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**Anna Hnydiuk-Stefan**

Opole University of Technology  
Department of Power Engineering Management  
e-mail: a.hnydiuk-stefan@po.opole.pl  
phone: +48 501 071 195

## **Analysis of Factors Affecting the Price of CO<sub>2</sub> Emission Allowances**





***Abstract.** The article presents results of a study analyzing what key factors affect the price of European Emission Allowances (EUA) and the strength of their impact. The article explains the underlying mechanism behind the correlation between these factors and EUA prices. Using such indicators as the price of Brent crude oil, coal and gas, and government auction monitor and political decisions, it is possible to make short-term, medium-term and long-term predictions of EUA prices, and consequently to plan production and profitability in companies that are obliged to participate in the emissions trading system. Owing to the complexity of principles that regulate the market and a high level of variation in the associated indicators, predictions are often very inaccurate. The probability of high EUA prices is a threat to the profitability of primary production.*

***Keywords:** CO<sub>2</sub> emissions, EU ETS, EUA, the Kyoto Protocol*

### **Introduction**

The CO<sub>2</sub> emissions trading system is one of the three mechanisms set out in the Kyoto Protocol, in addition to Joint Implementation projects (JI) and Clean Development Mechanism (CDM). All these mechanisms have been developed to counteract climate change by reducing the level of greenhouse gas emissions to the atmosphere. The most widespread of these mechanisms and one that extends beyond the timeframe of the Kyoto Protocol is the European emissions trading system (EU ETS), which is effective in EU member states. The aim of emissions



trading is to incentivise innovation and thus reduce the amount of CO<sub>2</sub> emissions. Initially, under the rules of the system, companies whose emission levels exceeded a set limit had to purchase EUA units, while those that operated efficiently could sell their surplus EUAs.

Since the emissions trading market was established in 2005, its scale has been growing rapidly and the value of transactions in 2007 reached 30 billion dollars. Some brokers predicted the market would become the largest commodity market in the world, whose value after merely one decade can reach the level of 1 trillion dollars [Kanter 2007]. Such a large market growth was unexpected for most companies obliged to participate in the system. As a result, they were unprepared to conduct a rational emissions trade and lacked the necessary knowledge about ways of effectively managing free allowances and predicting EUA prices (the so called EUA units) relative to units that had to be purchased. In addition, some companies (cement plants, sugar mills, CHP plants, steel mill, etc.) were confronted with a completely new field of activity, namely stock exchange trading.

Effective emissions management in the above mentioned sectors of the economy can be achieved by monitoring factors affecting EUA prices. The present article describes the most important factors which should be monitored to provide the basis for more accurate predictions of EUA prices, since after several years of emissions trading it is possible to identify certain market factors that can be used to predict the behavior of EUA units, which are the basic units of exchange in this relatively young market.

The article reports results of a study based on the analysis of EUA price fluctuations and how they are correlated with other commodity markets and the most important factors responsible for rises and declines in EUA prices. The results are useful above all for manufacturing companies to predict EUA price trends based on factors that most commonly affect this market.

## **1. Factors affecting the price of CO<sub>2</sub> emission allowances**

The EU emissions trading system (EU ETS) is a is one EU's policy element to combat climate change, and most of all is a key tool for reducing greenhouse gas emissions in cost effectively way. It is the first and by far the largest international carbon market.

EU ETS comprises more than 11,000 power stations and industrial plants in 31 countries, as well as airlines. The EU ETS works on the "cap and trade" principle. A "cap," or limit, is set on the total amount of certain greenhouse gases that can be emitted by installations covered by industrial plants, power stations and other energy-intensive installations in the system. For 2020 the target for emis-

sions from installations operating in the sectors included in the EU ETS is a 21% reduction compared to 2005. Under the European Commission's proposal, emissions are to be reduced by 43% by 2030. The second principle, i.e. "trade" means that companies after receiving free emission allowances from their governments can either buy extra emission allowances to cover their actual annual emissions or they can sell surplus allowance to other companies. The market also includes carbon offsets, which are allowances resulting from emissions reductions achieved in international emissions reduction projects implemented in developing countries (CDM projects) and developed countries (JI projects). By the end of April of the compliance cycle, companies obliged to participate in the emissions market have to surrender a certain number of allowances to cover the real emissions; otherwise they have to pay a penalty of 100 euro per each Mg of unsurrendered carbon permit. When a company uses efficient means of production or reduces its actual carbon emissions through modernisation, it can keep its spare carbon credits and use them to cover future emissions or sell them to another company which is short of EUAs to cover its own emissions.

The imposition of a limit on the total number of allowances available ensures that they have a market value. The European Commission believes that a sufficiently high price of carbon permits in the emissions market motivates companies to invest in clean, low-emission technologies. Another outcome is that the international trade in carbon offsets in the EU ETS market is the main driving force behind investments in clean technologies and low-emission solutions, especially in developing countries.

When EUA prices and the impact of other commodity markets are analysed, it is possible to notice a particularly high correlation between prices of Brent crude oil, gas, coal and German electricity. However, given the complexity of the emission market, any changes in the system resulting from political decisions cause considerable fluctuations and market immaturity manifests itself in frequent, large fluctuations triggered by news of possible cuts in the number of allowances available for free allocation or changes in regulations. In the light of basic economic principles, EUA prices should fall to zero once there is a large surplus of allowances of about of 2 billion tonnes even before the start of the third trading period of the Emissions Trading Scheme (Phase III), i.e. before 2012. Surprisingly, this prediction did not come true for a number of reasons explained in the remaining part of the article. A similar situation to what happened at the end of the second trading period could be observed at the end of the first trading period, when a surplus of allowances in the market drove EUA prices nearly to zero. The situation before Phase III meant that there was a surplus of 2 billion tonnes' worth of EUAs in circulation relative to the needs of all installations in the system. Prices levels in Phase I and II did not behave in the same way because of the risk associated with further developments in trading regulations, which appeared in the second period

and the fact that a large part of surplus allowances were kept in trading accounts maintained by energy-consuming installations, brokers and banks.

In addition, during the first phase there was no possibility of transferring or *banking* EUAs to be used in the second phase, which means that surplus allowances kept in accounts of companies were worthless. In contrast, surplus allowances in the second trading period could be banked and surrendered during the third phase. The most important aspects affecting the price of the market equilibrium of EUA and causing it to change will be discussed in the following part of the article.

### 2.1. Commodity markets

Prices of CO<sub>2</sub> emissions allowances vary considerably, quite like some commodities that make up the so-called energy mix. The biggest correlation was observed between the price of Brent crude oil, which causes a rise in the price of EUA units. The reason for that are positive signals indicating economic acceleration brought about by a higher demand for oil, which is used in many sectors of the economy. As a result of economic growth, energy production will be higher, which means energy producers will have to buy more EUAs.

Another indicator is the dark spread, which refers to the theoretical gross profit margin of coal-fired power plants from selling energy. Coal is the most emission-intensive fuel and requires the purchase of more EUAs by energy producers in order to cover their actual emission levels.

The dark spread of a coal-fired power plant from producing energy can be expressed by the following formula:

$$DS = P_{el} - P_c \cdot \eta_{el}, \text{ euro/MWh} \quad (1)$$

where:

$DS$  – Dark Spread, the difference between the market price of electricity and the market price of coal,

$P_{el}$  – the price of electricity,

$P_c$  – the price of coal per 1 MWh,

$\eta_{el}$  – power plant efficiency.

The profitability of electricity generated in coal-fired power stations, which accounts for the price of EUAs, is given by:

$$\text{Clean Dark Spread (CDS)} = \text{Dark Spread} - (\text{price of EUA} \times 0.96) \text{ euro/MWh}$$

Another indicator strongly correlated with EUA prices is the price of gas. In the case of drops in gas prices, prices of EUAs will start falling. This is the result of energy producers switching to gas-fired energy generation, which is less emis-

sion-intensive than coal-based generation. Hence, a fall in gas prices will result in a fall in EUA prices.

Energy generation in gas-fired power plants can be measured by means of the *Spark Spread*, which is an option traded on the stock exchange and refers to the profitability of electricity generated in gas-fired power plants. The profitability of electricity generated in gas-fired power plants is given by the formula:

$$SS = P_{el} - P_g \eta_{el}, \text{ euro/MWh} \quad (2)$$

where:

$SS$  – Spark Spread, the difference between the market price of electricity and the market price of gas,

$P_{el}$  – the price of electricity,

$P_g$  – the price of gas per 1 MWh,

$\eta_{el}$  – power plant efficiency.

The profitability of electricity generated in gas-fired power stations which accounts for the price of EUAs is given by:

$$\text{Clean Spark Spread (CSS)} = \text{Spark Spread} - (\text{price of EUA} \times 0.411) \text{ euro/MWh}$$

An increase in Spark Spread implies higher profits from burning CO<sub>2</sub>-emitting fuel per one 1 MWh, namely gas, may bring about a fall in EUA prices, resulting from a lower demand on the part of energy producers.

## 2.2. Political decisions

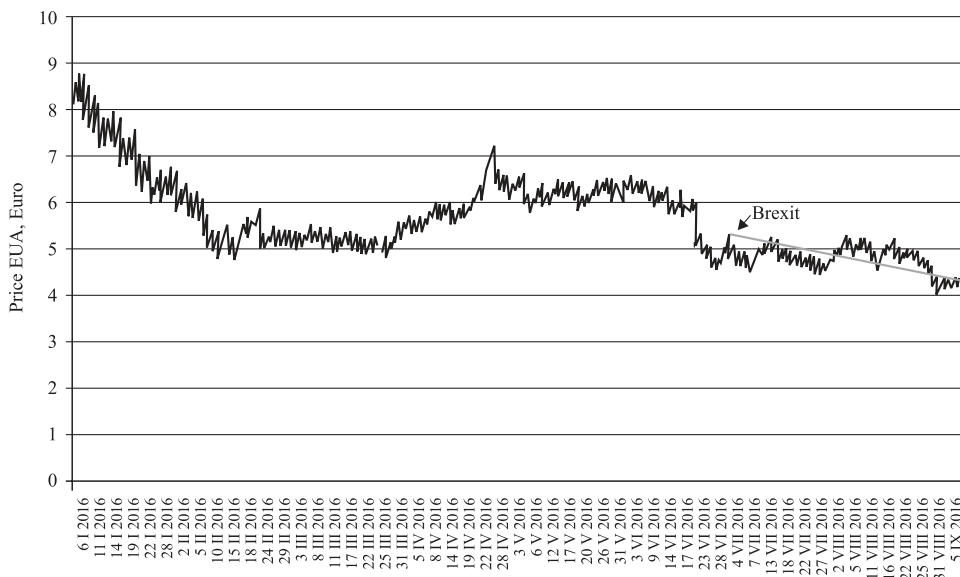
Tracking price fluctuations historically and the factors that affect them, it can be concluded that political decisions have the most significant influence on sudden rises and falls. In the absence of significant political events, the factors described in section 2.1 are the main determinants of EUA prices. However, given the fact that emissions market is still immature, it is highly vulnerable to political decisions and major events in the countries which are part of it.

Decisions of the European Commission which aim to raise the price of EUAs, such as *backloading* – an attempt to rebalance the market – have a significant impact on price fluctuations and disrupting regular price levels determined by the factors described in section 2.1.

One of the tools to limit the supply of EUAs, which will be introduced from January 2019 by the European Commission in order to affect the price of EUAs is the so-called Market Stability Reserve (MSR). It is intended to increase the effectiveness of the EU ETS by reducing the existing surplus of emission allowances. The solution is considered to be long-term and is expected to restore the system equilibrium. The idea behind it is to increase the system's resilience to

major shocks, such as the financial crisis that occurred during the second phase and adjusting the supply of allowances to be auctioned. The legislative proposal for MSR was submitted in January 2014. The date coincided with the adoption by the European Commission of a framework for the climate and energy policies until 2030. The European Parliament officially adopted the MSR on 7 July 2015 and the Council adopted it on 18 September 2015. By adopting the MSR mechanism, 900 million allowances to be auctioned in 2014–2016 are postponed or *backloaded* (i.e. withdrawn from the original auction calendar) and placed in the reserve of free allowances not allocated in the third phase. Under the MSR rules, the supply of EUAs to be auctioned is to be correlated with the demand. The total volume will be calculated annually and the number of EUA units available in the market will be announced by 15 May. The calculation will include phase II, i.e. the period when allowances could be banked. The total pool of allowances in circulation will also include certified emission reductions (CER) and emission reduction units (ERU), cancelled allowances and those transferred to the reserve. The first calculation will be made by 15 May 2017, when the surplus exceeds 833 million EUAs – 12% of surplus allowances in circulation will be transferred to the reserve (in 2021 it will be the excess supply from 2019). If the surplus falls below 400 million EUAs, allowances will be gradually released from the reserve,

Figure 1. EUA prices for 2016 showing decreases in the aftermath of the referendum about the United Kingdom's withdrawal from the European Union



Source: based on data from the ICE Exchange [www.theice.com](http://www.theice.com) [access: 12.09.2016].

increasing the number of available allowances (by 100 million EUAs annually). The gradual decrease in auction volumes will continue until 2029 and by this time the reserve is expected to grow to 3.89 billion EUAs.

The MSR regulation aims to increase the price of EUA units, since the current level in the region of 4-8 euros is too low to function as an incentive to reduce emissions in factories and trigger investment in low-emission technologies.

However, some political decisions can also cause considerable price decreases, such as the Brexit referendum, which contributed to a fall in EUAs (Figure 1). The reason for the decline was the uncertainty among investors trading in EUA futures, who are mostly based in London, just like the ICE Exchange, which accounts for 95% of EUA trade. The value of EU ETS market is not only determined by the trade in EUAs between companies obliged to participate in the system, which need EUA units to retain allocated emission limits and cover their actual emissions. A large part of allowance trading volume is in the hands of stock speculators and financial institutions trying to profit from allowance trading. This activity often results in massive sales or purchases of EUAs, which are rapid reactions to this type of speculation and cause sudden increases and declines in the value of EUAs.

### 2.3. Government auctions, the primary supply of EUAs

Government auctions are the primary supply of EUAs in the ETS. The auction calendar is planned one year in advance and the price is determined by individual auctions conducted using three auction platforms: EEX,<sup>1</sup> ICE and TGE.<sup>2</sup> Auctions can be accessed by financial institutions and direct market participants, that is energy-producing installations.

Using the Demand to Supply Ratio (DSR) for auctions it is possible to calculate the demand level for EUAs, and in this way determine the current trend. The lower the ratio, the lower the demand for EUAs, which is a negative market signal and contributes to the fall in EUA prices. When DSR is high, it contributes to price increases. This is a signal that the supply of EUAs in the market is too small to meet the existing demand.

Analyses of Phase III of ETS, which is the period when government auctions were introduced, have revealed that the price of EUAs was strongly affected by changes in volumes and dates set out in the regular auction calendar. When the regular schedule of supply in a given country is disrupted by a holiday break, there is a sudden price increase during the last auction before the break or the first one

<sup>1</sup> [www.eex.com](http://www.eex.com) [access: 12.09.2016].

<sup>2</sup> [www.tge.pl](http://www.tge.pl) [access: 12.09.2016].



after the break as a result of volume accumulation (market controlled by buyers), causing an increase in DSR.

### 3. Possibilities of predicting EUA price levels

EUA price levels are a crucial factor in production planning made by installations obliged to participate in the ETS. Given large price increases, production can even prove to be unprofitable. Because of regulations that govern this relatively young market, there are no restrictions on the upper limit of market prices. When a production company fails to cover its actual emission levels, it faces a penalty of 100 euro for each 1 Mg of CO<sub>2</sub> emissions, which can even lead to the company's bankruptcy; for this reason, the need to comply with the requirement by purchasing enough EUAs at the right time and at an optimal price is so crucial for many companies.

It is therefore extremely important to make accurate predictions of EUA price levels, which can be done by tracking indicators described in this article. Each production company should develop its own algorithm to assess the risk associated with EUA prices. The risk depends on the emission intensity.

Forecasts and risk assessment associated with EUA prices should be made in a short-term, medium-term and long-term time frame for a given time interval  $\langle 0, T \rangle$  and should include the following factors:

- price of gas,  $P_g$  – for short-term forecasting,
- price of coal,  $P_c$  – for short-term forecasting,
- price of electricity,  $P_{el}$  – for short-term forecasting,
- prices of EUAs in the primary market (government auctions),  $P_a$  – for medium-term forecasting,
- the number of EUAs in the primary market (government auctions),  $I_a$  – for medium-term forecasting,
- the possible direction of changes resulting from political decisions,  $Z$  – for long-term forecasting.

In the short term and given attractive EUA prices, allowances should be purchased on an ongoing basis in the spot market, while long-term production targets should be secured by allowances purchased in the derivatives market.

### Summary

The results of the study indicate that the price of EUAs is affected most by political decisions which determine the number of EUAs in circulation, the number of market participants and the involvement of financial firms. Other crucial factors include information from European markets, which directly influence in-

vestment decisions made by entities trading in EUAs and shape the level of energy commodities. Another important factor are prices of the energy mix in associated commodity markets, which can be important for short-term production planning. Less important, momentary changes are brought about by government auctions, which merely reflect the behaviour of commodity markets when they take place according to the regular schedule. Auctions results provide a secondary signal for market participants. Given a constant level of DSR for auctions, the signal for the market is neutral.

As shown earlier, EUA price forecasting is an extremely difficult challenge for companies obliged to participate in the ETS and is often very inaccurate because of changes in commodity markets and political decisions introducing new mechanisms that affect the price level and the number of EUAs in circulation.

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### Analiza czynników kształtujących poziom cenowy uprawnień do emisji CO<sub>2</sub>

**Streszczenie.** W artykule przedstawiono wyniki badań dotyczących wpływu najważniejszych czynników powiązanych z kształtowaniem poziomów cenowych EUA oraz przeanalizowano ich stopień oddziaływania. Wyjaśniono także mechanizm korelacji wymienionych parametrów z cenami EUA. Za sprawą wymienionych wskaźników takich jak ceny ropy Brent, węgla, gazu oraz monitoringu przebiegu aukcji rządowych i decyzji politycznych, możliwe jest prognozowanie ceny EUA w terminie krótko-, średnio- i długookresowym, a tym samym planowanie produkcji i jej opłacalności w zakładach obligatoryjnie objętych systemem handlu emisjami CO<sub>2</sub>. Z uwagi na złożoność zasad rynku oraz dużą zmienność wskaźników powiązanych, prognozowanie jest obarczone dużym błędem. Prawdopodobieństwo wystąpienia wysokich poziomów cenowych EUA jest zagrożeniem dla opłacalności podstawowej produkcji.

**Słowa kluczowe:** emisja CO<sub>2</sub>, EU ETS, EUA, Protokół z Kioto