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# Slovak electricity market and the price merit order effect of photovoltaics☆

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ABSTRACT

This paper analyses Slovak electricity market with a focus on photovoltaic energy. It evaluates the impact of the solar electricity penetration into electricity mix on spot prices, seeks evidence of the merit order effect in the Slovak electricity market and quantifies it based on hourly data. The multivariate regression analysis covers the period 2011–2016. The rather small merit order effect estimated by an OLS time series model leads to the small decrease of Slovak electricity wholesale prices. This spot price reduction attributable to the photovoltaics does not outweigh the costs of the support scheme borne by end users what implies a consumer loss.

## 1. Introduction

The Slovak Republic is quite an interesting example of OECD country with a per capita globally second highest (after France) share of nuclear power electricity, a very low share of fossil electricity and a government policy driven average share of photovoltaic electricity in its electrical energy production. This article for the first time provides an overview of Slovak electrical market with a focus on photovoltaic electricity and its merit order effect.

Compared to other European countries, the Slovak Republic, especially its southern part, belongs to a relatively sunny region. This implies a good potential for solar generation (Suri et al., 2007), better than in geographically close countries of Germany or the Czech Republic, which produce significantly more solar electricity both in absolute and relative (per capita) terms. Thanks to EU Renewable Energy Directive (EC, 2009), the photovoltaics in Slovakia have been largely supported by the government policy through generous subsidies, guaranteed feed-in tariffs and legal preferential treatment (RONI, 2016a). Effort to comply with Slovak national target of reaching 24% share of renewable electricity in 2020 (MECSR, 2010) led to a Slovak installed photovoltaic capacity in Watt per capita (108) comparable to countries such as Austria (109), France (101), or Spain (114) in 2015 (SolarExpert, 2018). While photovoltaic energy is in general a subset of solar energy, there is no concentrating solar power (CSP) project in Slovakia thus in this paper these terms are interchangeable, i.e. Slovak solar means photovoltaic.

Due to very low marginal costs of solar electricity we may expect that photovoltaic development contributes to the decline of wholesale electricity prices. Indeed, in a number of countries (Australia, Spain, Italy, Ireland, Germany and others- see Section 3) this so-called merit order effect of renewables has been shown. Yet the costs of photovoltaic support schemes are borne by final consumers. In Slovakia they fall within the tariff for system operation that is incorporated in the retail price and has been pushing it upwards.

While the main research question in the empirical part of this article deals with the existence of the photovoltaic merit order effect in the Slovak electricity market, we also answer following partial research questions: What is the size of possible merit order effect? To what degree the savings attributable to the merit order effect offset the costs of the related support scheme? Although numerous studies exist concerning the above-mentioned phenomenon in a number of countries, up to now nobody has assessed the merit order effect in the Slovak electricity market.

In the rest of this study we take a look at the Slovak electricity

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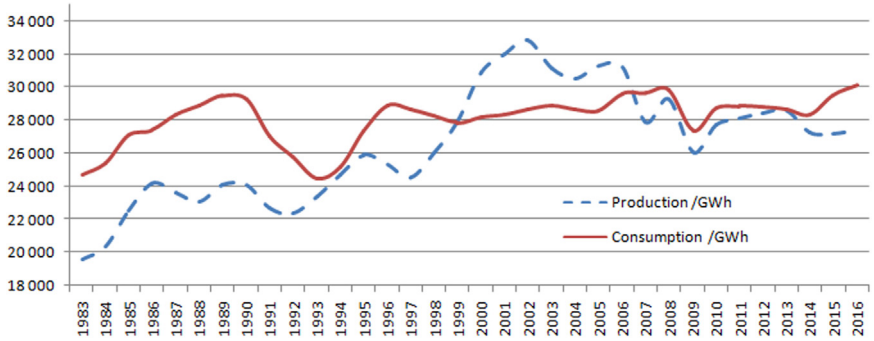


**Fig. 1.** Slovak electricity production and consumption in 1983–2016.
Source: Slovak electricity transmission system.

**Table 1**
Export and import in 2009–2016 (GWh).
Source: Slovak electricity transmission system, http://sepsas.sk/Vyroba_Spotreba.asp?kod=568

| Year | Export | Import | Balance |
|---|---|---|---|
| 2009 | 7682 | 8994 | 1312 |
| 2010 | 6293 | 7334 | 1041 |
| 2011 | 10,500 | 11,227 | 727 |
| 2012 | 13,079 | 13,472 | 393 |
| 2013 | 10,628 | 10,719 | 91 |
| 2014 | 11,862 | 12,963 | 1101 |
| 2015 | 12,611 | 14,968 | 2357 |
| 2016 | 10,598 | 13,249 | 2651 |

market (Section 2) and evaluate the impact of solar generation on spot prices over the years 2011–2016. Building on approaches described in the literature (Section 3) we construct a model (Section 4) and run an OLS regression on time series data (Section 5), the outcomes of which quantify the Slovak merit order effect and determine savings arising from a larger supply of electricity coming from photovoltaics (Section 6). We further calculate the costs and compare the results in order to conclude (Section 7) whether or not the savings outweigh the expenses and thus create a consumer surplus or loss.

## 2. Slovak electricity market

### 2.1. Production, consumption and interconnections

In Fig. 1 we summarize Slovak electricity production and consumption from 1983 to 2016. Since 1983 up to the end of 1990 the steady growth of electricity consumption was driven be energy-inefficient process of industrial development and general increase of Slovak consumption of goods and services. The sudden end of centrally planned economy after the November 1989 Velvet Revolution led to significant changes in Slovak economy which was in centrally planned Czechoslovakia oriented towards electricity intensive heavy manufacturing, in particular of military equipment. After the first few transition years and the establishment of independent Slovak Republic in 1993, the electricity consumption grew back to almost pre-transition level. Since 1996 the electricity consumption remains relatively steady, ranging from 27,386 to 30,103 GWh (the sudden drop in 2009 was due to the global crisis). However the generation is far more volatile. It went through a steady increase from 1997 to 2002 and shifted the Slovak Republic to the position of exporter for the period of 1999–2006, thanks to the nuclear power units in Mochovce newly connected to the grid in July 1998 (1st block) and December 1999 (2nd block).

Nuclear power plants do indeed play an important role in the Slovak electricity generation. After the permanent shutdown of the first nuclear power block Bohunice V1 in 2006, production fell under the level of consumption and Slovakia became a moderate importer of electricity. Note also the drop in the production in 2008 after the shutdown of the second block of Bohunice V1, and further decrease in 2009 due to the global crisis.

In 2016, the size of the measured flow of export and import was 10,598 GWh and 13,249 GWh respectively, according to the National Control Centre of Slovakia. The interchanges naturally fluctuate within a year and Slovakia might become an exporter at some point, fulfilling the needs of the Slovak energy grid and the grid of the neighbor countries (SEPS, 2018).

Focusing on the most recent years we observe a widening gap between the consumption and the production. The significance of the import has increased since 2013. The power system is, however, able to balance the difference thanks to the connections with neighbor markets – mainly the Czech Republic and Hungary, the former being the biggest exporter to Slovakia, the latter the biggest importer from Slovakia. There is also some less significant amount of electricity exchanged with Poland and Ukraine while the transmission systems of Slovakia and neighboring Austria are not connected at all. The volume of the electricity exported and imported is summarized in Table 1.

In order to facilitate the aforementioned exchanges, Slovakia became part of the 4 M Market Coupling involving the Czech Republic, Hungary and Romania in November 2014 (RONI, 2016b). The market coupling refers to integration of two or more electricity markets through an implicit cross-border allocation mechanism (ACER, 2013). It is perceived as a first step towards a fully integrated market allowing short and long term trading of energy, balancing services and security of supply across borders. This approach also contributes to higher market liquidity and optimal price volatility.

Nonetheless, in the case of Slovakia, the bidding zone remains identical with the political area of the country. It means that electricity can be transferred without requirement of transmission capacity allocation only between any two points within the Slovak Republic (Bems et al., 2016).

### 2.2. Market mechanism

Since the vertical unbundling implemented in Slovakia in 2007, competition has arisen among electricity suppliers and consumers are free in their choice (Meszaros et al., 2014). Electricity is traded as a commodity on an over-the-counter market or an exchange – in Slovakia it is the Power Exchange Central Europe (PXE, 2018), which is a part of the EEX Group since 2016. Products are usually monthly, quarterly and yearly packages, either traded on a forward (the delivery will be executed next year) or on a spot market (day-ahead basis) (Meszaros et al., 2014).

Due to the spot market nature, suppliers predict and purchase the amount of electricity they expect consumers to utilize, however, their predictions are not 100% accurate (RONI, 2016b). Thus there is always more or less electricity in the grid than necessary. The difference