

Anti-smog solutions and renewable energy resources development as a way to achieve low – carbon economy

Abstract. In the paper the latest power engineering technologies will be presented. Their goal is to save the environment by achieving requirements set in legal documents, such as the Paris Agreement adopted on COP 21, December 21, that replaces the expired in 2012 Kioto Protocol, the European Commission directives as well as the national normative documents. In order to achieve those requirements further efforts towards low emission economy of the EU need to be made.

Streszczenie. W referacie zostaną przedstawione najnowsze rozwiązania techniczne stosowane w nowoczesnej energetyce w celu ochrony klimatu i realizacji postanowień dokumentów, takich jak: porozumienie przyjęte na COP 21 w Paryżu w grudniu 2015 r., zastępujące wygasły w 2012 r. Protokół z Kioto, Dyrektywy przyjęte przez Komisję Europejską i zatwierdzone krajowe dokumenty normatywne. Realizacja celów zapisanych w tych dokumentach wiąże się z dalszymi wysiłkami na rzecz poprawy klimatu i dążenia do konkurencyjnej gospodarki niskoemisyjnej w UE. (**Rozwiązania antysmogowe oraz rozwój OZE jako sposób realizacji gospodarki niskowęglowej**).

Keywords: Paris Agreement, Climate Packet, renewable sources of energy (RSE), climate summit. (COP, Conference of Parties).

Słowa kluczowe: Paryskie Porozumienie, Pakiet Klimatyczny, Odnawialne Źródła Energii (OZE), szczyt klimatyczny (COP).

Introduction

At the beginning of the Match 2011 the European Commission presented a document titled: "A Roadmap for moving to a competitive low carbon economy in 2050". It contains a long – term plan for carbon dioxide emission reduction. When implemented it is expected to cause 80% reduction in greenhouse gases emission by 2050. A vast group of scientists claims that that way the worst consequences of the global warming could be avoided.

The Kioto Protocol originally expired in 2012. However all attempts to sign a new agreement have been failing from COP 14 (Poznan, Poland, 2008), to COP 17 (Durban, RSA, 2011). After long negotiations on COP 17 the new agreement term was set for 2015 and Kioto Protocol extended to 2020.

In Warsaw, November 2013, another United Nations Climate Change conference, COP 19, took place. It was participated by representatives from about 200 countries. Each of them was given a task to develop a plan for achieving a low carbon economy according to the European Commission Roadmap. The plans were presented on the following COP 20 (Lima, Peru, 2014) and the foundation for the new agreement was made.

In Paris, December 12th 2015, on COP 21 in Paris the new climate agreement, called The Paris Agreement was made. The main goal was set to keep the global warming below 2°C, and preferable 1.5°C [1] (see figure 1).

The participant countries would aim to balance the CO₂ and other greenhouse gases emissions with their removal, including forest absorption in the second half of the 21st century. The reduction of the CO₂ content via forest absorption leads to other positive side – effects, such as the improval of the water and soil quality as well as saving the biodiversity and wildlife migration prevention. The Paris Agreement is the first in the history document that obligates all the countries among the world to aim for the climate protection.

The Polish Prime Minister Beata Szydło submitted a complete documentation in New York on October 7th 2016, according to the schedule, hereby accepting and adopting the Paris Agreement. By the subsequent COP 22 the agreement was also adopted by: China, USA, Brazil, Canada, Mexico and the following EU countries: Poland, Austria, France, Germany, Hungary, Malta, Portugal and Slovakia. Because Poland was among few EU countries that adopted the agreement it could be individually represented at COP 22.

The UN conferences after the Paris Agreement

The COP 22 took place in Marrakesh (Morocco) on November 7th – 18th 2016. It was the first time the CMA (Conference of the Parties serving as the meeting of the Parties to the Paris Agreement) and CMP (Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol) participants deliberated over the climate agreements realization. The Polish delegacy, which consists of representatives of industry, science, State Forests and trade unions, took active role in negotiations because they wanted to spread the idea of forests absorption utilization to reduce the CO₂ content.

The subsequent COP 23 took place in Bonn, November 6th – 17th 2017. It was after the new president of USA, Donald Trump, made an administration of an oath. He declared that USA will withdraw from the Paris Agreement. The USA emits 16% of the worlds CO₂. This single fact may result in a need to settle a strong leadership and force the CO₂ emissions limitations to reluctant countries. Otherwise the major changes that would enable to save the Earth from deep consequences of the climate change are unlikely to happen. It applies especially to the worlds largest polluter: People republic of China (27.3% emissions), and India (6.8%) which rapidly increase the

emission rates. From 2005 to 2015 the CO₂ emission rates were reduced by following countries respectively: Poland 0.6%, Germany 0.9%, the whole EU 2%, USA 1.1%. However over the same timespan the emissions of China rose by 4.2% and of India by 6.8%. The next COP 24 was this year (2018) in Katowice, Poland.

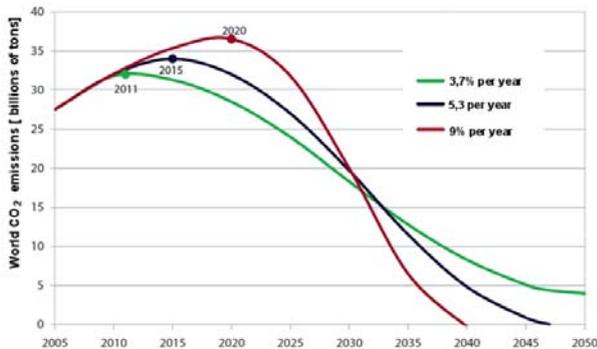


Fig. 1. The maximum rate of CO₂ emission reduction that would enable to stop the global warming at 2°C

The RSE law amendment and “Green Certificates”

The amended Renewable Sources of Energy law (RSE law) that came into force in the middle of this year (2018) regulates the very important auction system. It is a main manner to stimulate RSE investments with a goal for Poland to meet the requirements of the 3x20 Climate Packet. However it was suspended so far due to faulty regulations that allowed to receive both public and operational help independently. The amendment introduces the public accumulation rule. The investor can apply for operational help which is a guaranteed purchase price for energy for 15 years, annually risen by inflation factor. According to the accumulation rule that help should be lowered by any previously received public help, e.g. EU subsidy [2].

The amended RSE law introduces new auction system “shopping carts”:

1. First cart includes biofuels and biomass plants:
 - a. Plants running entirely on biogas gathered from landfills
 - b. Plants running entirely on biogas gathered from sewage treatment plants
 - c. Plants running entirely on biogas from source other from the mentioned above
 - d. Plants dedicated to burn biomass or hybrid plants
 - e. Multifuel plants that can run on biomass, bioliquids, biogas or agricultural biogas
 - f. Plants dedicated to burn biomass or hybrid plants of highly efficient cogeneration
2. Second cart includes power plant technologies that rely on such energy sources as:
 - a. Exclusively hydro energy
 - b. Exclusively geothermal
 - c. Exclusively sea wind energy
3. The third cart is dedicated to agricultural biogas plants
4. The fourth one includes land wind energy and solar power plants.
5. The last, fifth cart includes only hybrid power plants.

The National Fund for Environmental Protection and Water Management widely subsidizes RSE energy installations such as small water and wind power plants up to 10 MW, biogas, solar plants, energy saving and passive houses.

Table. 1. RSE plants combined power for March 31 2018 [3]

RSE plant type	Combined power			
	2015	2016	2017	2018
	MW	MW	MW	MW
Biogas	212,497	233,967	235,373	239,89
Biomass	1 122,670	1 281,065	1 362,030	1 363,570
Solar	71,031	99,098	103,896	110,563
Wind	4 582,036	5 807,416	5 848,671	5 856,818
Water	981,799	933,995	988,377	1 136,828
Combined	6970,033	8 415,541	8 538,347	8 707,769
Annual growth	941,396	1 445,508	122,,806	169,422

The Ministry of Energy, assumes that thanks to the nearest auctions mostly the investors who plan small, 1 MW and above wind farms will take advantage. They are anticipated to build wind farms of even 1 GW combined power. This year auctions should also strongly aid solar power plants of power up to 1 MW. The expected result is 750 MW of photovoltaic energy combined. Significant aid is also expected for hybrid power plants of power up to 180 MW.

The new EU electric power market regulations are expected to introduce rules for production, storage, autoconsumption and electric favor power resell for EU citizens. Those rules should favor especially roof – mounted solar panels, which dominated prosumer energy market. The key record for prosumer energy production is the 25 kW installation limit below which it is entirely free of the network charge.

Initially in the framework of so called winter pack the European Commission proposed to prioritize small energy producers as well, however the power limit for them was set for 50 kW. The newest Polish RSE law amendment also goes in this direction raising the precious micro – power plants power limit from previous 40 kW to 50 kW as well.

In the first month of 2018 the average price of green certificates in session quotes on Polish Power Exchange Market (TGE – Towarowa Gielda Energii s.a.) reached 49.05 PLN/MWh and was higher by 4.11 PLN that the average price on December 2017. It happened despite noticeably lower turnover, which on December was 1.045 TWh in comparison with 765.2 GWh on January. In first quotes from February the green certificate prices reached 50 PLN/MWh and maintain above this level since that moment. On February 6th the OZEX_A index reached 53.76 PLN/MWh while turnover was 58.3 GWh, on the next quote from February 8th these values were respectively 54.99 PLN/MWh and 91,3 GWh turnover. As this data shows the price in session quotes (OZEX_A) has a tendency to rise and almost reaches the quotes outside the session (OZEX_A_TP), which on February 8th reached 57.37 PLN/MWh with 126.4 GWh turnover.

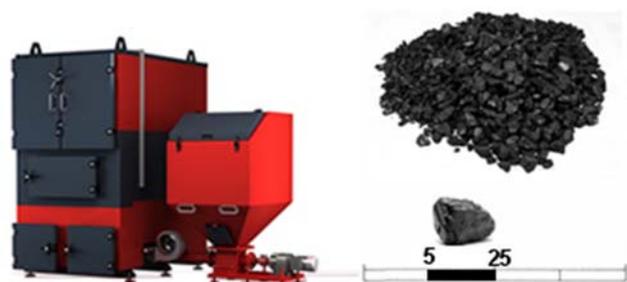


Fig. 2. Dero BIOMAX 150 kW furnaces and the eco-pea coal [4]

Modern coal power technologies

Polish electric power industry is based almost 80% on coal. The country has huge supplies of both black and brown coal. The reduction of pollution emission can be

achieved by implementing the newest technologies for domestic heating: furnaces fed with ecological fuel, the eco-pea coal (see figure 2) [4].

This solid fuel which consist of 5 to 25 mm sized grains is produced from high calorific brown or black coal of heating value $Q_d \geq 24$ MJ/kg, low sulfur content $S \leq 1\%$ and low humidity. Thanks to that when burned the SO_2 and ash byproducts are minimized. In modern furnaces it is supplied by an automatic feeders to retort burners. Such setup enables to lower the emission of CO_2 , aromatic hydrocarbons, doxins, tetrols and dust. A suitable certificate that proves the quality of the fuel is provided by the Institute for Chemical Processing of Coal in Zabrze (IChPW).

The newest achievement of scientist from IChPW in Zabrze is the low – emission coal or so – called blue coal. It is obtained by subjecting the regular type 31 and 32 black coal of heat value $Q_d = 24 \div 29$ MJ/kg to the process of almost complete degassing (se figure 3) [5].

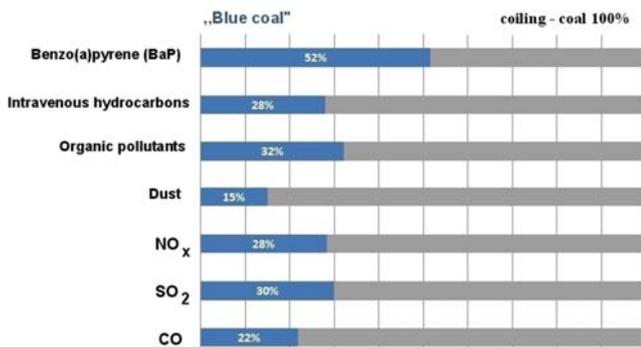


Fig. 3. The emission rates of toxic substances while burning blue coal as a percentage of emissions for regular black coal [5]

For solid fuels the sulphur, carbon, nitrogen dioxides and aromatic hydrocarbons is calculated according to the formula:

$$(1) \quad E = B \cdot w \cdot S \cdot A$$

where: B – the amount of the fuel burned in tonns, w – unit emissions for each of the polluting substances, S – sulphur content in %, A – ash content in %.

Due to previous degassing process when burned in classic furnaces (chute boilers, coal kitchens, conventional furnaces and fireplaces) the dust emission is lower by 40%, tar substances by 75% and the very toxic benzo(a)pyrene even by 90% compared to black coal. These values were reached during an on – site test in one of the Zabrze's tenements. The content of the other polluting substances compared to black coal burning were the following: $NO_x = 28\%$, $SO_2 = 30\%$, $CO = 22\%$. The blue coal is tested among others in Cracow's health estate Swoszowice (after setting up an agreement with local government), in Roszkow (Kryżanowice Municipality, near Raciborz) and in Jedlin – Zdroj, near Walbrzych. According to IChPW scientists preliminary evaluations the blue coal should be only about 10 – 20% cheaper than the eco – pea coal, while in contrast it enables to achieve great emissions reduction in almost any furnace type. The eco – pea coal to reach a similar effect requires a sophisticated, automatized therefore much more expensive furnaces, which are also more difficult to operate, especially for elderly.

Transportation

Most of the EU countries, as well as Poland, dynamically develop the electromobility. In larger cities there are already ongoing pilot programs that aim to relieve

the city centers from traditional, burdensome automobile transport. On the same time the pay-per-minute urban electric vehicle rental system is introduced for example by Vozilla in Wroclaw (Fig. 4). The rental electric vehicles are privileged for parking in he city center as they are exempt from the parking payments as well as there are special parking places dedicated only for them.



Fig. 4. The Nissan Leaf from Wroclawian electric urban car rental system Vozilla [6]

The hybrid gas-electric and entirely electric engines are transcending from individual to general transport vehicles. They are planned to be used among others in municipal services (like street cleaning and garbage collection) and some cities have already introduced such vehicles to their fleet. The further development of new tram lines is considered, especially in the areas where such projects were cancelled in the past due to lack of financing. The benefits of trams in city transport are obvious: zero emissions as well as no need for charging stations, which are required for electric cars.

There are also investments made to develop cycling infrastructure and promote cycling as a way for daily commuting. The city bike rental systems that are already operating for significant time are also further developed.

Biomass

As it was mentioned before, the first "shopping cart" of the amended RSE law was for biofuels. Poland has the largest potential for biomass production among all EU countries because it is gathered as a byproduct of agriculture (e. g. hay), animal breeding, forest and wood industry waste. The CO_2 emission reduction in agriculture have been already done to the large extent. The further reduction can be achieved by reducing the amount of the fertilizers used and better natural fertilizers usage, biogas plant construction to process the waste and the improvement of the foddors quality.

The heat value of the 1.5+2 tons biomass is equivalent to 1 ton of black coal.

Table 2. Average heat value of biomass [7]

Bomass type	Q_d , kJ/kg
Yelow hay	12 900 ÷ 15 200
Firewood	10 000 ÷ 18 000
Pellet	18 500 ÷ 21 000
Miscanthus	17 000 ÷ 19 000

The clean energy can be produced by burning the biomass alone or burning the biomass – coal mixture. In Poland several large biomass power plants have already been built, e.g. 190 MW power plant near Polaniec. The 2020 prognosis for biomass demand is 8 mln tons. Another biomass source, and therefore a way to reduce greenhouse gasses emissions, is the municipal waste segregation. The waste can be burned in thermal waste utilization boilers, producing heat as well as electricity. The appropriate installations are already built in several large cities like Konin, Białystok, Bydgoszcz, Kraków, Poznań, Szczecin, Rzeszów.

The government plan to battle pollution

The majority of the air pollution in Poland is caused by traditional way of domestic heating during the heating period, i.e. burning coal. The Polish Prime Minister Mateusz Morawiecki in September 2017 signed the Ministry of Development ordinance that banned from the market the outdated, eco – unfriendly types of coal furnaces. The law is a result of the government program to battle the smog. The ban came in life from July 2018.

On May 2nd 2018 the government funding program started to replace the obsolete coal furnaces with modern two – function gas furnaces that can both ensure hot water supply as well as heat the house. Their efficiency reaches $\eta=88\%$.

The two–function gas furnaces are also taken into consideration when constructing new buildings that cannot be connected to the central heating network either because they are too far away or because the network has no power reserves for new buildings. In such cases local boiler rooms are constructed.

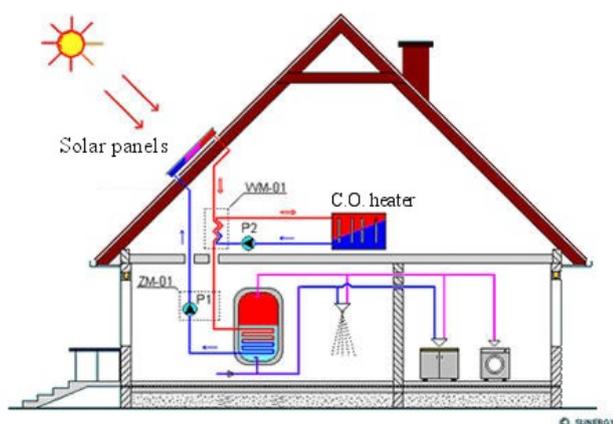


Fig. 5. The elements of heating system powered by via solar panels [8]

Another way to solve the problem with domestic heating are systems that incorporate renewable sources of energy. The most common are solar panels, either flat or vacuum – pipe type (Fig. 5). The parameters of such installation for a given family can be pretty easily estimated according to the formulas:

$$(2) \quad V = n \cdot l \cdot a$$

where: n – the number of people, l – daily consumption of hot water per person in l (a 60 l/person is typical estimate), a – the number of days in a given period (usually a year)

The energy needed to heat the water:

$$(3) \quad Q = V \cdot c_w \cdot (t_{wc} - t_{wz}) = V \cdot c_w \cdot \Delta t \cdot \eta$$

where: $c_w = 4,185 \approx 4,19$ kJ/(kg · K) – water specific heat, $\Delta t = t_{wc} - t_{wz}$ – the temperature difference between cold and hot water, typically 30°C (30 K), η – efficiency of the installation, usually 90% is assumed (0,9).

The cost of the solar heating installation according to list prices does not exceed 15 – 20 thousand PLN. The return time of the investment is about 10 – 15 years. The typical operational time of the installation is estimated for 30 – 35 years.

Another way for ecological improvement in domestic heating is electrical heating. Storage heaters can be installed that would automatically power up during the G12 tariff, the lowest one, in force during the lowest load of the National Power System.

As the air conditioning (AC) devices are more and more widely used it is worth to mention that some of them can not only cool the room during summer months, some of them can also do the opposite: provide heat during winter. Some of them can do that efficiently even down to -25°C outside temperature (some Mitsubishi models). The ratio between electrical power used and heat power transferred is marked as COP. The typical COP values are between 3 and 5. For example a COP = 3 rated AC device for each 1 kW of electrical power used will transfer 3 kW of heat power, either inside – out (cooling) or outside – in (heating).

The floor heating is also recently becoming popular. For an energy saving house the annual energy consumption on heating this way will stay below 80 kWh/m², and for passive houses below 15 kWh/m².

Conclusions

1. The Kyoto Protocol expired in 2012. Therefore on COP 21 in Paris, December 2015, with the participation of almost 200 representatives from all over the world the new climate agreement, called the Paris Agreement was settled. Its main goal is to stop the global warming before it reaches 2°C.

2. The amended RSE law came into force on the half of this year (2018) and regulates the very important auction system for renewable sources of energy. It is the main tool to stimulate the RSE investments with a long term goal to fulfill the requirements of 3x20 Climate Packet.

3. The amended RSE law introduces the public accumulation rule that replaced previous, faulty public help regulations due to which the whole project was suspended. Now the investor can apply for operational help which is a guaranteed purchase price for energy for 15 years, annually risen by inflation factor. According to the accumulation rule that help should be lowered by any previously received public help, e.g. EU subsidy.

4. The Prime Minister Mateusz Morawiecki on September 2017 signed the ordinance that banned from the market the outdated, eco – unfriendly types of coal furnaces. The law is a result of the government program to battle the smog. The ban came in life from July 2018.

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