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WASTE FROM THE THERMAL POWER PLANTS - SOME RECYCLING POSSIBILITIES THAT CONTRIBUTING TO ENVIRONMENTAL IMPACT MITIGATION

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Abstract

The problem of reuse, recycling and recovery of waste is our concern since at European level, is used, currently a huge amount of materials per year and per person and a significant amount of this materials become waste. The top priority is finding ways to reduce waste where possible, reuse what can be recovered, and recycle more and more amounts of waste. The paper aimed to present some possibilities of valorization of the ash and slag that results from coal (lignite) burning in the large boiler of this thermal power plant in order to achieve the mitigation of the environmental impact. These possibilities consist in experimental work there were achieve within the technological transfer project that is implemented by "Constantin Brancusi" University of Targu Jiu in partnership with industrial partner.

Key words: *bottom ash, fly ash, heavy metals, recycling, thermal power plant pollution.*

INTRODUCTION

The growth of industrial sector determined the growth of electricity demand in the last years. In the Stated Policies Scenario, global electricity demand grows at 2.1% per year to 2040, twice the rate of primary energy demand. In the Sustainable Development Scenario electricity plays an even larger role, reaching 31% of final energy consumption (Figure 1), (www.iea.org).

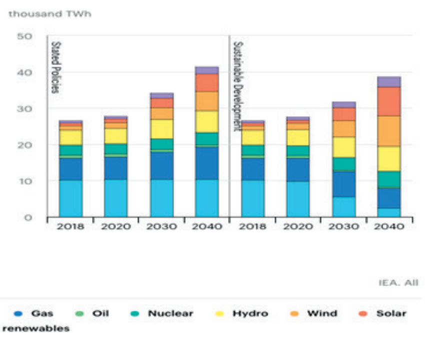

Figure 1. Electricity generation by fuel and scenario, 2018-2020

In this scenario, The Energy Strategy establishes that Romania will maintains the position of energy producer in the region and will played an active and important role in managing the situations stress at the regional level(http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

In 2016, a complex study of macroeconomic modeling, with simulation and comparison a numerous development scenario was realized.

To 2030, the results of this complex study, for the optimum scenario, looks an increase of energy production from nuclear sources from to 17.4 TWh in 2030, up to 23.2 TWh in 2035.

An increase up to 29 TWh will be recorded on total renewable sources, representing a share of 37.6% of total sources primary energy that will make up the energy mix in the year 2030 (http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

The energy produced by coal will be 15.8TWh and will representing a share of 20.6% (Figure 2) (http://energie.gov.ro/wpcontent/uploads/2019/02/NECP_EN_COM.pdf).

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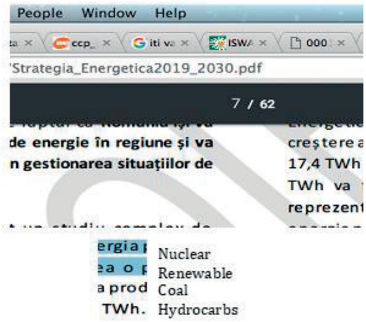

Figure 2. Evolution of energy production based on primary energy sources

In this situation the problem of coal combustion products or waste of energy production flow will still remain our concern in term of environmental factors.

The recovery, reuse and recycling are still very important and the circular economy is important too in this regard (Figure 3).

With the price of primary raw materials rising as supplies become scarcer and competition for them increases, European companies can become more competitive by cutting waste and its disposal costs, and using more recycled and recovered materials.

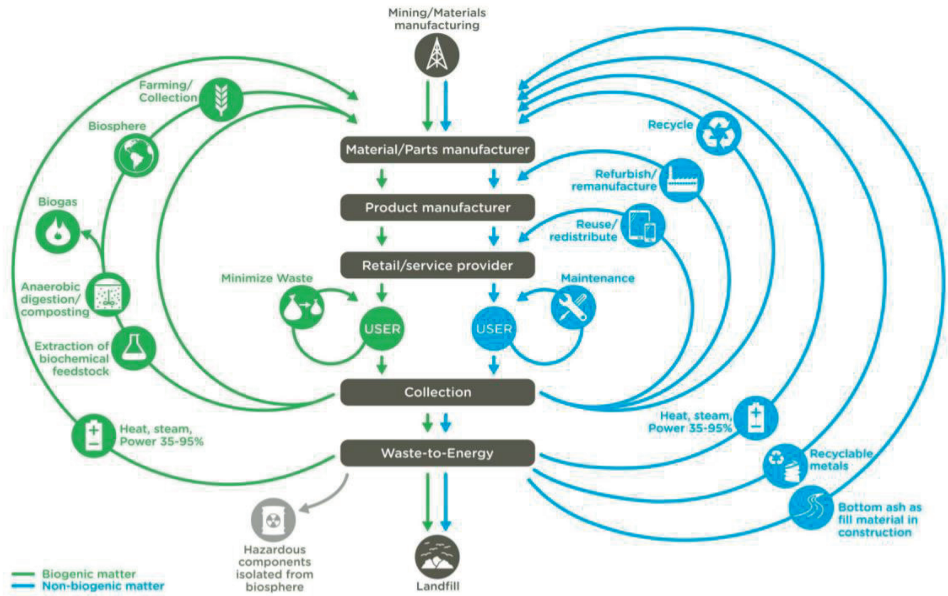

Figure 3. The circular economy concept (Ramboll K. K. et al., 2015)

Eco-innovation in industry saves money, opens up new growth opportunities and attracts customers. It is good not only for the environment but also for the economy and society (https://op.europa.eu/en/publication-detail//publication/07bba962-49c9-4992-a6a3-df826ced5ec2).

EU waste management policies aim to reduce the environmental and health impacts of waste and improve Europe's resource efficiency (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf).

The long-term goal is to turn Europe into a recycling society, avoiding waste and using unavoidable waste as a resource wherever possible (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf). The aim is to achieve much higher levels of recycling and to minimize the extraction of additional natural resources. Proper waste management is a key element in ensuring resource efficiency and the sustainable growth of European economies (https://ec.europa.eu/environment/waste/pdf/Waste%20brochure.pdf).

In the early days of the power generation industry, coal combustion products were considered to be a waste material

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(https://www.weenergies.com/environmental/ccp_handbook.pdf).

The properties of these materials were not studied or evaluated seriously and nearly all of the coal combustion products were landfilled (https://www.weenergies.com/environmental/ccp_handbook.pdf).

In the course of time, the cementitious and pozzolanic properties of fly ash were recognized and studied by several individuals and institutions (https://www.weenergies.com/environmental/ccp_handbook.pdf).

The products were tested to understand their physical properties, chemical properties and suitability as a construction material (https://www.weenergies.com/environmental/ccp_handbook.pdf).

During the last few decades these "waste" materials have seen a transformation to the status of “by-products” and more recently “products” that are sought for construction and other applications (https://www.weenergies.com/environmental/ccp_handbook.pdf).

The main coal combustion products that are generated by thermal power plant from Oltenia region are:

- bottom ash, with a diameter from 0.25 mm to 1 mm and more, which is collected at the furnace bottom;
- fly ash (with a diameter < 0.25 mm), which is collected from flue gases through electrostatic precipitators (ESP), and from there it is mixed with water and sent to a pumping station or is collected in silo in order to delivery in cement industry;
- gypsum, that results by flue gas desulfurization through introduction of wet limestone into the flue gases.

While the bottom ash and fly ash results by coal combustion into the boiler, the gypsum is producing in order to apply the regulation to reduce sulfur dioxide emission (SO_2), as can be seen in Figure 4 (Ramboll K. K. et al., 2015).

Annual, by coal combustion are generated the huge amounts of ash and slag. The usually method of coal combustion products storage is landfill that affects the important surface of the land with immediately consequences of soil, water (surface water, ground water) and air quality.

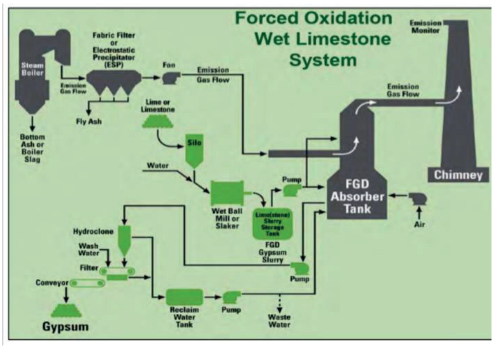

Figure 4. Coal combustion products generation (Ramboll K. K. et al., 2015)

The disposal cost of coal combustion products rose in last time due to significant changes in landfill design regulations in according with EU environmental policies. The utilization of coal combustion products in other industry as substitute of raw materials is solution to preserve existing licensed landfill capacity and thus reduces the demand for additional landfill sites.

Reusing of these coal combustion products can create many environmental, economic, and other benefits including:

- **Environmental benefits** such as reduced land surface for landfills, greenhouse gas emissions mitigation, because the replacement of natural raw material (like sand, limestone) with different kind of ashes leads to save the energy that is consumed in order to extract and processing of this natural raw material and reduced use of other natural raw materials.
- **Economic benefits** such as reduced costs associated with coal combustion products disposal, increased revenue from the sale of fly ash or gypsum, and savings from using coal ash in place of other, more costly materials.
- **Product benefits** such as improved strength, durability, and workability of different construction materials.

In term of pollution it is necessary to mention that ash and slag have a content of heavy metals and other substances that are known to be harmful to health. For example, the Thermal power plant Rovinari, that is the most important thermal power plant of Romania, generated in last three years the important amount of ash and slag, that was disposal to landfill. Also, based on the ash sample, was realized an assessment of the heavy metal content as can be seen in Table 1.

Table 1. The heavy metal quantity generated annually in last three years

Annually amounts	2017	2018	2019
Energy generated [GW]	6.442	6.072	5.667
Ash and slag disposed [millions of tons]	1.830	1.784	1.772
Mercury [kg]	55.23	51.769	34.669
Cadmium [kg]	0.078	0.0735	0.068
Arsenic [kg]	0.623	0.584	0.544
Chromium [kg]	0.566	0.530	0.495
Lead [kg]	0.653	0.612	0.571
Nickel [kg]	0.619	0.572	0.533
Zinc [kg]	0.39	0.362	0.337

The use of coal combustion products in construction industry reduces the need for raw materials, manufactured aggregates and cement.

The replacement of raw materials as natural aggregates (bottom ash can replace sand, that is mineral aggregate) and cement (cement can be replace at least partially with fly ash) helps to conserve energy and reduce emissions associated with manufacturing and processing of these materials. It is important to keep in mind that Portland cement is replaced, at least partially with fly ash, and, also it is important to mention that the amount of emission in term of CO_2 and other emissions to the atmosphere from cement production are reduced by decreasing the need for limestone calcination as well as the energy consumption.

MATERIALS AND METHODS

The amounts and qualities of coal combustion products depends of quality of coal and burned and the yield of technological flow.

The bottom ash and fly ash characterization were achieved within the project *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH, financing contract no. 92/08.09.2016, MySMIS Cod 105628* (UCBECOTECH Project).

The aim of industrial researches within this project is to realize the transfer of university know how from the previously projects ("*New building materials by eco-sustainable recycling of industrial wastes*" - EcoWASTES, LIFE10ENVRO729 project, "*Assessment of possible recycling directions of heavy & rare metals recovered from combustion waste products* - RAREASH" project) to the industrial partner in order to achieve some king of building materials (bricks, mortar, concrete, pavers, bordures) with bottom ash addition.

Usually, in construction industry are used, as basic raw materials, clay, sand, cement.

In term of chemical composition between three types of raw materials that are used in composition of construction material it can find some aspect of similarity and the different too, as is presented in the Table 2.

These similarities make possible the replacing of natural raw materials with waste form energy industry.

Table 2. Chemical composition of raw materials and coal combustion products

Raw material	Basic oxide compounds (%, mass)					
	Sio$_2$	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O+K_2O
Clay from Rovinari	63-68	14-17	5-6	0.8-1.1	1.5-1.8	4-4.5
Quarzite sand	85-89	4-5	2-3	1.5-2.5	0.4-1	1.7-2.2
Bottom ash Rovinari	40-50	16-21	8-9	9-14	2-3	1.2-3
Fly ash	14-45	10-25	4-15	15-40	3-10	0-10

RESULTS AND DISCUSSIONS

One of industrial partners that is involved in industrial researches of *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH project, is SC MACOFIL SA,* one of the largest producers of bricks made from burnt clay in Romania.

Within the works that were realised on the technological flow of SC MACOFIL SA were tested many experimental compositional variants of bricks with bottom ash content of 10% - 60%. The results of laboratory tests that were realized on the experimental bricks are present in Figures 6, 7, 8 and 9 (UCBECOTECH Project Technical Report, 2019).

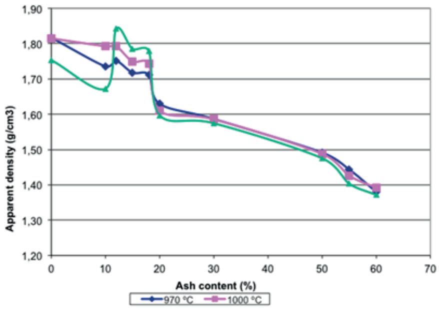

Figure 6. The variation of apparent density of processed mixture depending on the content

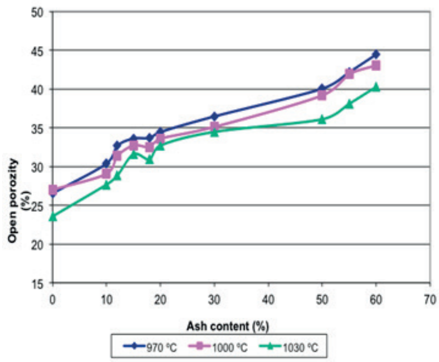

Figure 7. The variation of open porosity depending on the ash content

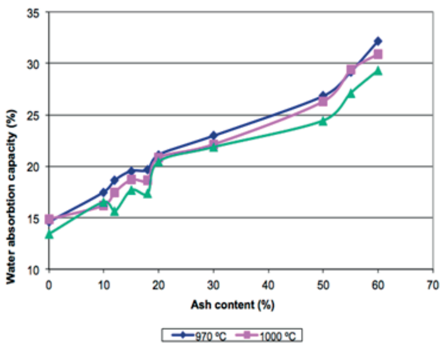

Figure 8. The variation of water absorption capacity depending on the ash content

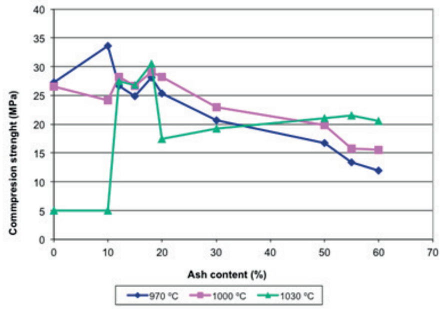

Figure 9. The variation of compression strength depending on the ash content

Following the variation of the physical parameters of the products according to the maximum temperature reached during the heat treatment, it is observed that in the case of burning at 1030ºC there are some areas of marked anomaly, especially in the compositional variants containing 10-20% ash of the power plant and more pronounced in the situation of the mechanical resistances, these being determined even by phenomena of deformation of the ceramic parts after combustion and cooling.

A first conclusion is that in the case of ash and clay mixtures, the temperature of 1030ºC represents too high a level of heat treatment, being recommended to carry out this process within a maximum of 970-1000ºC.

It is also found that the increase of the ash content in the procesed mixture determines a better stability of the products during the combustion, the argument being that of diminishing the negative effects after the combustion at 1030ºC.

In order to carry out the industrial works on the manufacturing flows of the construction bricks at MACOFIL SA, it was chosen to use 5%, 10% and 15% ash additions in the plastic mixture of extrusion molding, the results being very good.

CONCLUSIONS

The paper presented concrete solutions for the use of bottom ash in the construction materials industry, showing results of works carried out under industrial flow conditions.

Actually, the industrial research works were carried out jointly by the researchers from the university and the experts from the industrial partners SC MACOFIL SA.

The results of the performed works have responded positively to the expectations of the industrial partners, so that SC MACOFIL SA will take into consideration the introduction, in the current activity, the production of the different types of construction materials with a variable bottom ash content.

Thus, this industrial partner is an example of good practice, which will certainly be followed by other manufacturers of construction materials.

Ash and slag deposits cover large surface of land having the negative impact on the environmental because of different reasons, that where be expose above.

The recovery and reuse of power plant ashes represents an important way to reduce the impact against the environment caused by its landfill.

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