EVALUATING THE WELFARE IMPACTS OF CHANGES IN ENERGY SUPPLY

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Overview

The operation and development of the energy sector is almost unavoidably associated with the wide range of external economic effects, such as impacts on employment, industrial output, value added, current account state, etc. All these external impacts eventually result in welfare changes (in this case, economic welfare can be considered as generalization of different economic externalities), but they fail to have proportional impact on the actual decisions that are made by market players. Actually, external benefits are sometimes used as a marketing tool to encourage the local communities in supporting the decisions, which are already taken on the basis of internal factors, such as project profitability. Nevertheless, the role of economic externalities in energy planning is strenghtening due to increasing understanding about the importance of social responsibility.

There are at least three types of external economic impacts distinguished, namely direct, indirect, and induced impacts. Direct impacts are directly associated with the project or sector under consideration. Indirect impacts are achieved on the whole supply chain, ecpecially on the supporting industries. Finally, induced effects are usually defined as the impacts of changes in household expenditures due to direct and indirect effects (e. g., increased household comsumption which is a result of additional jobs that are created by direct and indirect impacts of changes in energy sector). However, induced external economic effects can also be caused by other factors, such as changes in prices for energy resources as this factor also affects the allocations of the funds available for economic agents.

Methods

Induced and other external economic effects cannot be properly analyzed separately from the whole economic context. Therefore, computable general equilibrium (CGE) models are seen as one of the most comprehensive tools in the evaluation of economic externalities and their impact on public welfare. The relevant advantages of CGE models are their ability to capture economy-wide impacts that are result of interaction between the energy sector and remaining economy (this is very important in the case of induced impacts), and possibility to analyse both sectoral impacts and generalized welfare impacts.

However, in pure form CGE models fail to represent complexity of the energy sector. Therefore, the integration of CGE and buttom-up modelling is needed to analyse the situation in the energy sector realistically. The model used for illustrative analysis of welfare impacts is composed of two modules: energy module (buttom-up energy planning model) which represents the energy sector, and economic module (top-down CGE model) for the analysis of external economic effects and welfare impacts. Both modules are rather flexible and adjustable according to the needs of analysis and data available.

The economic module covers all economic relationships which are usually depicted in the framework of social accounting matrix. Product formation in the economic module is based on the nested structure of constant elasticity of substitution (CES) functions combined with Leontiev function for depicting of intermediate consumption, and constant elasticity of transformation (CET) function for exports. The composite energy resource is formed by coupling (using CES functions) other energy sources, district heat, natural gas, and electricity. This composite energy resource is then coupled with the composite production factor consisting of labor and capital.

Despite of the fact that the model can be used for calculation of different welfare indicators, for general assessement of welfare changes Hicksian equivalent variation (HEV) is used. This indicator shows welfare losses (or benefits) expressed as an amount of money which should be added to (or deducted from) the consumers’ income in order to ensure a utility level equivalent to the utility in the benchmark scenario.

In principle, the energy module is simplified version of conventional bottom-up energy planning models, such as MESSAGE, MARKAL/TIMES, Balmorel, etc. However, an additional mechanism has been introduced for evaluation of changes in the energy sector and their reflection in economic module. The most important property is the description of links to the remaining economy. These links describe the use of inputs from the energy model per arbitrary unit (e. g., megawatt year produced, megawatt installed) and must be depicted next to each technology which is included into the energy module. Final consumption of energy resources is another point for linking of modules, inasmuch as output of the energy module refers to energy resources that are used in production process as well as in the final energy consumption.

Results

Analysis of the current energy situation in Lithuania has shown that after closure of Ignalina nuclear power plant (due to political commitments Unit 1 was closed on December 31, 2004, whereas Unit 2 was closed on December 31, 2009) electricity generation in Lithuania declined considerably. As a consequence, country's dependency on imports of energy resources has increased. Therefore, economic analysis, which has been performed using the model developed, covers these important issues. There are two general properties of the scenarios analysed: energy structure, and prices for imported energy resources. These properties reflect different mechanisms of changes in energy supply: alterations in energy structure are mainly caused by internal factors, while import price changes are determined by external factors, insofar as Lithuania is considered as a small open economy. The benchmark scenario represents structure of the energy sector as it was in 2008. Other scenarios represent structural deviations from the base case due to either changes of prices for imported energy resources (20% increase of prices for imported natural gas or electricity were considered) or energy structure changes (closure of Ignalina NPP and development of the use of renewable energy sources up to level of 2011 in the first group of scenarios, and additional electricity import limitations in the second one).

In all key scenarios analyzed the output of agriculture, food, paper, plastic, chemical products, other non-metallic and mineral products and services decreases, whereas output of forestry, textile and transport increases. Change of output in wood and other industries depends on the nature of changes in energy supply. Increase of prices for imported electricity and natural gas has negative impact on output of wood sector in the case of unchanged structure of the energy sector (before the closure of Ignalina NPP). However, the closure of Ignalina NPP along with the development of renewable energy sources has positive impact on the output of both forestry and other industries' products even in case of growing prices for imported electricity and natural gas.

All scenarios analyzed have negative impact on economic welfare. This negative impact, depending on scenario, may reach 25-1940 million Litas (0.03-2.63 percent of base level). The negative impact of increase of imported natural gas price is stronger than the effect of imported electricity price increase in all scenarios analysed. Greater negative impact is in the scenarios of changes in energy structure rather than in the analysed scenarios with import price change only. Negative impact on the HEV of shift from energy structure in 2008 towards the structure similar to 2011 is estimated to be 1,06 percent. Limitation of imported electricity in the case of changed structure of the energy sector would increase negative impact on HEV to 1,75 percent. To sum up, the maximization of domestic electricity production is not necessarily preferable if economic welfare is considered: depending on existing energy infrastructure, domestic production of electricity can cause bigger welfare losses than electricity import. On the other hand, least-cost scenario of the energy development also not necessarily results in positive welfare changes.

Conclusions

Welfare changes caused by the changes in the energy sector can be significant. They must be analysed taking into account broad economic context and various economic interrelationships. Welfare changes as well as other external economic effects can be captured by employing CGE models for the analysis of energy development scenarios.

Calculations of aggregated welfare indicator are used in this paper as an illustration of the importance of economic externalities. However, specific external economic impacts may be more relevant in the context of other policy changes and in considerations of distributional impacts. Thus, extended cost-benefit analysis that includes the analysis of external economic effects should be conducted when energy-related decisions are considered.

Further analysis is needed to assess the impacts on different groups of the society and dynamic nature of future development of the energy sector.

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