INTRODUCTION

Energy security is serious, if not the most important, issue for EU and also whole world. Unfortunately, generation of energy is still a problem for governments and also responsible people, how to deliver enough quantity of energy without destroying our environment. The EU’s primary energy security goals are to reduce pollution of our environment without limiting needs for energy which is strictly connected with progress in economy and science. Efforts have been directed to those technologies of energy generation which are effective, cheap and also clean.

Coal-fired power plants play an important role in providing energy at low prices. The reality is that coal is abundant, efficient, and less expensive than most other energy options and will remain an important part of our energy future.

Clean coal technology describes a new generation of energy processes, which have the ability to reduce air emissions and other pollutants.

Among the key options under development for use alone or in combination are:
- Optimising existing plants so they reduce emissions and increase the amount of electricity produced with the same amount of coal.
- Looking for best-available combustion technology, which seem to be circulating fluidised-bed (CFB) technology and also supercritical and ultra supercritical combustion. This option may also include burning biomass as a fuel, thus reducing the level of CO2 emissions, and oxy-combustion for collecting CO2-rich flue gas.
- Gasification - turning coal into a gas and removing impurities from the coal gas before it is combusted.
- Carbon capture and storage (CCS) - capturing the carbon dioxide from the flue gas and storing it underground or reusing it.

Poland is one of those countries where coal and lignite are still main fuels in energy production. Power plants using those fuels deliver almost 84% (2015) of energy necessary for both economy and citizens. Of course the quantity of energy produced by renewable energy sources grows every year (it was about 6.25% in 2015r.) but still is a small part of energy market and has its own problems. [3]

Conventional power plants are currently facing many challenges, both in ensuring the balance of power for a growing economy, increased reliability and quality of power supply end customers, and fulfillment of the obligations arising from EU law in the field of emission standards.

The questions as for the type emitted pollution and its impact on the environment as well as methods of reducing these pollutants caused by thermal power plants are presented in many elaborations. The problem was and is undertaken by many scientific, social and commercial researchers for many years. The discussions which are conducted often present conflicting arguments and conclusions.

Poland has been the signatory to the United Nations Framework Convention on Climate Change (UNFCCC) since 1994 and to its Kyoto Protocol since 2002 thus joining the international efforts aiming at combating climate change. One of the main obligations resulting from ratification of the Kyoto Protocol by Poland is to reduce the greenhouse gas emissions by 6% in 2008-2012 in relation to the base year and by 20% in 2013-20 jointly with the European Union. [2]

National emission of greenhouse gases to 2014 decreased almost 40% in comparison to a base year. This is really significant decrease considering necessity of development Polish economy to obtain level similar to the strongest economies in Europe.

Polish electricity sector is still the main cause of air pollution from the combustion of fuels. Out of the major pollutants emitted in total, power plants in Poland emit 52% total pollutants where carbon dioxide (CO2) is 51.8% and nitrogen oxides (NO2) are 0.2%. [2]

By-products of thermal power plant operation must be considered in their design and operation. Waste heat energy is released directly to the atmosphere or river/lake water, or indirectly to the atmosphere using a cooling tower with river or lake water used as a cooling medium. The flue gas from combustion of the fossil fuels is discharged to the air. This gas contains carbon dioxide and water vapour, as well as other substances such as nitrogen oxides (NOx), sulphur oxides (SOx), mercury, traces of other metals, and, for coal-fired plants, fly ash. Solid waste ash from coal-fired boilers must also be removed. Some coal ash can be recycled for building materials.
1. IMPLEMENTATION OF NEW CLIMATE AND ENERGY POLICY OF THE EU AND RES FOR 2030

2020 climate & energy package

The 2020 package is a set of binding legislation to ensure the EU meets its climate and energy targets for the year 2020. The package sets three key targets:

- 20% cut in greenhouse gas emissions (from 1990 levels),
- 20% improvement in energy efficiency comparing forecast for 2020,
- 20% of EU energy from renewables

The targets were set by EU leaders in 2007 and enacted in legislation in 2009. They are also headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth.

The EU is taking action in several areas to meet the targets.

Emissions trading system (ETS)

The EU emissions trading system is the EU's key tool for cutting greenhouse gas emissions from large-scale facilities in the power and industry sectors, as well as the aviation sector.

The ETS covers around 45% of the EU's greenhouse gas emissions.

In 2020, the target is for the emissions from these sectors to be 21% lower than in 2005.

In December 2008 EU adopted the regulatory package, which contains specific legal instruments for implementation of all the above tasks in the reduction of greenhouse gas emissions and increase the use of renewable energy sources

New 2030 climate & energy package

22 January 2014 the European Commission presented proposals for a new (sharpened) package of climate and energy until 2030. She offered him two objectives:

1) reduction of greenhouse gas emissions by 40%
2) increasing the share of renewable energy sources (RES) to 27% in final energy consumption.

The idea of 40% reduction of greenhouse gas emissions in 2030 was presented in the elaboration called "Energy Roadmap 2050". The document has not been formally adopted, but will determine courses of action in the EU in this area.

At the European Council summit held on 23-24.10.2014, the leaders adopted, among other things, the new climate and energy package prepared by the European Commission in January 2014.

Poland was successful in negotiations for a system of free permissions for power sector as for CO2 for emission on the level 40% to 2030. The Council agreed.

Poland managed to, among others, negotiate the maintenance of the system of free CO2 permits for the power sector on the level of 40% by 2030.

Council approved four important objectives:

1. reducing greenhouse gas emissions by 2030, by at least 40% compared to 1990 (the EU binding target),
2. at least 27% of energy (final energy consumption) from renewable sources by 2030. (EU binding target),
3. at least 27% improvement in energy efficiency by 2030. (EU indicative target),
4. supporting the project of a full internal energy market through urgent implementation of the order of 10% inter-system electricity.

15 July 2015 the European Commission published a draft revision of the Directive on the European emissions trading scheme (EU ETS) for the period 2021-2030 with a plan to reduce emissions by 43% compared to 1990 (disputes derogations fund modernization - proposal to exclude support for power plants emitting more than .550 kg CO2 / MWh which means for all coal-fired plants).

Published in the last years the forecasted demand for electricity, elaborated by different teams and government or commercial agencies, is relatively consistent in their predictions. They predict an increase of electricity consumption in Poland from 161 TWh in 2014 to the value of 186 ÷ 190 TWh in 2025.

These figures mean that energy consumption will grow by an average of 1.3-1.5% per year, or an average of 2.3 ÷ 2.6 TWh per year. However, the last three years have brought an increase in electricity consumption by an average of less than 1.2TWh. If this trend would remain for the next years, the consumption of energy by 2025 would increase by approx. 10 TWh.

2. GENERATION OF ELECTRICITY IN COAL POWER STATION

The process of energy conversion accompanying the production of electricity in power plants can be presented as follows

Fig. 1. Types of energy conversion in thermal power plant.

The most of pollution is created during burning of fuel (in Poland this is coal or lignite), so burning is the main source of troubles for those who want reduce harmful substances

Fig. 2. Diagram of the overall conventional coal-fired power plant [4]

3. POLLUTANTS EMITTED FROM POWER PLANTS

Conventional fuel combustion at power plants leads to the emission of gases containing liquid droplets and solid particles. This mixture, called exhaust gas, is removed from electricity-generating plants in a controlled manner, through the plants’ chimneys. The main pollutants emitted from power plant chimneys are:

- Sulphur dioxide (SO2): Coal plants are responsible for public health, including by contributing to the formation of small acidic particulates that can penetrate into human lungs and be ab-
sorbed by the bloodstream. SO2 also causes acid rain, which damages crops, forests, and soils, and acidifies lakes and streams.

- Nitrogen oxides (NOx): NOx pollution causes ground level ozone, or smog, which can burn lung tissue, exacerbate asthma, and make people more susceptible to chronic respiratory diseases.
- Particulate matter: Particulate matter (also referred to as soot or fly ash) can cause chronic bronchitis, aggravated asthma, and premature death, as well as haze obstructing visibility.
- Mercury: Coal plants are responsible for more than half of human-caused emissions of mercury, a toxic heavy metal that causes brain damage and heart problems.

Other harmful pollutants emitted annually from a typical, uncontrolled coal plant are: lead, cadmium, other toxic heavy metals, and trace amounts of uranium, carbon monoxide, which causes headaches and places additional stress on people with heart disease, hydrocarbons, volatile organic compounds (VOC), which form ozone, arsenic, which may cause cancer.

4. REDUCTION OF POLLUTION FROM ELECTRICITY GENERATION

As it was said before, sulphur dioxide, nitrogen oxides, carbon dioxide and dust are those which are under strict control of European Commission, so power plants try to reduce those substances at first. But new regulations which will be obligating in not so far future will cause that some other chemical substances should be reduced. The most common heavy metal contaminants are Cd, Cr, Cu, Hg, Pb, and Zn, other is As.

The average composition of the ash from biomass, coal, lignite is presented in the table below:

Tab. 2. The average composition of the ash from biomass, coal, lignite.

<table>
<thead>
<tr>
<th>Składniki popiołu</th>
<th>Biomasa [%]</th>
<th>Węgiel brunatny [%]</th>
<th>Węgiel kamienny [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>1 - 20</td>
<td>2 - 70</td>
<td>4 - 78</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2 - 12</td>
<td>1 - 40</td>
<td>7 - 40</td>
</tr>
<tr>
<td>CaO</td>
<td>20 - 50</td>
<td>0,5 - 50</td>
<td>0,5 - 10</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0,6 - 4,5</td>
<td>0,3 - 33</td>
<td>5 - 32</td>
</tr>
<tr>
<td>MgO</td>
<td>5 - 20</td>
<td>0,3 - 11</td>
<td>2 - 7</td>
</tr>
<tr>
<td>K₂O + Na₂O</td>
<td>13 - 45</td>
<td>0,1 - 25</td>
<td>3 - 6</td>
</tr>
<tr>
<td>SO₃</td>
<td>2 - 17</td>
<td>1 - 40</td>
<td>1 - 22</td>
</tr>
</tbody>
</table>

Some other pollutants appear in dust so both combustion gas and dust need to be cleaned before going to the atmosphere.

4.1. Reduction of Sulphur dioxide (SO2)

Flue gas desulfurization is commonly known as FGD and is the technology used for removing sulphur dioxide (SO₂) from the exhaust flue gases of power plants that burn coal to produce steam for the turbines that drive their electricity generators. The most common types of FGD contact the flue gases with an alkaline sorbent such as lime or limestone.

Tab. 3. FGD technology of desulphurisation using in coal-fired plants and thermal power plants [ARE 2015]

| Instalacje odsiarczania spalin używane obecnie w polskich elektrowniach i elektrociepłowniach - źródło ARE 2015r |
|---------------------------------------------------------------|---------------------------------------------------------------|
| Elektrownia/ Elektrociepłownia                                | Stosowane metody odsiarczania spalin                          |
| El. Belchatów                                                 | mokra wapienna                                                |
| El. Jaworzno III                                              | mokra wapienna                                                |
| El. Opole                                                     | mokra wapienna                                                |
| El. Łaziska                                                   | mokra wapienna oraz półsucha                                  |
| El. Kozienice                                                 | mokra wapienna                                                |
| El. Konin                                                    | mokra wapienna                                                |
| El. Pątnów                                                   | mokra wapienna                                                |
| El. Poleniec                                                  | mokra wapienna                                                |
| El. Rybnik                                                    | mokra wapienna, półsucha oraz sucha                           |
| El. Ostrołęka                                                 | mokra wapienna                                                |
| El. Dolna Odra                                                | mokra wapienna                                                |
| EC Siekierni                                                  | mokra wapienna oraz półsucha                                  |

As sulphur dioxide is responsible for acid rain formation, stringent environmental protection regulations have been enacted in many countries to limit the amount of sulphur dioxide emissions from power plants and other industrial facilities.

The first installation of flue gas desulfurization wet lime (the IOS/ FGD) was in Poland opened in Belchatów Power Plant in 1994. This started at the same time use in Poland appropriate
meals limestone (ie. Sorbents lime) to make desulphurisation in power plants, as well as to obtain gypsum synthetic. There were build another FGD installations in next 12 power plants in Poland.

For a typical conventional coal-fired power plant, FGD technology will remove up to 99 percent of the SO2 in the flue gases.

In this method, the dust-free exhaust gas is purified in an absorber by flowing in countercurrent limestone slurry. Located in the flue gas sulfur dioxide (SO2) is reacted with calcium carbonate (CaCO3), the main syntax-prettiness limestone, resulting in a sulfate hemihydrate (IV) calcium (CaSO3 · 1 / 2H2O), followed by oxidation with air fed from the outside and after crystallization - gypsum (CaSO4 · 2H2O).

Desulphurization products are received in the form of an aqueous slurry, which is then dewatered respective tapes or vacuum filters.

Implementation of the method of desulfurization for "wet" requires a relatively high investment, however, it is characterized by high effectiveness of desulphurization (90-99%) and obtaining products fully useful economically, which is synthetic gypsum.

4.2. Control of nitrogen oxides emissions (NOx)

There are three technologies (known as De-NOx processes) available for reducing the emissions of NOx from combustion sources:
- The lowest cost combustion control technology for reducing NOx emissions is referred to as Lo-NOx and can achieve up to a 50% reduction in NOx emissions compared to uncontrolled combustion.
- The most effective, but most expensive, NOx emission reduction technology is Selective Catalytic Reduction (SCR). It can achieve 90% NOx reduction and is currently (2008) the technology of choice for achieving very low levels of NOx emissions.
- Selective non-catalytic reduction (SNCR) falls between Low-NOx and SCR in both cost and effectiveness.

4.3. Reduction of carbon dioxide (CO2)

The leading technology for significantly reducing the CO2 emissions from coal-fired power plants is known as Carbon capture and sequestration (CCS). It is currently regarded as the technology which could significantly reduce coal-fired power plant carbon dioxide emissions while also allowing the use of the Earth’s abundant coal resources to provide the increasing global need for energy. However, CCS technology is still in development and it is not expected to be ready for widespread commercial implementation until about 2020. It involves capturing the carbon dioxide produced by the combustion of coal and storing it in deep ocean areas or in underground geological structures deep within the Earth's upper crust. The capture of the carbon dioxide from the coal combustion flue gases can be accomplished by using absorbents such as amines (see Amine gas treating). The carbon dioxide is then recovered from the absorbent and compressed into a supercritical fluid at about 150 atmospheres (15 MPA), dehydrated and transported to the storage sites for injection into the underground or undersea reservoirs. Compressing the carbon dioxide into a supercritical fluid greatly increases its density which greatly reduces its volume as compared to transporting and storing the carbon dioxide as a gas.

Since the current global emissions of carbon dioxide from all energy supply sources is 28 Gt per year, the scale of carbon dioxide storage required to make a major difference in those emissions is massive.

Reducing CO2 emissions generates high costs therefore now in Poland.

SUMMARY

It should be emphasized that according to the decisions and arrangements of many conferences of the United Nations and the efforts of the European Union concerning the environment and climate, industrialized countries including Poland have undertaken intensive activities aimed at reducing the negative impact of energy sector on the environment. As a result, these countries obtained a significant improvement in the environment, mainly through:
- implementation of technical progress in the energy sector, increase the efficiency of electricity and heat;
- installation of flue gas desulphurization equipment, devices limiting emissions of NO2
- dedusting devices, etc.,
- burning higher quality types of coal,
- use in municipal more clean energy - natural gas, electricity,
- implementation of more efficient appliances in industry, transport, households, etc.

The effect of these actions is improving the situation in the environment and for the local and regional scale reducing of sulfur and nitrogen oxides emission as well as dust emissions and improving water quality. Experience has shown that emissions reductions are achievable and economically beneficial. This is all the more reason why additional steps to achieve even greater reductions in both the near- and long-term should be taken.

BIBLIOGRAFIA
3. PSE, Raport Roczny 2015.
4. Conventional coal-fired power plant,
Methods for the reduction of harmful substances in the process of energy generation

W artykule omówiony został problem wpływu szkodliwych substancji wytwarzanych w procesie generacji energii elektrycznej na środowisko. Omówione zostały podstawowe regulacje prawne opracowane przez Komisję Europejską oraz metody redukcji tych substancji.

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