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EVALUATION OF THE ENERGY POTENTIAL OF BIOMASS AND TEXTILE WASTE FOR REPLACING FOSSIL FUELS IN THE CEMENT INDUSTRY

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1. INTRODUCTION

The utility Drisla – Skopje DOO is a public company and is the only legal landfill in the country, registered for collection, processing, and disposal of non-hazardous and hazardous waste, with a design capacity of 26,000,000 m^3. Biomass waste represents around 2% and textile waste around 5.8% of the total MSW landfilled at Drisla. The cement industry in Macedonia is permitted to use different waste types as alternative fuels, including biomass, wood, textile, RDF, plastics, paper, and packaging waste. The considered cement industry uses textile waste and biomass as alternative fuels with amount up to 35,000 tons per year for each waste type, or maximum to 35% substitution rate.

2. METHODOLOGY

The work is based on several calculations:

1) Thermal energy imported in the cement kilns using natural gas, 2) Amount of necessary alternative fuels for replacing natural gas, 3) CO_2 emissions saved by implementation of alternative fuels in the combustion process, 4) Reduction of natural gas consumption by substituting it with alternative fuels, and 5) Financial savings from reduction of natural gas consumed.

Sampling followed by elementary and technical analysis of both biomass and textile was performed before making the calculations (Tab.2).

Tab. 2. MSW ultimate and proximate analysis

Average ultimate (elementary) analysis of MSW			
Component		Content, % by weight, as rec.	Content, % by weight, dry
Carbon	C	28	37.3
Hydrogen	H	4	5.3
Oxygen	O	21.2	28.3
Nitrogen	N	0.3	0.4
Chlorine	Cl	0.2	0.3
Sulfur	S	0.3	0.4
Mineral matter	A	21	28
Moisture	W	25	0
Average proximate (technical) analysis of MSW			
Item		kJ/kg	kJ/kg
Low heating value (LHV)		10,546.50	14,839.00
High heating value (HHV)		11,475.25	15,235.56

First the natural gas consumption is defined for production of the necessary thermal energy for realization of the combustion process in the kiln and production of clinker. The value is calculated by multiplying the amount of natural gas consumed on a yearly basis with its low heating value. Different replacement ratios of textile and/or biomass versus natural gas are prescribed by the cement plant, starting with 5%, 10%, 15% and finally 20% alternative fuel used in the mix. Based on the thermal energy produced from natural gas and the prescribed percentage of replacement of alternative fuel, the thermal substitution from biomass and textile waste is defined. According to the thermal energy both fuels provide, the mass values of biomass and textile waste are calculated. Using the CO_2 emission factor from clinker production, the CO_2 emissions saved by implementing alternative fuels are generated. Additionally, the natural gas savings are calculated and expressed as financial savings considering the average gas prices per nm^3 for non-household consumers in Macedonia, defined by the Energy and Water services Regulatory Commission.

3. RESULTS

Two different alternative fuels were analyzed: (1) textile waste and, (2) biomass. Their potential to replace natural gas as an energy source for cement production was evaluated. Throughout the process of substitution of fossil fuel, the aim was to maintain the necessary operational parameters during the process and the set product quality.

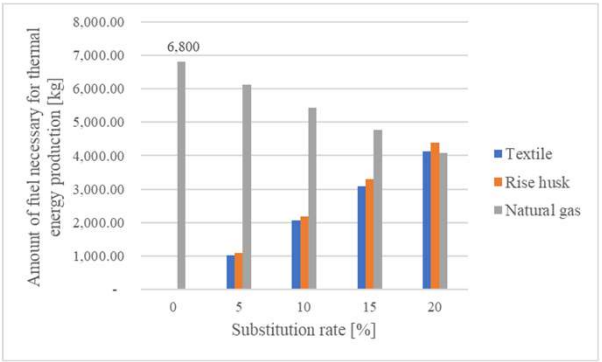

Fig. 1. Alternative fuel consumption for thermal energy production

Tab. 2. CO_2 and fuel savings based on the substitution rate

Percentage of Q to be replaced by AF	Thermal energy Q [MJ/year]	Mass of textile [tons/year]	Mass of rise husk [tons/year]	CO_2 emissions reduction [tons/year]	Cost reduction [euro/year]
5% of Q	16.75	1,029.19	1,098.36	1,155.26	940,479.67
10% of Q	33.5	2,058.37	2,196.72	2,310.52	1,880,959.35
15% of Q	50.25	3,087.56	3,295.08	3,465.77	2,821,439.02
20% of Q	67.00	4,116.74	4,393.44	4,621.03	3,761,918.70

The reduction of consumed natural gas depending on the replacement percentage was as follows: 5% alternative fuels lead to 680 tons natural gas saved, 10% - 1,360 tons, 15% - 2,040 tons, and 20% - 2,720 tons. This savings of resources generates financial benefits for the company, as follows: 5% substitution rate delivers 940,480 euro per year, 10% - 1,880,959 euro per year, 15% - 2,821,439 euro per year, and 20% - 3,761,919 euro per year. Apart from the financial aspect, the environmental aspect is analyzed, considering the CO2 emission reductions from decreased consumption of natural gas. When 5% natural gas is replaces with alternative fuels the CO_2 emissions saved are 1,155 tons per year, increasing as the percentage increases to 10% - 2,310 tons, 15% - 3,465 tons and 20% - 4,621 tons per year.

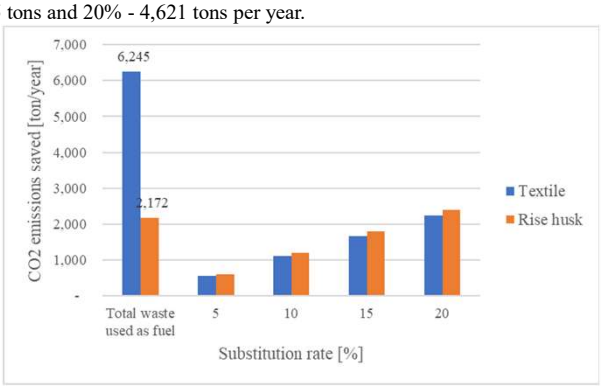

Fig. 2. CO_2 emissions reduction due to natural gas combustion reduction

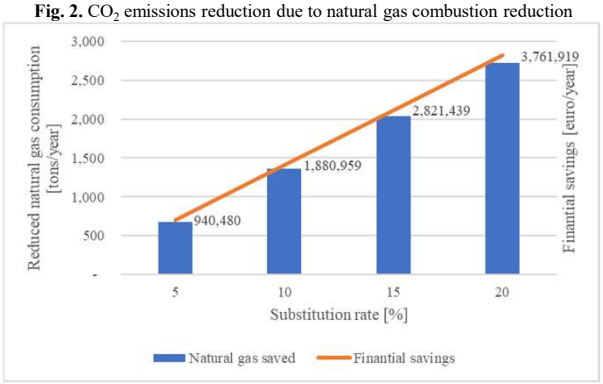

Fig. 3. Natural gas consumption reduction and derived financial savings

CONCLUSION

Implementing alternative fuels in the cement industry results in a reduced amount of fossil fuels utilized for clinker production, leading to economic savings for the company using each of the proposed waste types. Both biomass and textile waste have shown acceptable parameters for use as additive fuels in cement kilns without affecting product quality. Continuation of this analysis is necessary, as well as expansion to other waste types available on the market containing valuable properties and are in accordance with the predefined requirements of the cement plant for waste applicable as an alternative energy source.

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