Energy Policy 118 (2018) 69–76

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Decarbonisation perspectives for the Polish economy

Olga Kiuila

University of Warsaw, Faculty of Economic Sciences, Dluga 44/50 Str., 00-241 Warsaw, Poland

ARTICLE INFO

JEL:
C68
D58
Q43
Q58

Keywords:
Computable general equilibrium modeling
Dynamics
Energy technologies

ABSTRACT

In the coming decades the energy sector in Poland will undergo a substantial transition towards low carbon usage, which will have a predominant impact on the economy. Several modernization scenarios for energy policy are currently being discussed by the government and not yet concluded. The main objective of this paper is to provide a tool that allows to simulate such scenarios and to show the impact of decarbonisation on the whole economy. We propose an intertemporal hybrid general equilibrium modeling that incorporates energy technologies (bottom-up approach) directly into a macroeconomic structure (top-down approach). By accounting for wide adjustments in the economy, while controlling for all major constraints, the model gives a unique and detailed insight into the future shape of the energy sector and prospects of low carbon economy in Poland. Our simulation results suggest that there are no free lunches. No realistic energy mix allows to achieve sustainable positive economic growth when considerable emission reduction is to be achieved. The price on CO_2 will exceed EUR 100 for 30% emission reduction with respect to business-as-usual scenario. Gradual phase-out of coal requires focusing on biomass technology (the first best), nuclear and wind power (the second best).

1. Introduction

The Polish energy sector is dominated by electricity produced from bituminous coal and lignite (around 90%). These two types of energy sources have been developed due to substantial abundance of coal in Poland. The remaining sources of electricity production are natural gas, oil, biomass, hydro, wind, and photovoltaic (Fig. 1). There are two additional technologies (nuclear and solar) that are responsible for less than 1% of electricity supply in Poland, but this electricity is imported. In recent years the energy sector has been changing towards greater utilization of renewable resources with diminishing dependence on coal. Total production of electricity was growing from 145 TWh in 2000 to 159 TWh in 2007, but it has decreased later on due to financial crisis (IEA, 2016). The national forecast by the Ministry of Economy (2015) assumes that by 2050, 222 TWh will be achieved with coal dependence below 40%, due to nuclear energy (20%) and renewables (30%). However, a nuclear power plant was planned already 30 years ago, but never implemented.

The coal dependence in the heat production currently is of similar magnitude to that in the electricity sector. However, the official perspective does not foresee a decrease below 70% even in 2050. The only considerable change towards green economy in this sector is to double the utilization of renewables and increase the role of natural gas. In this study we concentrate on the power generation sector only, due to lack of detailed data for the heat generation sector.[1]

Polish energy sector is the main player responsible for the country's carbon emission. The main source of emission is combustion of coal (70% compared to the EU average of 30%) and petroleum products (20% vs EU average of 40%). The country is responsible for 8% of EU emission making it the sixth biggest emitter in the block. Average coal dependence is also high in comparison with the world economy, where it stands at 20% for share in total primary energy supply and 40% for electricity and heat sectors. Poland is an outlier in this regard with shares of 60% in primary energy supply and 94% in the electricity and heat sectors. The main reason is historical, as after WW2 it was decided that Polish energy security will be built on domestically available coal resources. Poland currently uses massive subsidies to boost the coal sector.

There is a broad range of studies that apply different quantitative approaches to simulate macroeconomic effects of environmental and energy policies. Even if each country faces unique challenges in its energy transition, similar concerns can be shared. The first concern is the choice of the tool to study economic effect of low carbon transition. Energy is a crucial economic input circulating in the economy, widely utilized as production factor and consumed in different forms by households. For this reason, any changes in energy sector will have a preponderant impact on the entire economy, thus partial equilibrium modeling is not always sufficient.

We propose a hybrid computable general equilibrium (CGE) modeling that incorporates energy technologies (bottom-up approach)

E-mail address: kiuila@wne.uw.edu.pl.

[1] Lack of technologies data is a common problem as described by Magil (2013).

https://doi.org/10.1016/j.enpol.2018.03.048
Received 23 May 2017; Received in revised form 19 March 2018; Accepted 20 March 2018

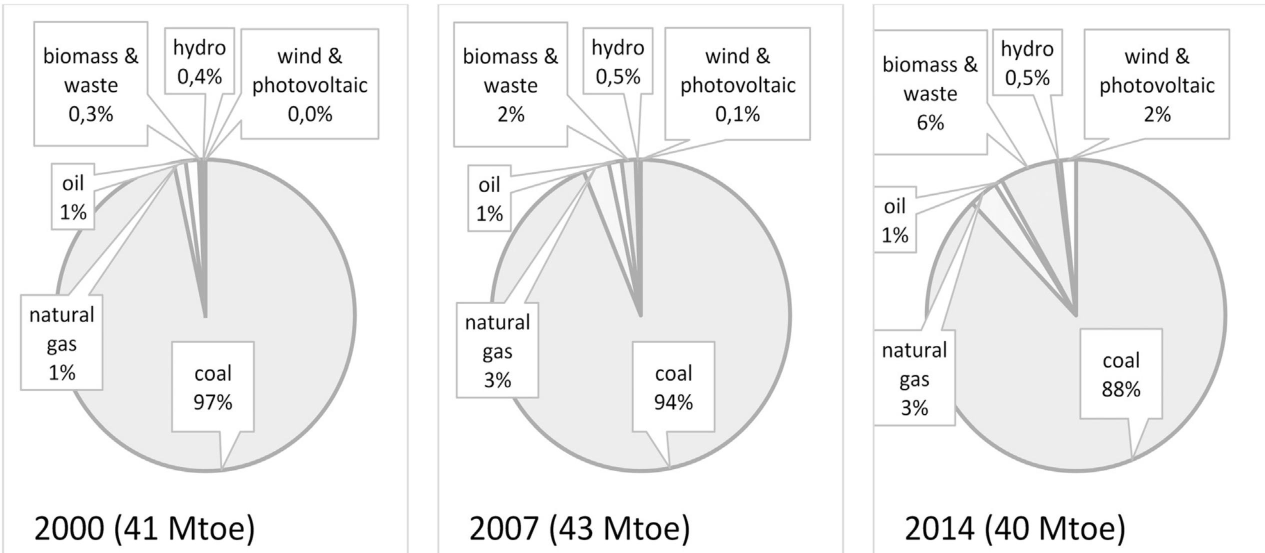

Fig. 1. Electricity generation by source in Poland.
Source: IEA (2016)

directly into macroeconomic structure (top-down approach). By accounting for wide adjustments in the economy, while controlling for all major constraints - such as energy balance and available capital stock - the model can give a unique and detailed insight into the future shape of energy sector and the low carbon economy in Poland. Technological details of bottom-up models and economic richness of top-down models formulated in a single framework allow to exploit the advantages of both model types. However, the model possesses several important limitations (no international trade, no unemployment, old database, limited amount of energy technologies). These problems will be addressed in its future versions.

Boehringer and Rutherford (2008) described the technics of hybrid modeling, where market equilibrium is formulated as a mixed complementarity problem in a static model. The complementarity approach allows to define both model types – top-down (general equilibrium) and bottom-up (partial equilibrium) – in a single mathematical format. The application of this technique into dynamic model is straightforward. We have followed this technique and specifically and applied the approach described by Kiuila and Rutherford (2013). The Authors compare two methods (economy-wide and sector-specific) and for both they found that hybrid and the traditional CGE modeling approaches yield similar results if the calibration process is precisely executed. However, the data limitations imply that precise calibration in traditional CGE modeling is usually not possible.

Poland faces unique challenges in its energy transition due to extreme dependence on coal. Nevertheless, there are many countries that are already going or will inevitably go through transition towards a low carbon economy. Markandya et al. (2015) look for trade-offs between economic growth and climate policy using dynamic CGE model for global economy. They evaluates that global carbon market can decrease the cost of emission reduction by 1% of GDP compared to the same target fulfilled just by national or regional economies. Similar conclusion was reached in Kiuila et al. (2016), a study of unilateral EU climate policy. The authors applied a static CGE global economy that was recalibrated for future periods. They showed that such unilateral policy is inefficient and insufficient to achieve the global carbon target. Mattoo et al. (2009) focused on border tax adjustments in order to correct price mechanism of domestic products in countries with active climate policy. The authors also used global dynamic CGE model for this purpose. Taking into account the last international agreement on climate change in 2016, there is a hope that there will be no need to implement such tax mechanism. The question is how much will it cost to the carbon intensive countries like Poland to fulfill the obligations.

Energy efficiency in a carbon intensive country like UK was investigated by Figus et al. (2017) using CGE analysis. They found that national energy efficiency program must include not only low income households. The increase in GDP due to energy efficiency delivers more in terms of increased household incomes than the efficiency improvement itself. Energy subsidies is another issue of climate policy that was analysed by Li et al. (2017) using a CGE model for Malaysia. Removing petroleum and gas subsidies will increase GDP by 0.6% and reduce carbon emission by 2–6%. Nong et al. (2017) have focused on Australia, a carbon-intensive country to evaluate cost of 28% carbon emission reduction using CGE model. The Authors concluded that the cost will be a 1.6% drop in GDP. Technological progress is the most important way to mitigate the pressure of carbon emissions reductions in carbon intensive countries. Dai et al. (2011) analysed this issue for China and found that electricity production based on coal will be replaced by electricity generation from oil and gas in order to achieve 30% carbon emission reduction.

There is a wide range of instruments that government may use for energy and environmental policy, but the most popular are market based instruments such as carbon tax, emission permits or subsidies for renewable energy. Kiuila and Rutherford (2013) prove that the emission permits are equivalent to carbon taxation only when no transaction costs are considered. However, market for emission permits creates a transaction cost which results in a deadweight loss higher than carbon taxation. Boussemart et al. (2017) has estimated the world shadow price of carbon at the level of 1213 and 2845 US dollars per ton in 1990 and 2011 respectively. Taking into account that the carbon price at the European market for emission permits (the biggest market in the world) has never crossed 40 US dollars, the above estimation shows that carbon abatement may become challenging at the worldwide level.

The leading approach to modeling economic effects of energy mix is general equilibrium. Mainly these are CGE models, but DSGE (dynamic stochastic general equilibrium) becomes also a popular tool for energy and environmental analysis. CGE approach is based on neoclassical theory and focuses on fiscal analysis, while DSGE is based on neokeynesian theory and focuses on monetary policy. Besides top-down modeling of energy mix used by economists, engineers focus on bottom-up approach. Bottom-up modeling is more precise for technologies analysis, but it usually fails to show the macroeconomic impact as well and the effects on factor reallocation between different non-energy sectors of production. As shown among others in Bhattacharyya (1996)