SPECIFIC FEATURES OF ELECTRICITY, ENERGY MARKET – PHENOMENON OF NEGATIVE PRICES

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Abstract

Features typical for the market of electricity and energy are causing a pressing issue for several reasons. Generally, governments of European countries (not only these) are already supporting sustainable resources for several decades. It is a political will and decision that it is necessary to help the electricity of renewable resources. The rationale behind this decision is essential, but lacking some circumstances that such support is including. It is possible to observe the issue of this measure and its consequences. Namely, it is a phenomenon of negative prices applied for electrical energy for wholesale. It is rather nonsense in economics that by buying any economic good, a buyer would get paid on top of obtaining, receiving a given product. This situation is observed for electricity market often, more frequently. It is a case when the market price is not serving its function. It has occurred due to measures regulating renewable energy. It is most probably the wrong solution for the new situation stemming from the introduction of new technology in the production of power, electricity. Paper explains why wholesale markets of power are sometimes using negative prices and their negative consequences. The explanation also includes the fact that negative rates are not implying cheaper energy for the consumer.

Keywords: electrical energy, negative price, renewable resources, regulation

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Introduction

Economists` opinions that have been prevailing by 2020 are in agreement about the market price being an important variable. If there is a situation of market failure[1], then the market price will not secure that the market economy would be producing an optimum quantity of goods[2]. It is often that market failure occurs for many possible reasons[3]. These reasons are described in

[1] Market failure is a situation at market when price itself is not a tool that can assure effective allocation of scare sources and consequently market produces less or more of a certain good.
[2] Terminology of good is economic one, here.
[3] For instance: existence of imperfect competition, existence of positive and negative externalities, existence of public good etc.

economic theory in detail. In these situations, it can be appropriate to "correct" market failure by government intervention, eventually by other central authority. In the case of market failure, it is the price itself that does not give correct information about the optimal production of goods. The problem of any government measures is that central authority most probably is only rarely able to identify the optimal quantity for production of a particular commodity as well as correctly set the price of a good. These problems are why a market regulation can cause more problems and damage then market if it would have been unregulated, despite the fact of market failure.

There are in praxis situations when market regulations are harmful. One of the examples is the situation of energy markets for electricity since the introduction of new technology to the praxis. That is the governments of the individual European countries (not only European) began some decades ago supporting so-called renewable resources (Zhai, Alberts, Cao, Zhao, & Yuan, 2010). After enforcement of such opinion, a political decision was met that it is needed to support "clean" production of electricity and energy. In the case of electricity production number of producers (especially traditional ones) provide huge negative externalities[4]. Details of this problem are reflected (Chvála, 2016; Haar & Haar, 2017) and among the main sources of negative externalities are coal powerplants. Thanks to its economic significance in the past it was possible for these companies to negotiate exceptions, such as toxic fossil waste "exempted from federal hazardous waste regulation" (Center, 2016; Chvála, 2016). As an example of negative externality, an illustrative fact for PM (Particulate matter) emissions (soot) from coal combustion alone "are responsible for 24.000 annual deaths in the US." (Banks, Marshall, & Schoengold, 2015). Existence of these negative externalities and exemptions, both linked to coal powerplants is in consequence possible reason for similar support as it is in case of renewable sources[5]. Detailed discussion on negative and positive externalities is a broad issue that cannot be delivered in this paper. This few sentences shall only point out that there were important reasons for support of renewable energy sources[6].

[4] Noting that positive externalities also exist. These can arise when producing power in traditional power plants – mainly in nuclear powerplants. Positive externality is for instance effective dismissal of nuclear weapons. In this respect it is up to expert discussion if Small and medium reactors – SMR - that are characterized by high security and low investment costs (compared to traditional nuclear powerplants) are or are not the future for power production. It is also a question if this SMR shall be supported as the renewable resources.

[5] Note that production of power from renewable resources can include negative externalities, e.g. changes in character of a country – wind powerplants etc.

[6] Yet, it seems that it would have been clear to use measures for internalization of negative externalities into total costs of powerplants – not to mention the emission limits and its exemptions.

The reasons for such decision were of importance though negatives were neglected. Images that such support inherently includes. Ignoring negatives makes one can observe problems caused by this supportive measure. An intriguing issue is the negative prices of electricity at wholesale markets. It is an economic question whether it is not nonsense that an act of buying of any good shall be accompanied by payment to a buyer for receiving that particular good. The character of the good can be part of the explanation, per se. The situation of this negative prices is to be observed more frequently around now (in markets with crude oil as well). It is a case when market price does not fulfil its basic function. One of the reasons is government regulation that was overstated regarding support of renewable energy. It can be argued about the degree of government solution of market failure and its negative influence at the electricity market both in economic and other terms – e.g. political terms.

Paper aims to explain why wholesale markets with electricity end up with the negative price and what are consequences of such price. The aim is as well to explain that negative rates do not mean cheaper electricity for a consumer in an examined period. Furthermore, the explanation includes uncertainty resulting from negative price. This uncertainty then leads to an undesirable decrease in investment to other than power plants supported by the government.

1 Negative price of electricity

The wholesale electricity market in the last decades is a market with a higher frequency of occurrence of negative prices[7]. A negative price is genuinely a payment of producer to a buyer for buying a particular good. It is being perceived as a regulation[8] with a negative influence on the electricity market. The negative impact of control was apparent thanks to specifics of traded good, i.e. electricity – also specifics of the entire market.

1.1 Specifics of electricity and the entire energy market

Apart from other goods electricity is a specific one, that is why measures of the central authority at this market shall be cautious.

Primary specifics of good (electricity) and the entire market of energy are the following:

1) Electricity is good that rather cannot be stored.[9] (There are options of batteries: lead-acid,

[7] In Europe it is a source of negative prices for electric energy mostly Germany due to high production in wind power plants. Naturally, this is influencing also neighboring countries, such as the Czech Republic (where number of days with negative prices has grown significantly since 2017) or in Belgium ("Elektřina," 2019).

[8] Regulation with negative influence is meant overestimated support of energy of renewable resources.

[9] The storage is not totally excludable but its possibilities and significance in terms of impact upon economy rather neglectable. Methods of electricity storage are included to intensively researched problems. If it had been

lithium-ion, saltwater – with its pros and cons that can be summarized till now as storage is too costly).

2) Electricity is good that is limited in trade. It means that individual countries can sell a limited amount of power e.g. for its neighbours regards the capacity of cross-border transmission (9), it is rather impossible that some country would buy or sell this product from or to geographically distant lands. For instance, the Czech Republic (or another European country) could hardly be buying or selling this product from or to the USA. It is due to technical limitations.

It follows from 1) and 2) that the electricity market is specific for selling what was produced immediately and consuming it also on the spot. Aside from this market ha to include geographically "close" regions and countries.

3) Electricity demand has a specific shape. Its price elasticity is close to zero. It means that in one moment, demanded quantity reacts to price absolutely at minimum (if at all)[10]. Electricity market demand depends on other variables and facts: a season of the year, the exact hour for buying and consumption (peak or night time) et cetera.

4) Electricity demand is predicable at a fairly good level.

5) At the electricity market, there are various groups of producers.

The first group of producers are traditional ones. They are producers using as inputs either one: crude oil, coal, natural gas, peat, nuclear materials as inputs.

The second group are electricity producers using renewable resources as inputs. As inputs, the producers take advantage of wind energy, sun, water, geothermal energy, biomasses in the form of biofuels and other sources of energy inflow.

Government approaches the two above mentioned groups differently. While the first group does not achieve any subsidy, the second group of producers (producers of electricity using renewable resources) is supported by the government by feed-in-tariff (so-called green

possible to store efficiently relatively huge quantity of electricity, it would had solved many problems related to shiftiness of electricity producers that are using renewable resources.

[10] In longer time span one could observe consumers` reactions (e.g. in case of households it is purchase of appliances that has lower power requirement). It is hardly estimated what proportion of consumers is motivated by electricity price when buying an appliance and what proportion is motivated by other factors (e.g. effort to behave ecologically). Apart from this it is not only a consumer decision him/herself. Conditions to meet the decision must be fulfilled for consumer, market conditions, e.g. there must be appliance that is efficient in terms of power requirements at disposal. This is why it can be concluded that in long run is the electricity demand more elastic. Its estimation is rather complicated.

bonuses). Overview of green bonuses provided by the Czech Republic for wind power plants and production of electricity from the sun, photovoltaic are shown in Tables 1 a 2. In the Czech Republic, the subsidy amount to support individual producers of power is set by the Energy regulatory office ("Elektřina," 2019).

Referring to tables one and two, individual producers are obtaining different support depending on the type of energy. Support also differs due to the establishment's year, the year of the power plant started to operate (Kongnam & Nuchprayoon, 2009). Comparing other countries` approach, which is not a merit of this paper, would provide us with information that among states are also differences.

Tab. 1: Purchase price and annual green bonuses for electricity produced by wind powerplants

Date of establishing production and operation since(including)	till (including)	Purchase price CZK/MWh	Green bonuses CZK/MWh
-	31.12.2003	4 254	3 372
1.1.2004	31.12.2004	3 843	2 961
1.1.2005	31.12.2005	3 657	2 775
1.1.2006	31.12.2006	3 338	2 456
1.1.2007	31.12.2007	3 280	2 398
1.1.2008	31.12.2008	3 200	2 318
1.1.2009	31.12.2009	2 918	2 036
1.1.2010	31.12.2010	2 730	1 848
1.1.2011	31.12.2011	2670	1 788
1.1.2012	31.12.2012	2 612	1 730
1.1.2013	31.12.2013	2 435	1 553
1.1.2014	31.12.2014	2 268	1 386
1.1.2015	31.12.2015	2 186	1 304
1.1.2016	31.12.2016	2 089	1 207
1.1.2017	31.12.2017	2 048	1 166
1.1.2018	31.12.2018	2 008	1 126
1.1.2019	31.12.2019	1 969	1 087
1.1.2020	31.12.2020	1 930	1 048

Source: ("Energetický regulační věstník,Cenové rozhodnutí Energetického regulačního úřadu č. 3/2019 ze dne 26. září 2019, kterým se stanovuje podpora pro podporované zdroje energie," 2019)

Tab. 2: Purchase price and annual green bonuses for electricity produced by photovoltaic power plants

Date of establishing production and operation since(including)	till (including)	Installed performance production in [KW] since	till (including)	Purchase price CZK/MWh	Green bonuses CZK/MWh
-	31.12.2005	-	-	8 353	7 282
1.1.2006	31.12.2007	-	-	17 096	16 548
1.1.2008	31.12.2008	-	-	17 096	16 025
1.1.2009	31.12.2009	0	30	16 040	14 805
1.1.2009	31.12.2009	30	-	15 922	14 851
1.1.2010	31.12.2010	0	30	14 939	13 704
1.1.2010	31.12.2010	30	-	14 821	13 750
1.1.2011	31.12.2011	0	30	8 963	7 728
1.1.2011	31.12.2011	30	100	7 054	5 983
1.1.2011	31.12.2011	100	-	6 573	5 502
1.1.2012	31.12.2012	0	30	7 219	5 984
1.1.2013	30.6.2013	0	5	3 917	2 682
1.1.2013	30.6.2013	5	30	3 252	2 017
1.7.2013	31.12.2013	0	5	3 434	2 200
1.7.2013	31.12.2013	5	30	2 794	1 559

Source: ("Energetický regulační věstník,Cenové rozhodnutí Energetického regulačního úřadu č. 3/2019 ze dne 26. září 2019, kterým se stanovuje podpora pro podporované zdroje energie," 2019)

The Czech Republic (the CR) was the most subsidizing country in 2015 in line with study of CEER (Regulators, 2017). It was subsidizing for renewable sources measured with weighted average support level [in EUR/MWh]. The CR did support roughly 185 EUR/MWh. There were 26 countries observed in total. France was approximately an average supporting country (108 EUR/MWh) and the United Kingdom below average (75 EUR/MWh). A fact is that 17 states did not achieve the average, i.e. (110.22 EUR/MWh) out of 26 (two-thirds were below that level).

Interesting point of view is the technology used in countries supporting renewable sources. The CR was the most supporting country (437.96 EUR/MWh measured by indices of weighted average support level) concerning the production of solar energy among European countries in 2015. It was only France that almost measured up with 254.07 EUR/MWh. Rest of the European countries were supporting less – the subsequent sum was 287.82 EUR/MWh in Italy. The lowest support was 18.52 EUR/MWh in Sweeden. Next item in power production is

wind energy, where the highest supporting country was Germany. Although it was supporting less than the CR for wind energy – onshore in 2015 (Ibid.), it was in total sum with offshore wind energy the most generous country in Europe (onshore 68.82 EUR/MWh and offshore 154.58 EUR/MWh).

Regard discussion on negative price is more important the fact, whether the government's support of electricity producers using renewable resources is not too generous and thus does not prevent the market from settling in equilibrium. For example, consider the situation on September 29th, 2019, when was the last price at the intraday market of electricity $-11.39 EUR/MWh$ at 5 p.m. and the actual exchange rate was approximately 25.84 CZK/EUR. It was evident that in such situation, also after payment of a sum for receiving electricity, this was a lump sum of about 294.3 CZK per MWh, was the production of power using renewable resources – thanks to generous support – still cost-effective[11]. Thus in this situation, producers were not in favour of limiting, decreasing their production, for they were still producing with a positive result, profit.

Another fact is that electricity produced from renewable resource depends directly on weather, e.g. wind starts/stops blowing, sunshine etc. Production is not guaranteed and producers are not reliable enough.

1.2 Some consequences derived from specifics of the electricity market

A) The first crucial problem is that electricity producers using renewable resources (PURR) are not reliable in due delivery and quantity delivered responding to requirements of consumers. Therefore, they are able to function only as a supplement of production. On the other hand, traditional electricity producers (EP) are reliable and have the technology to provide sufficient electricity for changing demand.

B) The second problem in electricity production is linked with limitations of production technology that some (mainly traditional) producers does not allow in the short-run[12] to shut down production. For some equipment, it is necessary to be continuously kept at

[11] Tables 1 and 2 valid till 1.1.2020. In this text are shown, because of clarification of government`s support valid in this time span. Example provided refers to 2019. T was in this year when producers of OZE (renewable resources) were also supported (amount of support can be found in ("Elektřina," 2019). How much was the profit of individual producer for 1MWh depends on operating costs. However, this are in case of wind power plants or photovoltaic ones low. It means that producers of OZE generated profit.

[12] It is not thought in economic terminology, i.e. short run. It is used here in sense of a few hours (during the night for instance).

least at the minimum performance (such as nuclear reactors) (Liu et al., 2017; Locatelli, Bingham, & Mancini, 2014; Mignacca & Locatelli, 2020).

EP sell at wholesale market to the operators of transmitting and distribution system (TSO). These operators must equalize electricity supply and demand on non-stop bases. In a network has to be sufficient quantity of energy to supply for every consumer and at the same time there cannot be too much of power that nobody wants so the network would not be overloaded.

In a situation where the electricity market would not be regulated at all and at the same time would be failing, the wholesale prices would have been assuring that EPs were given the right signals about the energy needs in a day. EP would have been adjusting themselves with supplied quantity. As said, demand is highly inelastic, i.e. EPs[13] have to notice in case of demand change (or its decrease or increase) the change of price and adjust the supplied quantities to the situation arising at the market. If the demand would be rising, prices would increase and would cause that supplied quantity shifts upwards. The opposite applies for the decrease in demand, prices decrease, and quantity supplied too. Changes in market prices would be the one to secure the equilibrium of the market.

As mentioned above the electricity market fails in quantity supplied and in creating negative externalities for which the government regulates it. In practice, it means that EP using renewable resources are supported in line with valid Directive of the European Parliament and of the Council (EU) 2018/2001 of December 11th 2018 on the promotion of the use of energy from renewable sources. It entered into force December 24th 2018 with transposition into national law till June 30th 2021. It is a new version of Directive 2009/28/EC and Regulation on Governance of the Energy Union and Climate action that is regulating planning and reporting of five dimensions of Energy Union including decarbonization. It also includes a goal for the European Union as a whole to achieve at least 32% ratio of energy produced from renewable sources in energy consumption by 2030.

It was shown that some EP are supported for each produced MWh. If the electricity cannot be stored and supplied quantity reacts only a little, then it gives rise to situations of negative prices at the wholesale market. Reason for which an amount provided responds only a little is the issue of electricity produced using renewable sources, where the support of government is so high that after subtracting the payment to TSO it often still increases profits of EP. These producers using renewable sources are paid out of public budget for each MWh.

[13] Demand side does not almost react to price, i.e. to adjust for equilibrium at this market it means almost always that it must be only supply side to adjust – thus supplier corrects its supplied quantity.

Such a measurement is wrong in itself. However, it is undesirable to pay such a high amount that EPs are also producing when electricity demand is minimal. Such practice of regulation in an inappropriate extent is most probably a reason for negative prices at the wholesale market.

Conclusion

A negative price is not an advantage for a consumer, for it does not provide a reduction in the consumption of electricity.

Reduction on electricity does not happen for EP are obtaining support from public resources, i.e. means that is collected from subjects of a given economy. Electricity is paid in full only the method of payment is not transparent. These means would not have to be paid, or they could have been used differently[14].

TSO must solve situations where the supplied quantity of energy in specific time sequences is significantly surpassing volume demanded and this fact is increasing costs to TSO and makes power costlier[15] in the situation described by tables 1 and 2.

Aside redistribution of means itself holds the inefficiency and increased transaction costs, i.e. it is a factor increasing the total price of electricity for subjects in the given economy.

There are reasons to assume that support of renewable energy influences the lowering of investment into traditional power plants that are necessary for the functioning of the economy. Based on this assumption, it can be expected that the market will face a shortage of traditional EP[16] that are able to produce a sufficient amount of energy during peaks. This is way then the price of electricity will increase.

1) It could be concluded that the solution to future electricity production shifts or is neglected, and thus the industry as a whole is destabilized. As it was explained, traditional EP should be providing electricity primarily, and the additional supply shall provide the electricity produced with new technologies, renewable sources. As for decision-making about which powerplants to consider for traditional EP, it should be met in time. (This investment is usually financed from public budgets.) Particular

[14] In the Czech Republic the payment supporting purchase of electricity produced using renewable resources (OZE) is include in the consumer`s payment. This payment is an item in regulated part of the price (REPUBLIKA, 2000).

[15] It is meant the total price of electricity including all payments that consumers have to pay in order to repay the support for EP.

[16] This fact can be even more significant in respect to the assumption that electricity demand will increase due to developing countries requirements over time.

traditional powerplants are producing with different technology and thus with different costs (including positive and negative externalities as well).

2) Discrimination of some EP could be noticed. This discrimination can be vindicated for externalities caused in production are different for different techniques used. Externalities are not explaining the extent of support in full. For some EP create positive externalities.

3) Other deformation and discrimination begin to arise on the market. (This some latent, hidden negative phenomenon may appear as a consequence imposing redistribution of means in an unequal way – poor versus wealthy.) It is, for instance, a case of support to installation of solar panel on top of roofs. At first sight, it might appear to be a neutral supporting measure in terms with individual subjects of the economy. In practice, it is not neutral. The solar panels can be installed for those citizens that own a house or a flat. Those who do not possess any flat nor a hose (it can also be assumed that on average, those citizens are poorer), cannot even think about the solar panels. It is also apparent that given subject, an owner of a flat, must ask for agreement of the rest of the flat owners in the block of flats (the roof is common). This means that the installation of the solar panels on the roof is more complicated (putting aside other technical and legal issues that arise in a higher block of flats or historical buildings etc.). In short, this subsidy (applied to the installation of the solar panels) can be used mostly by individual owners of houses (i.e. mostly more affluent subjects of the economy). Such redistribution of means is undesirable in the economy.

The problem of negative prices sketched, examined and framed in the fact that it influences profitability, power plants` yields and externalities linked to traditional electricity production. For the time being, it is a matter of fact that without conventional power plants, it is barely possible to secure a functional market economy. Subsidies for electricity producers using renewable resources entail problems typical for regulation as well as rather unusual consequences in the form of negative prices that can be worth discussion.

The industry of power suppliers changed the structure to monopolistic competition. Such structure advertises in order to signal quality. This quality is in the sense of renewable resources that shall cause no harm to the environment. This way differentiate the product and create a positive externality that should traditionally be conveyed to a consumer, but in

transmitting network, it is not possible to distinguish electricity, say from the nuclear power plant and wind one. Therefore, it uses the subsidies as a way of internalization of this market inefficiency.

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