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The merit order effect of Czech photovoltaic plants

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ABSTRACT

We assess the impact of photovoltaic power plants on the electricity supply curve in the Czech Republic. The merit order effect is estimated as the elasticity of electricity spot price with respect to change in supply of electricity from renewable sources. Data for the Czech electricity spot market from 2010 to 2015 are analyzed as this is the period with the steepest increase in a renewable generation capacity. The effect is estimated separately for solar and other renewable sources. We find a significant difference between these two groups. Our results show that based on hourly, daily and weekly data energy produced by Czech solar power plants does not decrease electricity spot price, creating double cost to the end consumer. However, the merit order effect based on averaged daily and weekly data is shown to exist for other renewable sources excluding solar (mainly water and wind). This contributes to the conclusion that the Czech renewables policy that prefers solar to other renewable sources may be considered as suboptimal.

1. Introduction

Photovoltaic power plants in the Czech Republic were subsidized as a part of the EU "20-20-20" energy strategy implementation. The combination of a very generous public support scheme and a significant photovoltaic technology price reduction led to a solar boom (Timilsina et al., 2012; Janda et al., 2014). Nowadays, in the Czech Republic there are four times more photovoltaic plants than wind plants (in terms of the MWh production, for details see Table 5), in spite of the fact that in other central European countries wind plants prevail. Before legislation reacted to the photovoltaic boom (by the end of 2010), the Czech installed solar capacity rose from 40 MW in 2008 to 1960 MW in 2010 (ERU, 2015). The Czech subsidy for solar electricity dropped from initial 15,565 CZK/MWh (i.e. about 620 euros) in 2006 to zero for newly built commercial photovoltaic plants in 2014 (ERU, 2013).

Progressively more ambitious goals of the Energy Strategy of the EU (2014) indicate the growing importance of energy sustainability and of renewable energy sources (RES) support. This paper contributes to the current merit order effect (MOE) discussion through the analysis of the Czech electricity market with the focus on renewable sources, in particular solar power plants.

The merit order effect of renewable energy sources stems from their almost zero short run marginal costs (SRMC) (given by the nature of sunlight, wind or water). Consider the merit order (supply) curve which ranks power plants according to their short run marginal costs. Because of very low SRMC, RES enter "first" (from the left) shifting the entire supply curve to the right. This shift of the supply curve to the right that happens when RES enter the market, ceteris paribus, causes price decrease. This is the mechanism of the merit order effect, for graphical illustration see Fig. 1. Large amounts of renewable energy may push the marginal (price setting) plant out of the market and cause a price decrease. This effect is reinforced by fixed spot demand.

The exact marginal costs differ but there is some general merit order as illustrated by Fig. 1, from the left to the right according to the typical SRMC: supported renewable sources – solar, wind, hydro –, baseload nuclear plants, lignite and coal (often marginal) and peaking gas and oil (marginal in case of no wind, no sun and high demand). Merit order curve is not "fixed" but in the short-run, it is usually fairly stable.

Given the specific Czech electricity market conditions, our analysis focuses on the photovoltaic power plants. In 2013 photovoltaic plants produced less than one quarter of the total volume of the supported energy sources in the Czech Republic but they received more than 60% of 37 billion CZK subsidies paid (OTE, 2013) as shown in Fig. 2. Current Czech RES production shares are quite surprising when compared to the predictions made before the solar boom. Back then Czech Republic expected the biomass to constitute about 80–85% of RES (Havlíčková et al., 2011).

The MOE in theory decreases electricity wholesale price (i.e. it is negative) which benefits the consumers, yet at the same time, RES causing the MOE are financed through electricity surcharge and subsidies which are passed on the end consumers, causing additional

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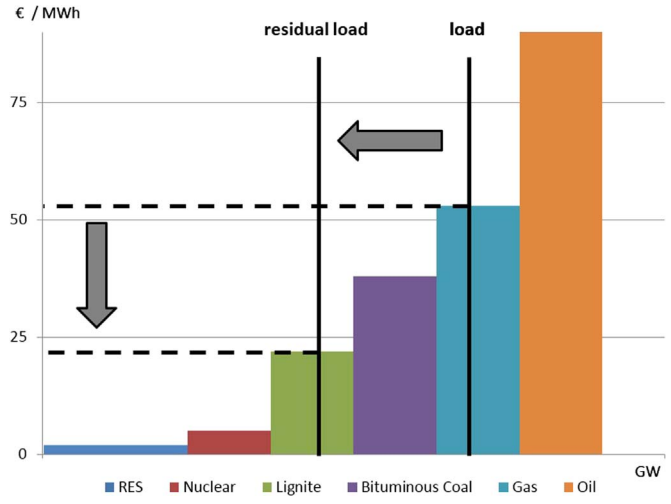

Fig. 1. Merit order effect mechanism (illustrative scheme).

costs to consumers. Thus, do benefits outweigh the costs? There are studies that claim that MOE offsets the cost of subsidies like Dillig et al. (2016) or McConnell et al. (2013), there are also studies like Clò et al. (2015) which distinguish between RES plants whose MOE counterbalances the costs of support (wind) and those that does not (solar) and finally there are studies such as Munksgaard and Morthorst (2008) that show that cost of subsidies are compensated by the MOE only to some extent. There is not a general agreement as the effect is always case specific reflecting market design, feed-in tariffs, rules and other conditions.

Our results suggest that not only is the overall Czech MOE fairly small, but in addition, it does not apply to all RES. Specifically, we find the relationship between electricity wholesale market spot price and photovoltaic production to be non negative (i.e. higher quantity does not lead to lower price). As a result, solar electricity creates a double cost to the end consumer — both through the subsidy and through the inverse merit order effect.

The rest of the paper is structured as follows. Section 2 introduces the Czech energy market and renewable sources policies. It is followed by Section 3 which focuses on the relevant literature. Section 4 describes the utilized dataset, followed by Section 5 on methodology. Section 6 presents the results, Section 7 provides further discussion of the results and Section 8 concludes.

2. Czech energy market and renewable sources policies

2.1. Market design

The Czech electricity market is characterized by a very positive attitude towards nuclear power (Keller et al., 2012), by a dominant position of brown coal in the Czech electricity generation (Bejbl et al., 2014; Recka and Scasny, 2016) and by a strong role of electricity export since the Czech Republic ranks sixth in the world and fourth in Europe in electricity exports (Sivek et al., 2012b). For the amount of Czech electricity export and its share on consumption see Table 1. In the long run Czech electricity demand is expected to grow slowly (CEPS, 2015b) but given that the country is a net exporter the reserve margin is significant, see also Table 2 on installed capacity and actual production.

Table 1
Czech electricity production, consumption and export 2010–2015.

Electricity in GWh	2010	2011	2012	2013	2014	2015
Gross production	85,910	87,561	87,574	87,065	86,003	83,888
Gross consumption	70,962	70,517	70,453	70,177	69,622	71,014
Export	14,948	17,044	17,120	16,887	16,300	12,516
Share of Export on Consumption	21%	24%	24%	24%	23%	18%

Source: ERU Annual Report on the Operation of the Energy System in the Czech Republic in 2015.

Table 2
Czech 2015 electricity production and installed capacity.

2015	Production (GWh)	Installed capacity (MW)	Installed capacity share (%)
Nuclear	26,840.8	4290.0	20
Steam	44,816.5	10,737.9	49
Combined cycle gas	2749.0	1363.3	6
Gas and combustion	3574.7	859.9	4
Water	1794.8	1087.5	5
Pumped storage	1276.0	1171.5	5
Wind	572.6	280.6	1
Photovoltaic	2263.8	2074.9	10
TOTAL	83,888.2	21,865.6	100

Source: ERU Annual Report on the Operation of the Energy System in the Czech Republic in 2015.

The difference between installed capacity and production is significant, however, better way of describing the available capacity overhang is through Fig. 3 which pictures the expected overall Czech available power in 2015 as the sum of the necessary reserves, national load (gross consumption) and what "remains" can be perceived as possible trade opportunity. Fig. 4 displays the excess supply i.e. what remains when national load and necessary reserves are covered. The expected total available production includes all planned outages and maintenance and it is based on detailed information from individual generators provided to the Czech Electricity Transmission System (CEPS, 2015b).

Full liberalization of the Czech electricity market was reached in 2006. Since then generation, transmission and distribution are vertically unbundled and consumers are free to choose their supplier.

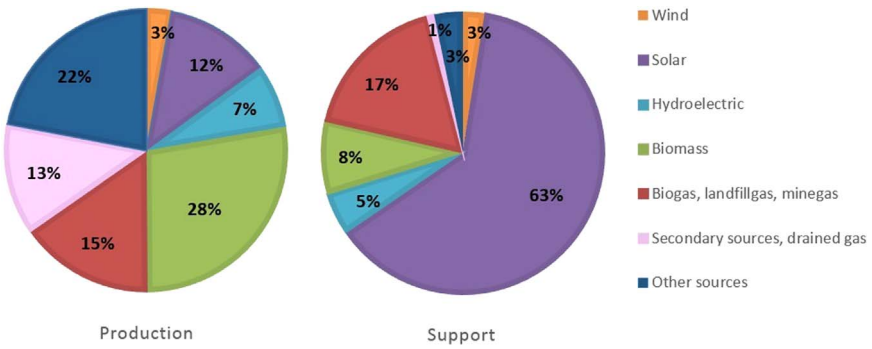

Fig. 2. Shares of volumes produced (left) and shares of support paid (right) by type of RES or secondary sources, Czech Republic, 2013. *Source*: OTE Annual Report 2013.