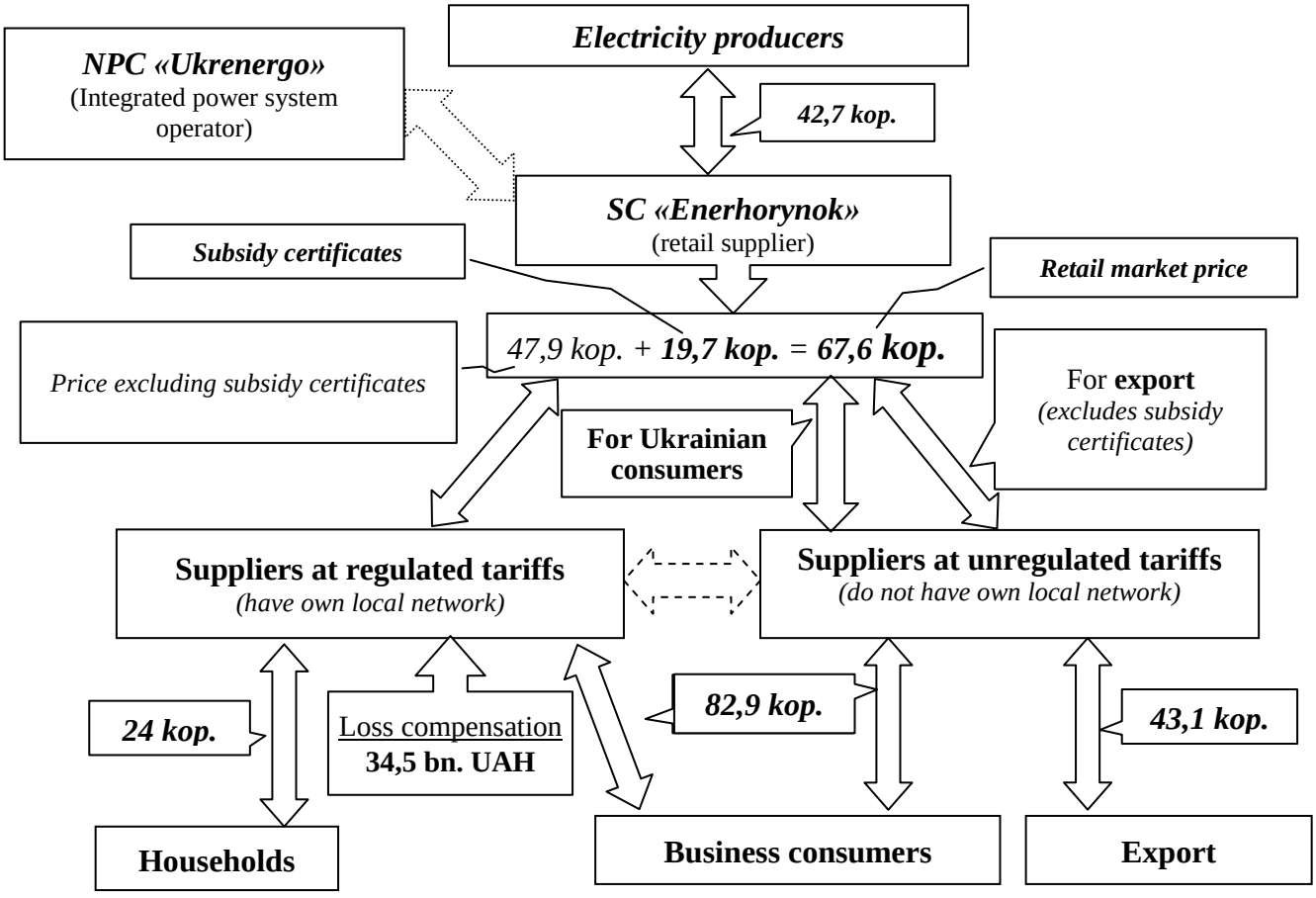
Although aforementioned considerations complicate revision of existing consumer and producer support measures, they do not reduce the relevance of their systematic analysis. In this context, wide range of social and economic aspects of Ukrainian electricity tariff reform remain to be clarified. Particularly, further research has to be done to clarify consequences for different groups of economic agents and

[1] As long as there is no conventional definition of term "subsidy", we would not discuss here disadvantages and benefits of different approaches, but consider the one adopted from (Moor and Calamai, 1997). **Subsidy** is any measure that keeps prices for consumers below the market level or keeps prices for producers above the market level, or that reduces costs for consumers and producers by giving direct or indirect support.

analyze effective compensatory mechanisms for poor households. Existing papers consider these issues in rather bounded context, do not account for specific features of existing cross-subsidization scheme and sidestep a problem of reform implementation in a socially acceptable way (Ogarenko and Hubacek, 2013).

## Electricity subsidies

Among all types of economic activities in Ukraine, only power industry utilizes mechanism of cross-subsidization, which arises due to the tariff setting for residential consumers being far below the estimated retail level. At the same time, costs compensation for the electricity consumed by households is performed through setting artificially high tariffs for business users (see Figure 1).




Prices for 1 KW-h excluding VAT (2012).

| | |
|---|---|
| ⟺ | Electricity charge |
| ⟺ | Local networks transit charge |
| ⟺ | Scheduling and high-voltage power grids transmission charge |

**Figure 1. Ukrainian electricity market scheme**
Source: SC "Enerhorynok", SSSU and NERC.

In recent years, electricity production costs and consumption volumes have been rising, while tariff for residential users remain unchanged, as a result subsidy certificates payments exceeded 8,7% of Government budget in 2012 (see Figure 2). Over 2005-2012 real electricity subsidy volumes quadrupled.

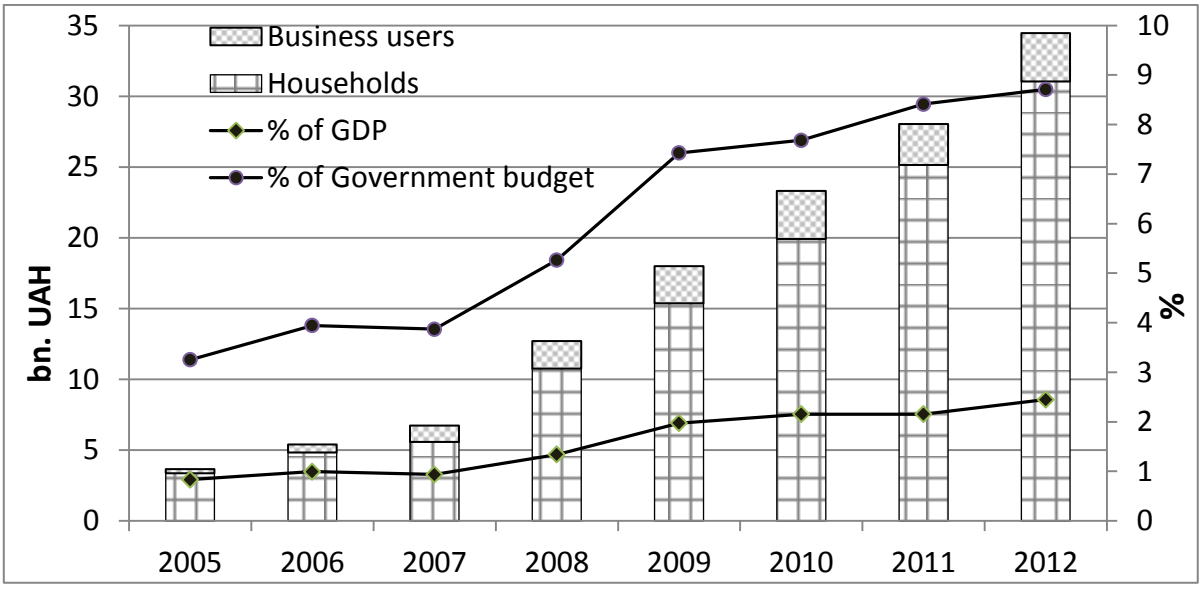



**Figure 2. Electricity subsidies volumes**[2]

Source: SSSU, NERC and National Bank of Ukraine.

In these circumstances, households electricity expenditure share reduced from 3% in 2000 to 1,4% in 2012 (NERC; SSSU, 2013). Naturally, subsidies increase was not the only factor for the aforementioned reduction, equally important issue was households' purchasing power rise: 4,2 times over 2000-2012 period (SSSU). Over the same period nominal wages rose 13 times, while electricity tariffs for residential users only doubled. As a result, currently Ukrainian households' electricity expenditure share is half as high as the average for the EU-27 rate, three times less than share of spending for Croatia and Czech Republic and only 25% of Slovak households' expenditure rate (see Figure 3). Even taking into account cross-country electricity consumption volumes difference, for instance, per capita electricity consumption in Slovenia is 3 times higher than in Romania and 2,1 times more than

[2] Subsidized business users include consumers that are charged with tariffs differentiated by time period, urban electric transport, mining companies, child centers "Artek" and "Moloda hvardiia", enterprises engaged in innovative projects and customers that receive electricity for residential outdoor lighting.

in Ukraine, domestic residential consumers also have significant advantages considering purchasing power parity (see Figure 3).

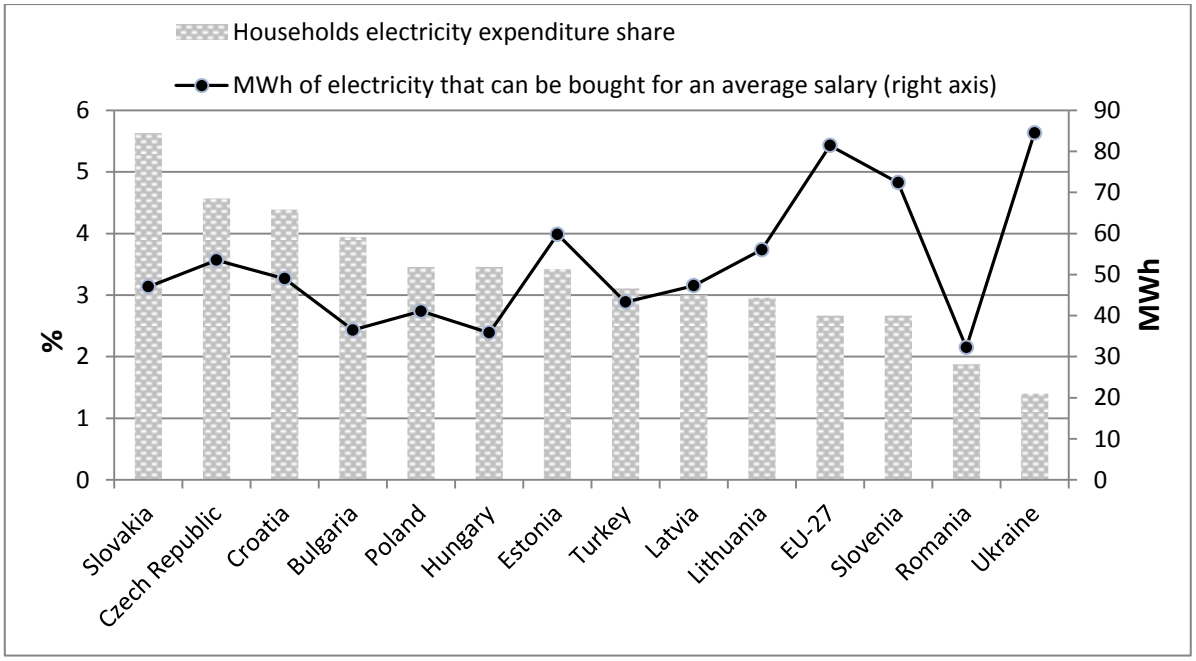



**Figure 3. Households electricity expenditure share (2012)**
Source: NERC and SSSU (2013).

Thus, in Ukraine the average salary can buy 1,2-2,6 times more electricity than in Central and Eastern European countries, while general purchasing power level is 2,1-3,6 times lower. This indicates existence of substantial pricing mechanisms imbalances and distortions considering electricity and other consumer goods, which only amplifies drawbacks of current cross-subsidization mechanisms. In addition, for businesses discrimination through overcharged tariffs hinder market competition, contribute to inefficient resources allocation, structural reforms deceleration, lead to adverse environmental effects, reduce investments attractiveness and encourage entrepreneurs to non-productive activities

Despite a declared social focus, the existing subsidization system is discriminative against financially disadvantaged citizens. In particular 2nd income decile households receive 35% less subsidies than consumers from 10th decile (see Figure 4)

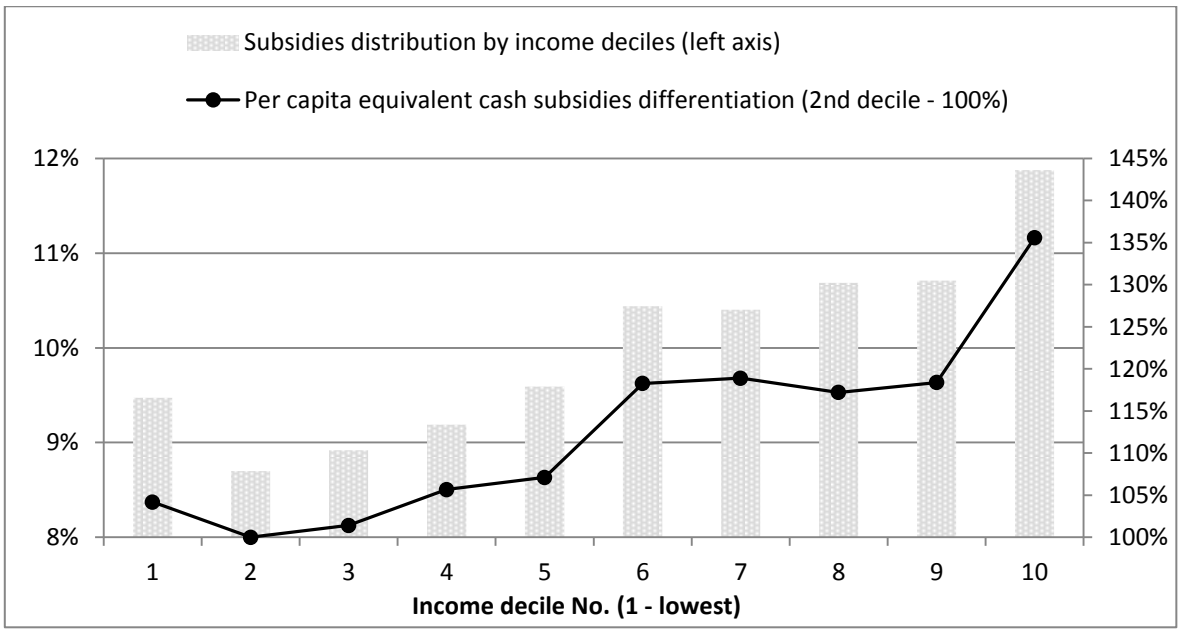



**Figure 4. Electricity subsidies distribution by income deciles**

Source: SSSU (2012), Households' survey, Mehovich (2011, 2012), NERC (2009, 2011a, 2011b, 2011c)[3]

Notwithstanding the emphasis of leading international institutions (IMF, IEA, World Bank) on the urgency of electricity tariff adjustment to an economically justified level for different consumer categories and corresponding requirements of "EU-Ukraine Association Agenda to prepare and facilitate the implementation of the Association Agreement" currently no active supporting measures are being undertaken.

On October 24th 2013 the Parliament of Ukraine has adopted the Law of Ukraine No 663-VII "On Basic Principles of the Electricity Market Functioning".

[3] Calculations based on 2011 data.

Equalized disposable income per capita calculation is based on the existence of households' semi-fixed costs (accommodation payments, energy fees, durables purchase etc.), which leads to some savings depending on household's size. Methodologically, this approach is based on the equivalence scale that is used in the national poverty investigation practice. Within this method, a weight 1,0 is given to the first adult, while other household's members receive weight 0,7 (SSSU, 2012). According to the processed data for the year 2011, per capita equivalent general income (per month) was 841 UAH for the I-st decile households and 4021 UAH for the X-th decile. While the highest rate for the whole data sample was 21757 UAH.

Realistic (economically feasible) electricity tariff for households was assumed to be 1,01 UAH (excl. VAT) per KWh (NERC, 2011a).

To calculate the electricity consumption volumes for households from the sample, we assumed that electricity monthly usage history for every individual household is in phase with aggregate monthly residential consumption. For every household from the sample a separate equation was estimated. January electricity consumption volume was an unknown variable, while electricity consumption for other months was assumed to be a share from January consumption (coefficients for every month were based on the aggregate monthly residential consumption). Within the equation, the product of unknown monthly consumption volumes times price (depends on consumed and households category) was equated to the known household's cash expenditures on electricity (yearly based). An equation was solved using the chord method. Electricity consumption volume based on the average residential prices for Ukraine was used as an initial value. In most cases three iterations of the chord method were enough to find the solution with 0,01 UAH accuracy.

Although, it declares the creation of new market model, comprehensive households' subsidies abolishment is not called for. This Law only changes support mechanisms for certain consumer categories by creating a Fund for cost imbalance distribution, which would obtain a (mandatory) part of the revenues received as a result of business activity from nuclear power plants, hydroelectricity power plants (other than micro, mini and small hydroelectricity power plants) and those energy suppliers that import electricity. Essentially, the Law states that full electricity market will be introduced by July 1st 2017 – after the adoption of necessary regulations. It should be noted that the following energy policy scenario analysis is fully based on the existing electricity market model.

## Modelling framework

Revealed pricing disparities on the Ukrainian electricity market can be viewed as free-standing arguments for subsidization policy shift. At the same time, utilization of international experience without detail consideration of national social and economic specifics may significantly decrease the efficiency of appropriate energy policy measures. Given the relevance of tariff reform analysis in the context of different groups of economic agents and applicability of compensation mechanisms investigation, a static computable general equilibrium (CGE) model was adopted.

The CGE model employ was developed in the "Institute for Economics and Forecasting, Ukrainian National Academy of Sciences" as part of the research project "Energy markets regulation in the context of Ukraine's international obligations". The circular flow diagram describes the core of Ukraine's CGE model (see Figure 5).

Within CGE methodology it is assumed that producers are maximizing profits, while households – utility. Enterprises are producing goods and providing services, employing capital, labor and intermediate products. The latter may be either produced by national manufacturers or imported. Domestic producers sell at internal market or export. In the domestic market final goods and services are purchased by households (including non-profit institutions serving households), government or contributes gross capital formation. Households receive labor and capital payments, as money

transfers, including retirement benefits and educational scholarships. Government earns revenue and receives tax payments.

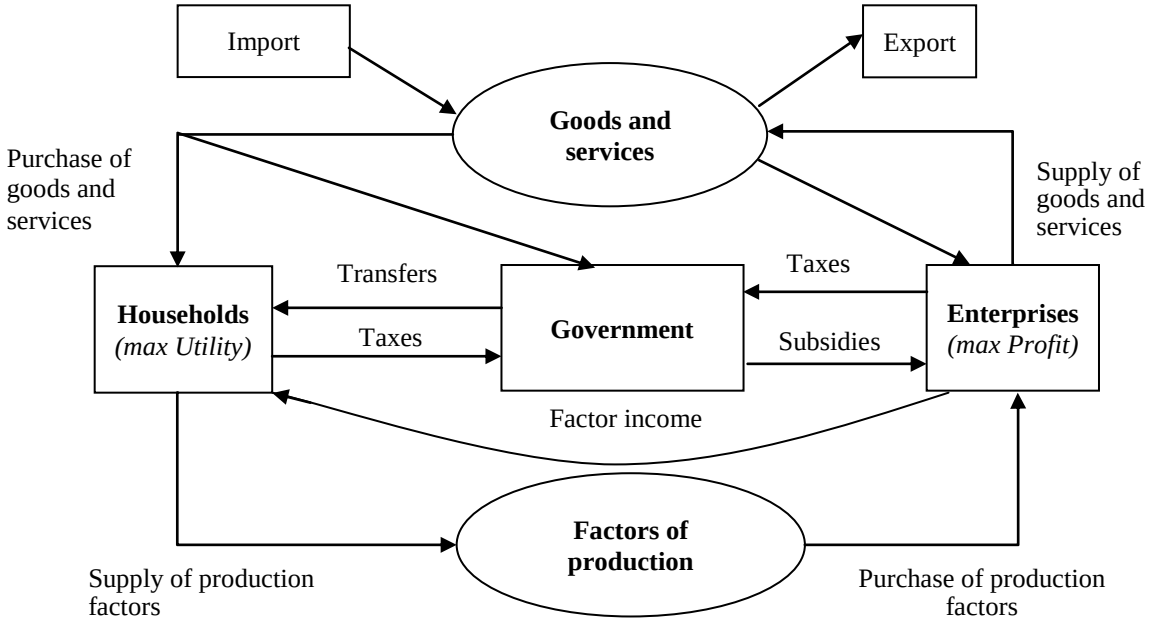



**Figure 5. Ukraine's CGE model circular flow**

*Source*: developed by author

Tax rates on production and import, aggregate trade deficit level and marginal propensity to save are held constant, while tax revenues, foreign exchange rate and gross capital formation volumes are endogenous.

Ukraine's CGE model utilizes constant elasticity of substitution[4] (CES) production functions, within which special cases are Cobb-Douglas (substitution elasticity equals "1") and Leontief (substitution elasticity equals "0") production functions. In order to ensure a flexible representation of substitution processes for different product groups, Ukraine's CGE model incorporates multi-nested CES (see Figure 6).

Through separate production blocks the model represents substitution processes for imported and nationally produced goods, investments decisions, household and government consumption etc.

[4] Elasticity of substitution indicates relative consumption quantities changes resulting from the corresponding relative price changes.

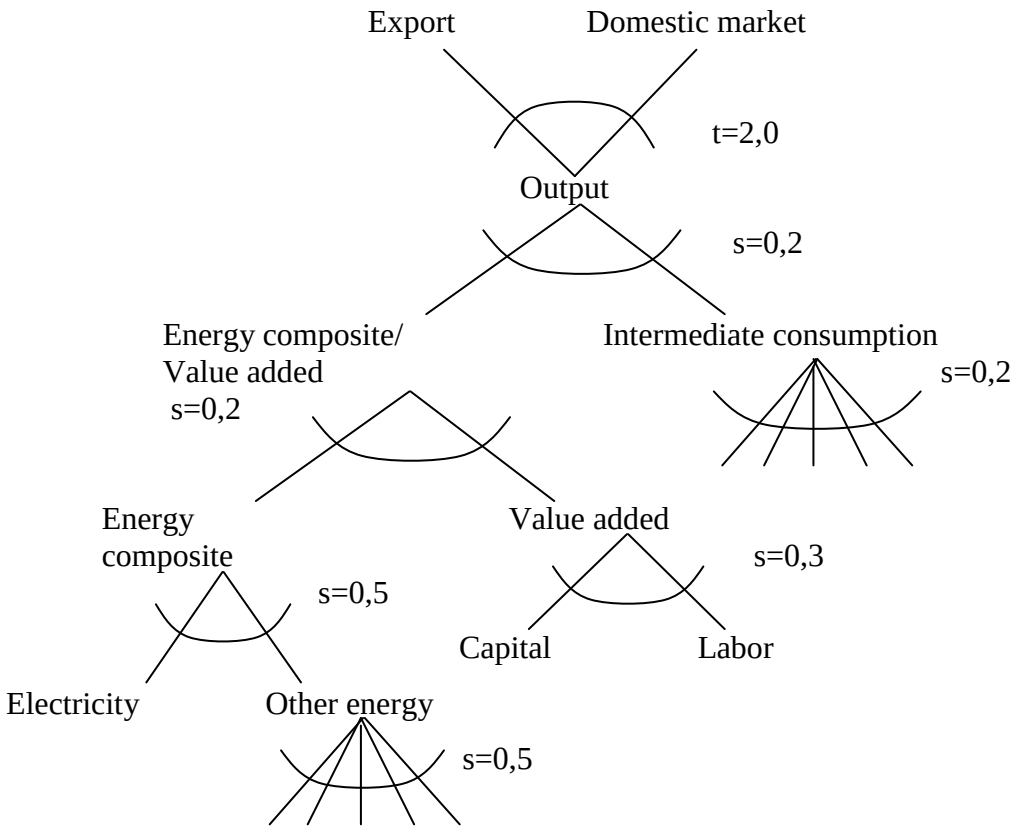



**Figure 6. Ukraine's CGE model production structure**[5]

*Джерело*: developed by author

Ukraine's CGE model equilibrium is characterized by three types of conditions:

1) Zero profit[6];
2) Market clearance[7], and
3) Income balance.

Key input data used for CGE model calibration is represented via Social Accounting Matrix (SAM) – an extended version of input-output (IO) table that incorporates additional information regarding transfers between economic agents. Apart from IO table it includes disaggregated fiscal revenues structure, sectoral investments distribution, detailed households' consumption structure depending on income level, Pension fund and Social security funds transfers. *While detail consideration of Ukraine's SAM construction is not an issue for this article, it would be beneficial to highlight key challenges of the approach. Firstly,* the Ukrainian IO

[5] Symbol "s" denotes elasticity of substitution, "t" – elasticity of transformation.
[6] No producer earns an "excess" profit, i.e. unit cost of production must not be lower than unit revenue. At the same time, production costs include capital earnings, so this condition does not ignore positive gross profit.
[7] Market demand must not exceed market supply (for every commodity).

table for consumer prices contains information about "Financial intermediation services indirectly measured". It represents a difference between interest, received by financial institutions under credits, and paid under deposits (SSSU, 2013b). In the IO table, because of the impossibility of depicting distribution by activity, this indicator is reflected in the intermediate consumption with a separate column in the "Finance" row, and when determining gross value added (VA) it is shown with minus sign. In order to equate the rows and columns in the intermediate consumption matrix "Financial intermediation services indirectly measured" data was divided between other economic activities proportionally to VA shares.

*Secondly*, in Ukraine's CGE model value of Gross operating surplus, mixed income (GOSMI) is interpreted as return on capital, which is one of the factors of production. According to the economic principles, production functions' arguments have to be non-negative, while in Ukrainian 2011 IO table three industries have negative GOSMI. Literature review revealed two approaches to solving this problem: sector aggregation (through adding the appropriate IO table's rows and columns) and wage account adjustment – return on capital is set to zero and wage account is correspondingly reduced (Rutherford and Paltsev, 1999; Tochiczkaya and Shimanovich, 2007).

Obviously, both approaches have unique benefits and drawbacks. Sector aggregation has no influence on GOSMI and labor payments, while account adjustment, a widely used CGE calibration approach[8], sets to zero capital share coefficient for the corresponding industry. At the same time, a substantial advantage of the second method is conservation of initial IO table's sectoral structure, which is critical when a particular industry is under policy investigation. In Ukraine's CGE model we used modified a wage account adjustment procedure in order to make the GOSMI value positive. In addition, some economic activities, due to their insignificance, were aggregated into two sections: "Real estate, renting and business

[8] A standard approach that is applied by most CGE developers: capital share is defined as a GOSMI share in the corresponding industry output.

activities" and "Other community, social and personal service activities". As a result, Ukraine's CGE model includes 30 economic activities.

*Thirdly*, an important issue of Ukraine's SAM construction was representation of cross subsidization in electricity sector. On the one hand, prices for intermediate and final consumption are endogenous within CGE model. On the other hand, model's calibration approach assumes that in a base year all relative prices are equal[9]. So electricity subsidies inclusion into Ukraine's SAM should not only keep monetary balance but also account for methodological aspects of calibration approach. In view of this, cross subsidization scheme is represented via intermediate electricity consumption tax for industrial users along with final consumption subsidies for households. Electricity tax and subsidies administration within Ukraine's CGE model is performed through the use of separate economic agent.

After the base year CGE model calibration, scenario analysis is performed by changes to exogenous parameters. This leads to the violation of initial equilibrium conditions fulfilment: output structure and quantities, volumes of consumption, export, import, capital formation and other aggregates, due to the alteration of the operational environment, which are no longer optimal within predefined criteria. In order to find a new equilibrium, a system of nonlinear equations, which describe economic agents' behavior, is solved. The difference between initial and new equilibrium data represent the effects arising from scenarios investigated.

## Scenarios and effects of electricity tariff policy

Elements of the investigated scenarios can be divided into two groups. The first one includes different options of electricity tariff rise and does not consider any compensating mechanisms. Within the second group, a wide variety of compensatory options aimed at full or partial elimination of negative effects for residential users is considered, where

[9] As long as employed in most CGE models functions are homogenous of degree zero in prices, so simultaneous multiplication of all prices by any positive constant would not influence equilibrium outcome. So, in most CGE models, only relative prices matter. Considering this fact, usually price of one good or bundle of goods is fixed (chosen as a numeraire). Often a Harberger convention is adopted for a benchmark SAM. All prices are normalized to 1, so that quantities represent expenditures.

***«SE» scenarios*** – full or partial elimination of electricity subsidies for residential users, where:

- ***«SE1»*** – 30% reduction;
- ***«SE2»*** –50% reduction, and
- ***«SE3»*** – full elimination.

***«CM» scenarios*** – include compensatory mechanisms that ensure inalterability of households' real income. Depending on the scenario compensation is made to all or 30% of households. While all scenarios assume utilization of direct financial support they differ in terms of compensation funds' sources.

- ***«CM11»*** – compensation is made to I-III deciles through the rise of taxes on production and import[10];
- ***«CM12»*** – compared to «CM11» all households receive compensation;
- ***«CM21»*** – compensation is made to I-III deciles using Government budget funds (direct transfers), tax rates are fixed;
- ***«CM22»*** – compared to «CM21» all households receive compensation, and
- ***«CM31»*** – compensation is made to I-III deciles through partial preservation of cross subsidization (compared to the corresponding «SE» scenarios ).

Three out of 18 scenarios consider only subsidies elimination (decrease), while other 15 additionally provide five compensatory measures for each type «SE» scenario. Furthermore, we consider two options of policy economic effects allocation. Within the first one (***A***), it is assumed that electricity price decrease for business consumers would lead to the corresponding production costs reduction. This would consequently result in partial price abatement, export volumes rise and, considering fixed balance of payments, national currency appreciation. Under this scenario, households' losses from residential electricity tariff rise would be partially compensated by relative price decrease for other imported and domestically produced goods. For the second (***B***) policy option it is assumed that electricity price reduction

[10] Account all taxes and duties that apply to production activities. Including value added tax (VAT), import and export duties, excise duties, price markups, payments for geologic exploration, forest tax, state tax, license payments, transport tax, land tax etc. In 2011 VAT, duties and excise taxes amounted for 84% of all taxes on production and import.

for business users would not influence production costs, but result in investment volumes rise. Consequently, households would not realize positive deflationary effects.

As long as all calculations are based on the static CGE model, some subsidy reform effects are not captured. In particular, investments increase, which dominates for all scenarios, does not result in a factor productivity change and essential technological improvements. Due to the short and middle term nature of the analysis, production functions' technological coefficients are assumed constant, which substantially reduces positive macroeconomic effects of subsidies elimination, including output, GDP and export growth. In the long run, productivity increase would also offset households' purchasing power decrease due to lower marginal costs and, consequently, lower prices and higher wages. Thus, in the long-run, economic effects may be more positive.

As modelling results show, subsidies elimination consequences heavily depend on the behavior of business. Within the cost reduction scenario (***A***), even in the absence of any compensatory measures, subsidies reduction does not lead to adverse macroeconomic effects. Electricity price decrease for intermediate consumers, output and investments growth offsets households final expenditure decrease, as a result GDP level remains unchanged (see *Table 1*). Alternatively, investments growth option (***B***) does not directly show cost improvement, as positive effects from investments volumes change are not fully captured in a short- and mid term. This not only results in severe economic effects for households, but also leads to the negative macroeconomic consequences, including GDP and output reduction (see *Table 2*).

According to the scenarios, 30% subsidies removal would result in a residential electricity price rise to 0,5 UAH or by 108% (based on the 2012 data, excl. VAT), 50% subsidies removal – to 0,67 UAH or by 179% and finally complete subsidies elimination would raise residential price to 1,1 UAH (by 358%); at the same time retail market prices would drop to 0,62 UAH (by 8%), 0,58 UAH (by 14%) and 0,48 UAH (by 29%) respectively.

*Table 1*

## Economic effects of electricity tariff policy shift (option A)[11]

| Indicator \ Scenario | SE1 | SE2 | SE3 | SE1 | | | | | SE2 | | | | | SE3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 |
| **Output** | 0,57 | 0,93 | 2,09 | 0,57 | 0,57 | 0,57 | 0,57 | 0,57 | 0,93 | 0,93 | 0,93 | 0,93 | 0,92 | 2,11 | 2,04 | 2,11 | 2,11 | 2,00 |
| **GDP** | 0,39 | 0,67 | 0,90 | 0,39 | 0,39 | 0,39 | 0,39 | 0,39 | 0,67 | 0,67 | 0,67 | 0,67 | 0,67 | 0,91 | 0,90 | 0,91 | 0,91 | 0,91 |
| **HHs income[12], bn. UAH** | 2,52 | 3,18 | 3,20 | 2,52 | 2,52 | 2,52 | 2,52 | 2,52 | 3,23 | 3,20 | 3,23 | 3,23 | 3,19 | 3,83 | 3,50 | 3,83 | 3,90 | 3,43 |
| **HHs income** | 0,29 | 0,36 | 0,37 | 0,29 | 0,29 | 0,29 | 0,29 | 0,29 | 0,37 | 0,37 | 0,37 | 0,37 | 0,36 | 0,44 | 0,40 | 0,44 | 0,45 | 0,39 |
| **I decile (lowest)** | 0,04 | -0,15 | -0,84 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **II** | 0,10 | -0,01 | -0,49 | 0,10 | 0,10 | 0,10 | 0,10 | 0,10 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **III** | 0,14 | 0,08 | -0,29 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,07 | 0,07 | 0,07 | 0,07 | 0,07 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **IV** | 0,19 | 0,17 | -0,06 | 0,19 | 0,19 | 0,19 | 0,19 | 0,19 | 0,17 | 0,16 | 0,17 | 0,17 | 0,16 | -0,11 | 0,00 | -0,11 | 0,00 | -0,16 |
| **V** | 0,20 | 0,21 | 0,02 | 0,20 | 0,20 | 0,20 | 0,20 | 0,20 | 0,21 | 0,20 | 0,21 | 0,21 | 0,20 | -0,04 | 0,00 | -0,04 | 0,00 | -0,08 |
| **VI** | 0,26 | 0,31 | 0,23 | 0,26 | 0,26 | 0,26 | 0,26 | 0,26 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 | 0,18 | 0,10 | 0,18 | 0,17 | 0,12 |
| **VII** | 0,30 | 0,39 | 0,40 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 | 0,38 | 0,38 | 0,38 | 0,38 | 0,38 | 0,36 | 0,28 | 0,36 | 0,35 | 0,30 |
| **VIII** | 0,33 | 0,46 | 0,56 | 0,33 | 0,33 | 0,33 | 0,33 | 0,33 | 0,45 | 0,45 | 0,45 | 0,45 | 0,45 | 0,51 | 0,44 | 0,51 | 0,51 | 0,46 |
| **IX** | 0,38 | 0,56 | 0,82 | 0,38 | 0,38 | 0,38 | 0,38 | 0,38 | 0,56 | 0,55 | 0,56 | 0,56 | 0,55 | 0,77 | 0,70 | 0,77 | 0,77 | 0,71 |
| **X (highest)** | 0,49 | 0,77 | 1,34 | 0,49 | 0,49 | 0,49 | 0,49 | 0,49 | 0,77 | 0,76 | 0,77 | 0,77 | 0,76 | 1,30 | 1,21 | 1,30 | 1,29 | 1,22 |
| **GFCF[13]** | 0,55 | 0,81 | 1,86 | 0,55 | 0,55 | 0,55 | 0,55 | 0,55 | 0,82 | 0,81 | 0,82 | 0,82 | 0,81 | 1,90 | 1,79 | 1,90 | 1,91 | 1,80 |
| **Government final consumption** | 0,48 | 1,43 | 1,55 | 0,48 | 0,48 | 0,48 | 0,48 | 0,48 | 1,40 | 1,42 | 1,40 | 1,40 | 1,42 | 1,25 | 1,47 | 1,25 | 1,22 | 1,53 |
| **Share of additionally preserved subsidies[14]** | | | | | | | | 0,00 | | | | | 0,16 | | | | | 1,6 |

Source: developed by author

[11] The table contains real data changes (%) relative to the base year, unless noted otherwise. Numbers in column SE2 represent estimates for 50% subsidies removal and no compensatory measures, while numbers in column CM11 within SE2 scenario (col. No. 10) also show estimates for 50% subsidies removal but compensation is made to I-III deciles through the rise of taxes on production and import. For example number "2,00" in the third row of the last column indicates that under the scenario of full subsidies elimination (SE3) and application of social support measures (CM31), which includes compensation to I-III deciles through partial preservation of cross subsidization (so actually due to these measures 6,6% of initial subsidies amount will be still preserved), output level should increase by 2,00%.

[12] Indicates HHs real income decrease relative to the benchmark case.

[13] Gross fixed capital formation.

[14] Indicators are adopted only for «CM31» scenario, they show essential percentage increase in a cross-subsidization level compared to «SE» scenario.

*Table 2*

## Economic effects of electricity tariff policy shift (option B)[15]

| Indicator \ Scenario | SE1 | SE2 | SE3 | SE 1 | | | | | SE2 | | | | | SE3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 |
| **Output** | -0,05 | -0,10 | -0,18 | -0,02 | -0,62 | -0,02 | 0,10 | -0,14 | -0,05 | -1,14 | -0,05 | 0,18 | -0,26 | -0,07 | -2,76 | -0,07 | 0,49 | -0,57 |
| **GDP** | 0,24 | 0,37 | 0,38 | 0,25 | 0,16 | 0,25 | 0,27 | 0,23 | 0,38 | 0,20 | 0,38 | 0,43 | 0,34 | 0,41 | -0,09 | 0,41 | 0,52 | 0,32 |
| **HHs income, bn.UAH** | -4,20 | -7,80 | -18,82 | -3,49 | 0,00 | -3,49 | 0,00 | -4,00 | -6,46 | 0,00 | -6,46 | 0,00 | -7,34 | -15,57 | 0,00 | -15,57 | 0,00 | -17,51 |
| **HHs income** | -0,48 | -0,89 | -2,15 | -0,40 | 0,00 | -0,40 | 0,00 | -0,46 | -0,74 | 0,00 | -0,74 | 0,00 | -0,84 | -1,78 | 0,00 | -1,78 | 0,00 | -2,00 |
| **I decile (lowest)** | -0,64 | -1,22 | -2,96 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **II** | -0,60 | -1,12 | -2,70 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **III** | -0,56 | -1,05 | -2,54 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| **IV** | -0,53 | -1,00 | -2,41 | -0,58 | 0,00 | -0,58 | 0,00 | -0,65 | -1,09 | 0,00 | -1,09 | 0,00 | -1,20 | -2,63 | 0,00 | -2,63 | 0,00 | -2,88 |
| **V** | -0,53 | -0,99 | -2,37 | -0,59 | 0,00 | -0,59 | 0,00 | -0,65 | -1,09 | 0,00 | -1,09 | 0,00 | -1,19 | -2,63 | 0,00 | -2,63 | 0,00 | -2,84 |
| **VI** | -0,51 | -0,95 | -2,29 | -0,57 | 0,00 | -0,57 | 0,00 | -0,64 | -1,06 | 0,00 | -1,06 | 0,00 | -1,17 | -2,54 | 0,00 | -2,54 | 0,00 | -2,79 |
| **VII** | -0,48 | -0,89 | -2,16 | -0,54 | 0,00 | -0,54 | 0,00 | -0,61 | -1,00 | 0,00 | -1,00 | 0,00 | -1,12 | -2,41 | 0,00 | -2,41 | 0,00 | -2,67 |
| **VIII** | -0,47 | -0,87 | -2,08 | -0,53 | 0,00 | -0,53 | 0,00 | -0,60 | -0,98 | 0,00 | -0,98 | 0,00 | -1,10 | -2,35 | 0,00 | -2,35 | 0,00 | -2,61 |
| **IX** | -0,42 | -0,77 | -1,85 | -0,48 | 0,00 | -0,48 | 0,00 | -0,55 | -0,88 | 0,00 | -0,88 | 0,00 | -1,00 | -2,11 | 0,00 | -2,11 | 0,00 | -2,38 |
| **X (highest)** | -0,33 | -0,60 | -1,45 | -0,37 | 0,00 | -0,37 | 0,00 | -0,46 | -0,68 | 0,00 | -0,68 | 0,00 | -0,84 | -1,64 | 0,00 | -1,64 | 0,00 | -2,01 |
| **GFCF** | 2,06 | 3,37 | 6,73 | 2,11 | 1,24 | 2,11 | 2,38 | 1,97 | 3,46 | 1,85 | 3,46 | 3,97 | 3,20 | 6,95 | 2,69 | 6,95 | 8,21 | 6,13 |
| **Government final consumption** | 0,64 | 1,30 | 2,01 | 0,31 | -0,56 | 0,31 | -1,35 | 0,60 | 0,67 | -1,07 | 0,67 | -2,41 | 1,14 | 0,48 | -3,63 | 0,48 | -7,02 | 1,77 |
| **Share of additionally preserved subsidies** | | | | - | - | - | - | 2,23 | - | - | - | - | 4,19 | - | - | - | - | 10,44 |

Source: developed by author

[15] See footnotes 11-14.

The distinction in households' income and consumption structures by decile groups determines differentiation of tariff reform effects. As long as high-income households receive relatively more money from capital earnings, domestic users from IX and X deciles suffer much less (gain relatively more) from electricity price increase. On the whole, cross-subsidies elimination exhibits pronounced regressive effects towards vulnerable domestic consumers: with a decrease in household income relative to the loss of subsidy increase.

Received estimates of the subsidies elimination effects largely depend on the producers' behavior. Within option "A" and 30% subsidies reduction, moderate production costs decrease even lead to the positive aggregate effects for households and thus compensation measures may not required. At the same time, the same scenario but under option "B", leads to the adverse welfare effects for all groups of households.

In case of 30% subsidies reduction, compensation applied to the I-III deciles may be regarded as an adequate social policy approach, since the decline in other households real income does not exceed 0,6%. While for the cases of 50% and 100% subsidies reduction, aggregate household losses increase substantially and for some groups exceed 2,9% in the latter case.

As long as the compensation approach utilizes the concept of unchanged real households' income, nominal cash transfers to the residential consumers significantly differ within "A" and "B" policy options. In particular, under the investments growth option, aggregate households' loss is almost four times more than in the cost reduction case. It should also be noted that for all studied compensatory measures real income of households, which do not receive social assistance, reduces in comparison to the corresponding scenario without compensation. This is explained by the fact that these households indirectly induce support payments and consequently bear additional expenses.

According to the investigated scenarios, the most appropriate compensatory option is partial preservation of cross subsidization («CM31» scenario). This approach bears no additional burden on the Government budget and does not require

significant regulatory changes. However, given the specific nature of this concept, it should be used only in the case of 30-50% subsidies reduction (scenarios «SE1»-«SE2»).

The disadvantage of the compensation through tax increases is an inflationary issue. This approach leads to the sale prices increase and resulting real income decline for households that do not receive benefits, as a result aggregate loss grows. In the case of compensation based on the Government budget funds there is no addition tax burden on producers and households do not suffer from additional inflationary pressure, while all expenses are bared by the State and leads to the government expenditure reduction for some cost categories.

Key positive effects of cross-subsidization reduction come from the production costs decrease, manufacturing capacity rise and investments volumes increase in the real sector of Ukrainian economy. Under the cost reduction option, the highest growth rates are observed for the industries that not only extensively consume electricity but also electricity-intensive goods and services (see *Table 3*). Such economic activities include mining of coal and lignite; extraction of peat, mining of uranium and thorium ores, mining of quarrying, except of energy producing materials», manufacture of basic metals and fabricated metal products, manufacture of coke oven products, and processing of nuclear fuel. These industries simultaneously benefit from lower electricity prices and intermediate consumption costs reduction based on inter-industry effects. The decrease in production costs makes these activities more efficient and enables them to attract additional economic resources.

Within the investment growth scenario, patterns of production increase do not significantly change, unlike underlying growth factors (see *Table 4*). In comparison to the cost reduction option, structural demand shifts are not price-induced, but owe to investors disposable income increase. This leads to the simultaneous growth of electricity-intensive industries and key capital goods producers. The decline in consumer-oriented industries is caused by the households' solvency decrease and a simultaneous final consumption structure shift.

*Table 3*

## Output effects of the electricity tariff policy shift (option A)[16]

| Activity\Scenario | SE1 | SE 2 | SE 3 | SE 1 | | | | | SE 2 | | | | | SE 3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 |
| Agriculture, hunting and related service activities | -0,50 | -0,81 | -2,04 | -0,50 | -0,50 | -0,50 | -0,50 | -0,50 | -0,80 | -0,80 | -0,80 | -0,80 | -0,79 | -2,00 | -1,98 | -2,00 | -1,99 | -1,87 |
| Forestry, logging, fishing, fish farming and related service activities | -1,57 | -2,78 | -5,75 | -1,57 | -1,57 | -1,57 | -1,57 | -1,57 | -2,77 | -2,78 | -2,77 | -2,77 | -2,76 | -5,62 | -5,63 | -5,62 | -5,60 | -5,44 |
| Mining of coal and lignite; extraction of peat; mining of uranium and thorium ores | 1,98 | 2,82 | 8,64 | 1,98 | 1,98 | 1,98 | 1,98 | 1,98 | 2,83 | 2,81 | 2,83 | 2,83 | 2,77 | 8,73 | 8,54 | 8,73 | 8,74 | 7,94 |
| Extraction of crude petroleum and natural gas | -0,67 | -1,15 | -2,41 | -0,67 | -0,67 | -0,67 | -0,67 | -0,67 | -1,15 | -1,15 | -1,15 | -1,15 | -1,14 | -2,44 | -2,43 | -2,44 | -2,44 | -2,34 |
| Mining of quarrying, except of energy producing materials | 4,71 | 8,11 | 17,45 | 4,71 | 4,71 | 4,71 | 4,71 | 4,71 | 8,10 | 8,10 | 8,10 | 8,10 | 8,04 | 17,38 | 17,28 | 17,38 | 17,37 | 16,66 |
| Manufacture of food products, beverages and tobacco | -0,23 | -0,41 | -1,16 | -0,23 | -0,23 | -0,23 | -0,23 | -0,23 | -0,40 | -0,40 | -0,40 | -0,40 | -0,40 | -1,07 | -1,11 | -1,07 | -1,07 | -1,01 |
| Manufacture of textiles and textile products; manufacture of wearing apparel; dressing and dyeing of fur | -0,74 | -1,29 | -2,99 | -0,74 | -0,74 | -0,74 | -0,74 | -0,74 | -1,28 | -1,28 | -1,28 | -1,28 | -1,27 | -2,93 | -2,95 | -2,93 | -2,92 | -2,79 |
| Manufacture of wood and wood products; manufacture of pulp, paper and paper products; publishing and printing | -0,51 | -0,93 | -2,22 | -0,51 | -0,51 | -0,51 | -0,51 | -0,51 | -0,92 | -0,93 | -0,92 | -0,92 | -0,92 | -2,15 | -2,22 | -2,15 | -2,14 | -2,06 |
| Manufacture of coke oven products; processing of nuclear fuel; | 4,03 | 6,66 | 15,63 | 4,03 | 4,03 | 4,03 | 4,03 | 4,03 | 6,67 | 6,64 | 6,67 | 6,67 | 6,60 | 15,68 | 15,37 | 15,68 | 15,69 | 14,81 |
| Manufacture of refined petroleum products | -0,63 | -1,14 | -2,39 | -0,63 | -0,63 | -0,63 | -0,63 | -0,63 | -1,14 | -1,15 | -1,14 | -1,14 | -1,14 | -2,37 | -2,47 | -2,37 | -2,36 | -2,29 |
| Manufacture of chemicals and chemical products; manufacture of rubber and plastic products | -0,07 | -0,20 | -0,69 | -0,07 | -0,07 | -0,07 | -0,07 | -0,07 | -0,19 | -0,20 | -0,19 | -0,19 | -0,19 | -0,63 | -0,74 | -0,63 | -0,62 | -0,60 |
| Manufacture of other non-metallic mineral products | 1,15 | 1,91 | 4,12 | 1,15 | 1,15 | 1,15 | 1,15 | 1,15 | 1,91 | 1,90 | 1,91 | 1,91 | 1,89 | 4,16 | 4,04 | 4,16 | 4,16 | 3,96 |
| Manufacture of basic metals and fabricated metal products | 5,85 | 10,03 | 22,34 | 5,85 | 5,85 | 5,85 | 5,85 | 5,85 | 10,03 | 10,01 | 10,03 | 10,03 | 9,95 | 22,35 | 22,01 | 22,35 | 22,36 | 21,31 |
| Manufacture of machinery and equipment | -0,30 | -0,67 | -1,52 | -0,30 | -0,30 | -0,30 | -0,30 | -0,30 | -0,67 | -0,68 | -0,67 | -0,67 | -0,67 | -1,47 | -1,58 | -1,47 | -1,46 | -1,43 |
| Manufacturing n.e.c. | 1,13 | 1,93 | 3,90 | 1,13 | 1,13 | 1,13 | 1,13 | 1,13 | 1,93 | 1,92 | 1,93 | 1,93 | 1,92 | 3,91 | 3,78 | 3,91 | 3,91 | 3,76 |
| Production and distribution of electricity | -1,83 | -4,27 | -3,17 | -1,83 | -1,83 | -1,83 | -1,83 | -1,83 | -4,27 | -4,27 | -4,27 | -4,27 | -4,33 | -3,14 | -3,23 | -3,14 | -3,14 | -3,93 |
| Manufacture of gas; distribution of gaseous fuels through mains | 1,07 | 1,81 | 4,04 | 1,07 | 1,07 | 1,07 | 1,07 | 1,07 | 1,82 | 1,81 | 1,82 | 1,82 | 1,80 | 4,06 | 3,97 | 4,06 | 4,06 | 3,86 |
| Steam and hot water supply | 0,77 | 1,48 | 2,60 | 0,77 | 0,77 | 0,77 | 0,77 | 0,77 | 1,48 | 1,48 | 1,48 | 1,48 | 1,48 | 2,54 | 2,56 | 2,54 | 2,53 | 2,54 |
| Construction | 2,05 | 3,55 | 7,39 | 2,05 | 2,05 | 2,05 | 2,05 | 2,05 | 3,55 | 3,55 | 3,55 | 3,55 | 3,53 | 7,42 | 7,39 | 7,42 | 7,42 | 7,14 |
| Mining of coal and lignite; extraction of peat; mining of uranium and thorium ores | 0,45 | 0,66 | 1,49 | 0,45 | 0,45 | 0,45 | 0,45 | 0,45 | 0,66 | 0,66 | 0,66 | 0,66 | 0,66 | 1,53 | 1,43 | 1,53 | 1,53 | 1,45 |
| Trade; repair of motor vehicles, household appliances and personal demand items | 0,02 | -0,01 | -0,13 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,00 | -0,01 | 0,00 | 0,00 | 0,00 | -0,07 | -0,14 | -0,07 | -0,06 | -0,07 |
| Activity of hotels and restaurants | -1,79 | -3,06 | -6,51 | -1,79 | -1,79 | -1,79 | -1,79 | -1,79 | -3,06 | -3,06 | -3,06 | -3,06 | -3,04 | -6,48 | -6,45 | -6,48 | -6,48 | -6,22 |
| Activity of transport | 0,05 | 0,02 | 0,06 | 0,05 | 0,05 | 0,05 | 0,05 | 0,05 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,09 | 0,08 | 0,09 | 0,10 | 0,07 |
| Post and telecommunications | -0,34 | -0,59 | -1,46 | -0,34 | -0,34 | -0,34 | -0,34 | -0,34 | -0,58 | -0,58 | -0,58 | -0,58 | -0,58 | -1,43 | -1,42 | -1,43 | -1,43 | -1,35 |
| Financial activity | -0,18 | -0,31 | -0,70 | -0,18 | -0,18 | -0,18 | -0,18 | -0,18 | -0,31 | -0,31 | -0,31 | -0,31 | -0,31 | -0,69 | -0,71 | -0,69 | -0,69 | -0,66 |
| Real estate, renting and business activities | 0,06 | 0,10 | 0,01 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,10 | 0,10 | 0,10 | 0,10 | 0,10 | 0,04 | 0,01 | 0,04 | 0,04 | 0,05 |
| Public administration | 0,38 | 1,18 | 1,19 | 0,38 | 0,38 | 0,38 | 0,38 | 0,38 | 1,15 | 1,17 | 1,15 | 1,15 | 1,17 | 0,93 | 1,13 | 0,93 | 0,90 | 1,18 |
| Education | 0,39 | 1,16 | 1,21 | 0,39 | 0,39 | 0,39 | 0,39 | 0,39 | 1,14 | 1,16 | 1,14 | 1,14 | 1,16 | 0,98 | 1,16 | 0,98 | 0,96 | 1,21 |
| Health care and provision of social aid | 0,45 | 1,23 | 1,41 | 0,45 | 0,45 | 0,45 | 0,45 | 0,45 | 1,20 | 1,22 | 1,20 | 1,20 | 1,22 | 1,19 | 1,35 | 1,19 | 1,16 | 1,39 |
| Other community, social and personal service activities | 0,01 | 0,17 | -0,21 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,17 | 0,17 | 0,17 | 0,17 | 0,17 | -0,26 | -0,20 | -0,26 | -0,26 | -0,15 |

Source: developed by author

[16] The table contains real data changes (%) relative to the base year.

*Table 4*

## Output effects of the electricity tariff policy shift (option B)[17]

| Activity\Scenario | SE1 | SE 2 | SE 3 | SE 1 | | | | | SE 2 | | | | | SE 3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 | CM11 | CM12 | CM21 | CM22 | CM31 |
| Agriculture, hunting and related service activities | -0,24 | -0,40 | -1,02 | -0,20 | 0,19 | -0,20 | -0,09 | -0,06 | -0,32 | 0,37 | -0,32 | -0,12 | -0,06 | -0,80 | 0,85 | -0,80 | -0,33 | -0,14 |
| Forestry, logging, fishing, fish farming and related service activities | -0,01 | -0,10 | -0,27 | 0,14 | 1,63 | 0,14 | 0,85 | 0,36 | 0,20 | 2,98 | 0,20 | 1,52 | 0,61 | 0,47 | 7,50 | 0,47 | 3,74 | 1,44 |
| Mining of coal and lignite; extraction of peat; mining of uranium and thorium ores | -2,16 | -3,75 | -6,14 | -2,06 | -3,45 | -2,06 | -1,59 | -2,87 | -3,56 | -5,93 | -3,56 | -2,66 | -4,96 | -5,70 | -11,66 | -5,70 | -3,59 | -9,18 |
| Extraction of crude petroleum and natural gas | -0,27 | -0,44 | -0,82 | -0,29 | -0,42 | -0,29 | -0,39 | -0,19 | -0,49 | -0,72 | -0,49 | -0,67 | -0,28 | -0,94 | -1,50 | -0,94 | -1,38 | -0,42 |
| Mining of quarrying, except of energy producing materials | 0,53 | 0,89 | 1,79 | 0,47 | -1,35 | 0,47 | 0,27 | -0,29 | 0,78 | -2,54 | 0,78 | 0,41 | -0,65 | 1,51 | -6,42 | 1,51 | 0,63 | -1,98 |
| Manufacture of food products, beverages and tobacco | -0,31 | -0,54 | -1,29 | -0,21 | 0,00 | -0,21 | 0,14 | -0,15 | -0,36 | 0,00 | -0,36 | 0,28 | -0,24 | -0,85 | -0,04 | -0,85 | 0,71 | -0,53 |
| Manufacture of textiles and textile products; manufacture of wearing apparel; dressing and dyeing of fur | -0,31 | -0,55 | -1,29 | -0,24 | 0,24 | -0,24 | 0,15 | -0,10 | -0,41 | 0,45 | -0,41 | 0,31 | -0,14 | -0,94 | 1,05 | -0,94 | 0,80 | -0,27 |
| Manufacture of wood and wood products; manufacture of pulp, paper and paper products; publishing and printing | 0,00 | -0,04 | -0,20 | 0,08 | -0,20 | 0,08 | 0,45 | 0,16 | 0,11 | -0,43 | 0,11 | 0,80 | 0,26 | 0,16 | -1,39 | 0,16 | 1,83 | 0,52 |
| Manufacture of coke oven products; processing of nuclear fuel; | -0,38 | -0,72 | -0,88 | -0,33 | -3,44 | -0,33 | -0,01 | -1,20 | -0,61 | -6,21 | -0,61 | -0,01 | -2,20 | -0,64 | -14,16 | -0,64 | 0,83 | -4,58 |
| Manufacture of refined petroleum products | -0,11 | -0,22 | -0,44 | -0,08 | -1,00 | -0,08 | 0,18 | -0,01 | -0,16 | -1,84 | -0,16 | 0,34 | -0,01 | -0,29 | -4,48 | -0,29 | 0,90 | 0,07 |
| Manufacture of chemicals and chemical products; manufacture of rubber and plastic products | 0,13 | 0,18 | 0,26 | 0,20 | -0,77 | 0,20 | 0,52 | 0,20 | 0,32 | -1,50 | 0,32 | 0,92 | 0,32 | 0,59 | -4,08 | 0,59 | 2,06 | 0,58 |
| Manufacture of other non-metallic mineral products | 0,72 | 1,16 | 2,30 | 0,75 | -0,29 | 0,75 | 0,96 | 0,54 | 1,23 | -0,68 | 1,23 | 1,62 | 0,83 | 2,47 | -2,33 | 2,47 | 3,43 | 1,42 |
| Manufacture of basic metals and fabricated metal products | 0,58 | 0,93 | 1,92 | 0,60 | -3,04 | 0,60 | 0,78 | -0,40 | 0,97 | -5,64 | 0,97 | 1,31 | -0,89 | 2,02 | -13,82 | 2,02 | 2,84 | -2,57 |
| Manufacture of machinery and equipment | 0,80 | 1,27 | 2,57 | 0,86 | 0,04 | 0,86 | 1,25 | 0,84 | 1,39 | -0,14 | 1,39 | 2,13 | 1,37 | 2,86 | -1,32 | 2,86 | 4,66 | 2,71 |
| Manufacturing n.e.c. | 0,16 | 0,27 | 0,41 | 0,17 | -1,12 | 0,17 | 0,32 | 0,00 | 0,27 | -2,10 | 0,27 | 0,56 | -0,04 | 0,43 | -5,42 | 0,43 | 1,11 | -0,33 |
| Production and distribution of electricity | -6,5 | -11,1 | -18,8 | -6,5 | -7,4 | -6,5 | -6,3 | -7,3 | -11,0 | -12,2 | -11,0 | -10,7 | -12,2 | -18,7 | -21,7 | -18,7 | -18,0 | -21,5 |
| Manufacture of gas; distribution of gaseous fuels through mains | -0,14 | -0,24 | -0,45 | -0,12 | -1,02 | -0,12 | -0,06 | -0,32 | -0,21 | -1,85 | -0,21 | -0,09 | -0,57 | -0,37 | -4,35 | -0,37 | -0,08 | -1,25 |
| Steam and hot water supply | 0,06 | 0,15 | 0,03 | -0,01 | -0,55 | -0,01 | -0,33 | -0,02 | 0,02 | -1,01 | 0,02 | -0,58 | -0,01 | -0,28 | -2,76 | -0,28 | -1,73 | -0,31 |
| Construction | -0,08 | -0,13 | -0,40 | -0,05 | -0,39 | -0,05 | -0,03 | -0,35 | -0,08 | -0,71 | -0,08 | -0,03 | -0,64 | -0,28 | -1,82 | -0,28 | -0,17 | -1,63 |
| Mining of coal and lignite; extraction of peat; mining of uranium and thorium ores | 1,82 | 2,98 | 5,95 | 1,86 | 1,11 | 1,86 | 2,09 | 1,75 | 3,05 | 1,67 | 3,05 | 3,49 | 2,84 | 6,13 | 2,46 | 6,13 | 7,20 | 5,46 |
| Trade; repair of motor vehicles, household appliances and personal demand items | 0,00 | -0,03 | -0,16 | 0,07 | -0,32 | 0,07 | 0,36 | 0,06 | 0,09 | -0,62 | 0,09 | 0,65 | 0,08 | 0,15 | -1,73 | 0,15 | 1,49 | 0,11 |
| Activity of hotels and restaurants | -0,11 | -0,22 | -0,54 | -0,08 | 1,36 | -0,08 | 0,26 | 0,22 | -0,15 | 2,52 | -0,15 | 0,47 | 0,41 | -0,38 | 6,30 | -0,38 | 1,13 | 1,02 |
| Activity of transport | -0,01 | -0,05 | -0,09 | 0,03 | 0,40 | 0,03 | 0,27 | -0,01 | 0,03 | 0,74 | 0,03 | 0,48 | -0,03 | 0,10 | 1,92 | 0,10 | 1,18 | -0,07 |
| Post and telecommunications | -0,16 | -0,28 | -0,69 | -0,12 | 0,41 | -0,12 | 0,06 | -0,04 | -0,21 | 0,78 | -0,21 | 0,13 | -0,06 | -0,52 | 1,97 | -0,52 | 0,29 | -0,13 |
| Financial activity | -0,08 | -0,15 | -0,33 | -0,07 | -0,12 | -0,07 | 0,01 | -0,04 | -0,13 | -0,21 | -0,13 | 0,03 | -0,07 | -0,28 | -0,47 | -0,28 | 0,09 | -0,12 |
| Real estate, renting and business activities | 0,04 | 0,05 | -0,01 | 0,06 | 0,21 | 0,06 | 0,24 | 0,07 | 0,10 | 0,36 | 0,10 | 0,43 | 0,11 | 0,11 | 0,73 | 0,11 | 0,91 | 0,13 |
| Public administration | 0,61 | 1,22 | 1,91 | 0,32 | -0,36 | 0,32 | -1,11 | 0,59 | 0,67 | -0,71 | 0,67 | -2,00 | 1,10 | 0,58 | -2,68 | 0,58 | -5,93 | 1,75 |
| Education | 0,53 | 1,06 | 1,61 | 0,27 | -0,27 | 0,27 | -1,01 | 0,51 | 0,57 | -0,54 | 0,57 | -1,81 | 0,96 | 0,41 | -2,17 | 0,41 | -5,37 | 1,48 |
| Health care and provision of social aid | 0,46 | 0,95 | 1,40 | 0,22 | -0,37 | 0,22 | -0,98 | 0,43 | 0,48 | -0,70 | 0,48 | -1,76 | 0,82 | 0,26 | -2,50 | 0,26 | -5,17 | 1,21 |
| Other community, social and personal service activities | 0,13 | 0,27 | 0,26 | 0,08 | 0,32 | 0,08 | -0,14 | 0,20 | 0,17 | 0,57 | 0,17 | -0,24 | 0,36 | 0,03 | 1,07 | 0,03 | -0,99 | 0,53 |

Source: developed by author

[17] The table contains real data changes (%) relative to the base year.

Regardless of the implemented compensatory measures nature, the decrease in cross-subsidization results in the investments volumes growth, with an increase in gross capital formation of up to 20 bn UAH.

CGE calculation results may substantially depend on the values of exogenous parameters, particularly elasticities of substitution and transformation. For example, as shown in (Taylor and von Arnim, 2006), a large shift in elasticities values may even turn welfare gains from international trade into losses. To some extent, such results are determined by the economic essence of these parameters and high uncertainty not only about their future but also retrospective values. Under otherwise equal conditions, higher elasticities substitution effects are stronger, which leads to the undervaluation of adverse effects and optimistic assessment of positive effects. Lower elasticities lead to the adverse situation. At the same time, econometric estimates of elasticities values are often unreliable due to statistical and methodological difficulties (see Koesler and Schymura, 2012; Okagawa and Ban, 2008). A widespread approach to check a CGE modeling results validity is a performance of sensitivity analysis (Bohringer et al., 2004; Hermeling and Mennel, 2008; Jensen and Tarr, 2012).

Following Jensen and Tarr (2012) for every investigated scenario we sequentially increased and reduced elasticities values by 50% relative to the baseline level. Due to the substantial volume of the resulting data (24 elasticity values, 36 scenario and over 200 representative economic variables), *Table 5* presents sample of the sensitivity analysis results for one scenario.

*Table 5*

**Sensitivity analysis results (the case of «SE3» scenario for option A)**[18]

| | Parameter's value | | | Aggregate output | | | Households' income | | | GFCF | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | L | C | U | L | C | U | L | C | U | L | C | U |
| $\sigma_{mkl}$ | 0,15 | *0,3* | 0,45 | 2,03 | 2,09 | 2,14 | 0,35 | 0,37 | 0,38 | 1,87 | 1,86 | 1,85 |
| $\theta_i$ | 1,0 | *2,0* | 3,0 | 1,72 | 2,09 | 2,47 | 0,34 | 0,37 | 0,39 | 1,87 | 1,86 | 1,85 |
| $\sigma_{io}$ | 0,1 | *0,2* | 0,3 | 2,03 | 2,09 | 2,15 | 0,36 | 0,37 | 0,37 | 1,86 | 1,86 | 1,85 |
| $\sigma_{enel}$ | 0,25 | *0,5* | 0,75 | 2,10 | 2,09 | 2,08 | 0,27 | 0,37 | 0,46 | 1,86 | 1,86 | 1,85 |
| $\sigma_{en}$ | 0,25 | *0,5* | 0,75 | 2,09 | 2,09 | 2,09 | 0,37 | 0,37 | 0,37 | 1,86 | 1,86 | 1,86 |
| $\sigma_{vaen}$ | 0,15 | *0,3* | 0,45 | 1,74 | 2,09 | 2,45 | 0,33 | 0,37 | 0,40 | 1,84 | 1,86 | 1,88 |
| $\sigma_{lk}$ | 0,15 | *0,3* | 0,45 | 2,09 | 2,09 | 2,08 | 0,41 | 0,37 | 0,34 | 1,79 | 1,86 | 1,89 |
| $\sigma_{dm}$ | 1,0 | *2,0* | 3,0 | 1,81 | 2,09 | 2,37 | 0,38 | 0,37 | 0,35 | 1,81 | 1,86 | 1,89 |
| $\sigma_{gov}$ | 0,25 | *0,5* | 0,75 | 2,09 | 2,09 | 2,09 | 0,37 | 0,37 | 0,36 | 1,85 | 1,86 | 1,86 |
| $\sigma_{hh}$ | 0,25 | *0,5* | 0,75 | 2,03 | 2,09 | 2,13 | 0,02 | 0,37 | 0,65 | 1,68 | 1,86 | 1,97 |
| $\sigma_{inv}$ | 0,25 | *0,5* | 0,75 | 2,08 | 2,09 | 2,10 | 0,36 | 0,37 | 0,37 | 1,86 | 1,86 | 1,85 |
| $\sigma_{ra}$ | 0,1 | *0,2* | 0,3 | 2,07 | 2,09 | 2,10 | 0,37 | 0,37 | 0,36 | 1,75 | 1,86 | 1,97 |

Source: developed by author

Although in general estimates are satisfactory (for most cases the deviation for the baseline does not exceed 5%), some parameters have tangible impact on the aggregate results. For example, in the case of transformation elasticities deviation of total industrial output reached the level of 20%. Somewhat less significant effect is

[18] *Conventions:*
L – lower elasticity value (50% reduction comparing to central value);
C – central elasticity value;
U – upper elasticity value (50% increase comparing to central value);
$\sigma_{mkl}$ – substitution elasticity between intermediate goods and energy composite/value added;
$\theta_i$ – transformation elasticity between export and domestic consumption;
$\sigma_{io}$ – substitution elasticity in intermediate consumption;
$\sigma_{enel}$ – substitution elasticity between electricity and other energy;
$\sigma_{en}$ – substitution elasticity between other energy(excludes electricity);
$\sigma_{vaen}$ – substitution elasticity between energy composite and value added;
$\sigma_{lk}$ – substitution elasticity between capital and labor;
$\sigma_{dm}$ – substitution elasticity between domestic production and imports (Armington block);
$\sigma_{gov}$ – substitution elasticity between in the general government's demand block;
$\sigma_{hh}$ – substitution elasticity in the households' demand block;
$\sigma_{inv}$ – substitution elasticity between investment goods;
$\sigma_{ra}$ – substitution elasticity in the representative agent's demand block (allocates recourses for investments, deficiency payments for Government budget, Pension fund and Social security funds).
Over 5% deviation from the central cases level is highlighted.

seen for Armington and value-added substitution elasticities. But the most substantial changes occur due to the households' demand block elasticity deviation. And while qualitatively welfare effects do not change, their quantitative differentiation is rather high. In this context, consequences of electricity subsidies elimination for residential consumers strongly depend on the possibilities of substitution between electricity and other energy products, as well as availability of final electricity consumption reduction options and energy efficiency measures implementation.

## Conclusions

Further development of Ukrainian economy heavily depends on the urgency and depth of electricity sector restructuring. This includes alteration of current subsidization approach, which despite the social orientation discriminates adversely not only the interests of industrial consumers but also low-income households.

As the modelling results show, in the middle- and long-term electricity tariff increase leads to the positive macroeconomic consequences, however in the short term households may face negative regressive income effects, which require external funds allocation for compensatory measures. In addition, magnitude of the expected households' real income decrease significantly depends on the producers' behavior. In particular, the way businesses would utilize funds arising from electricity tariffs reduction, where for cost reduction and investments, has a direct impact on overall prosperity in the country. Overall, most economic agents have short-term benefits from the existing subsidization mechanism. An exception may be a group of manufacturers who currently are key producers of the residential users' compensation payments.

At the same time, further preservation of existing subsidization scheme poses a serious threat not only to the economy but also to the energy security of Ukraine. In this context, reported estimates allow to more adequately access the risks and long-term benefits of tariff reform, and develop socially acceptable ways of its implementation.

Promising directions of further research include the analysis of tariff reform implementation stages and investigation of reform effects under new electricity market model.

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