Characterization, Classification and Standardization of Fly Ash of Kosovo Lignite-Fired Power Stations as Industrial Construction Product

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***ABSTRACT*:** *Kosovo generates around 6000 GWh of electrical energy annually. Over 97% of this is produced by lignite-fired power-plants and less than 3% by hydro-plants. The lignite combustion, around 8 Mt/a, besides the emission of gases, produces a residue ash, fly ash and bottom ash. Since the first operation of power-plants in 1962 up to now, this ash was removed and stockpiled as a waste without utilization, which presents a great threat as pollutant for people and environment. It is a fact that many countries utilize their fly ash as cement substitute in concrete production and/or as additive in concrete for achieving specific properties in construction sector; as fill material in road construction; industry as filler etc. But in Kosovo, the Fly ash is literally only a waste. In the world, the cement is the second most consumed substance after water, and its production emits around 5% of* CO_2 *globally; from 900* $kgCO_2/t$*- 935* $kgCO_2/t$ *of cement. The results show that for 1kg of cement substituted by 1kg fly ash, we will have 1kg less* CO_2 *in atmosphere, i.e. less green house gases, less global warming. The core part of this paper is to classify the Kosovo fly ash based on its chemical and mineralogical analyzes, and standardize this waste to an industrial product conform international standards, specifically European and American standards. If we standardize this waste to a construction product, then the utilization of Fly ash from Kosovo TPP would be of a great importance environmentally and economically.*

Keywords: *Kosovo, fly ash, characterization, classification, standardization*

I. INTRODUCTION

In Kosovo the first lignite-fired power plant unit Kosova A1 started operating in 1962 and all over the years other units A2, A3, A4, A5, and B1 and B2. These units combusting lignite as fuel generate up to 97% of electrical energy in Kosovo. This is a significant indicator that Kosovo is profoundly dependent from the energy produced by thermal power plants (TPP) since the contribution of electricity produced by hydro-power plants (HPP) is very of low with a participation of less than 3%. The orientation of Kosovo for a sustainable energy production by TPP is based on the fact that Kosovo possesses huge lignite reserves around 14 bt [1], the third place in Europe after Germany and Poland. This abundance of Kosovo with lignite as fuel has made the Kosovo Government to plan the construction of one other TPP unit "The New Kosovo", with anticipated installed capacity 1000 MW in the first phase, and with another 1000 MW in the second phase [2].This unit of New Kosovo is anticipated to be operational in 2016. Since the first operation of TPP units in 1962 till 2012, the energy production of all units sums 158,829,841 MWh [3]. This energy production annually consumes around 7-8 Mt lignite [4]. In other terms, for the production of 1 MWh of electrical energy approximately 1.4 t of lignite is consumed as fuel, i.e. 1.4t/MWh for Kosovo B units and 1.8t/MWh for Kosova A units.[3][5].

The burning process of lignite besides the emission of gases generates an amount of ash as combustion byproduct. Around 80% of this ash flies with flue gases and before exiting the stack gets captured by Electrostatic Precipitators-ESP (or electro-filters) in the form of Fly Ash. 20% of ash falls down as bottom ash. Both ashes are waste and for decades have been transported and dumped to the stockpiles; they have not been utilized at all. From the analyses of Kosovo lignite, the content of ash in lignite is around 14-17% by mass [6]. This indicates that from burning of 1ton lignite the residue ash is around 160 kg. A calculation shows that up to 2012, in Kosovo there are around 27 Mt of unutilized fly ash. Only in 2012 the lignite combustion in TPP produced around 1 Mt of fly ash. The aim of this paper is to characterize, based on its chemical and mineralogical composition, and standardize this unutilized fly ash to an industrial beneficial product and produce with it environmentally friendly concrete-green concrete.

II. ELECTRICITY GENERATION IN KOSOVO

Basically Kosovo's power demand is supplied by thermal power plants (TPP) combusting lignite as fuel and a small amount is a contribution from hydro-power plants (HPP). In terms of percentage 97% of electricity is provided by Kosovo Energy Corporation KEK (in Albanian: Korportata Energjetike e Kosovës), which is a public owned enterprise situated in the central part of Kosovo, and the 3% is supplied by low capacity HPP in different regions. [4].

Table I. Energy production by Kosovo TPP and HPP in a period from 2002-2012 [5][3]

	Energy produced by TPP		Energy produced by HPP		TPP+HPP GWh
	GWh	%	GWh	%	
2002	3151.7	97.52	80	2.48	3231.7
2003	3221.1	98.44	51	1.56	3272.1
2004	3481.1	96.88	112	3.12	3593.1
2005	3999.5	97.32	110	2.68	4109.5
2006	3970.5	97.54	100	2.46	4070.5
2007	4309.5	97.88	93.2	2.12	4402.7
2008	4505.8	98.35	75.7	1.65	4581.5
2009	5260.0	98.34	88.7	1.66	5348.7
2010	5481.0	97.94	115.5	2.06	5596.5
2011	5696.4	98.69	75.4	1.31	5771.8
2012	5847.2	98.90	65.0	1.10	5912.2

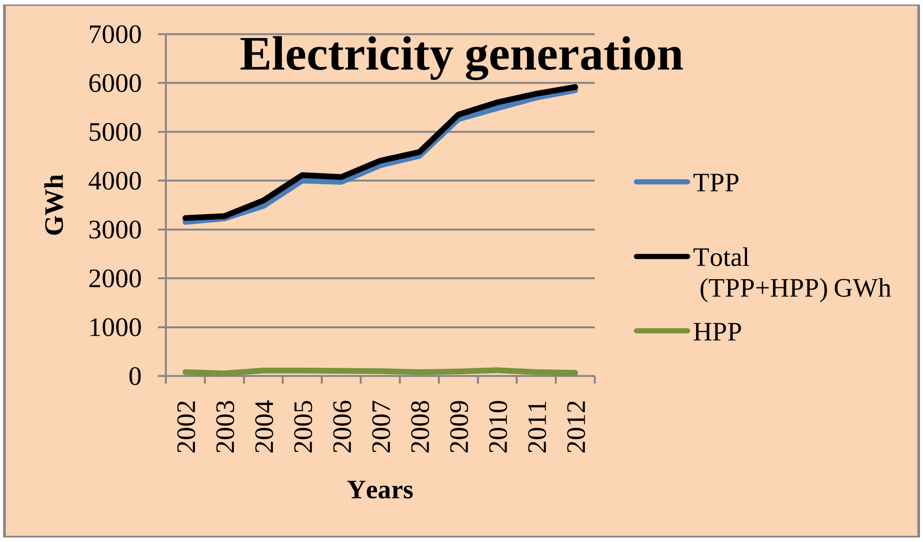

Figure1: Electricity generation from TPP and HPP in Kosovo

From the Table I and the Fig. 1 it can be seen that, for a decade, 97.98 % of electrical energy is produced by TPP and only 2.02 % is the contribution of HPP. This low electrical generation from HPP dictates the prospect of Kosovo energy to be basically oriented towards a sustainable generation from TPP.

As it is shown in Table I, the greater quantity of electrical energy in Kosovo is produced by Thermo Power Plants-lignite-fired power plants. The construction of KEK units was done over the period since 1962 till 1984. The Kosovo Energy Corporation-KEK consists of two thermal power plants Kosova A with five Units: A1, A2, A3, A4, A5 and Kosova B with two generating units: B1 and B2.

The overall installed power capacity of TPP Kosova A and B is 1478 MW and for each generating unit is given in the table below

Table II. Overview of installed capacity of Kosova (A+B) TPP [7]

TPP	**Unit**	**Commission year**	**Installed capacity MW**	**Available capacity**		**Technical minimum load MW**	
				Generator	Entry	Generator	Entry
Kosova A	A1	1962	65	0	0	0	0
	A2	1965	125	0	0	0	0
	A3	1970	200	135	110	110	100
	A4	1971	200	135	110	110	100
	A5	1975	210	135	110	100	97
Total Kosova A			800	405	330	320	297
Kosova B	B1	1983	339	290	265	200	182
	B2	1984	339	280	265	200	182
Total Kosova B			678	570	530	400	364

Since the capacity of HPP is very low, only 52.15 MW**,** in regard to the requirements in Kosovo, the electricity production generally is covered by KEK TPPs. The energy which is converted in thermo power plants to electrical energy is the energy of lignite with which Kosovo is abundant, thus lignite represents an outstanding source for energy generation in Kosovo and will remain as principal fuel for electricity generation in the long term future.

III. LIGNITE OF KOSOVO

With 14,700 Mt, Kosovo possesses the world's fifth-largest proven reserves of lignite. Lignite deposits of Kosovo are distributed across Kosova (here Kosova as a region within the Republic of Kosovo), Dukagjini and Drenica Basins. The Kosovo lignite open-cast mines are operated as one as most favorable lignite deposits in Europe due to its geological condition. The average stripping ratio for 1 ton of coal is 1.7 m^3 of top soil overburden, and the average deposits thickness of 40 m. With an average of net calorific value (NCV) of 7.8 MJ/kg, lignite of Kosovo is considered of high quality for exploitation and utilization for electricity generation. These parameters of lignite make the generation of electricity to be of a low cost comparing to the countries in region [1].

A study "Energy Strategy and Policy of Kosovo", by EU Pillar, PISG Energy Office, ranks Kosovo as third in Europe with 10000 Mt economically exploitable resource of lignite. Thus Kosovo represents one of the richest sources of lignite in Europe. In the Table IV below it is shown the ranking of some European countries based on lignite exploitable resources.

Table IV: Exploitable lignite reserves in European countries in Bt [6]

Country	Germany	Poland	Kosovo	Hungary	Turkey	Greece	Czech R.	Romania	Bulgaria	Macedonia	Slovakia	BiH	Slovenia	Spain
Bt	42.8	14.0	10.0	7.8	5.9	4.2	3.5	3.0	2.5	1.7	0.38	0.31	0.15	0.04

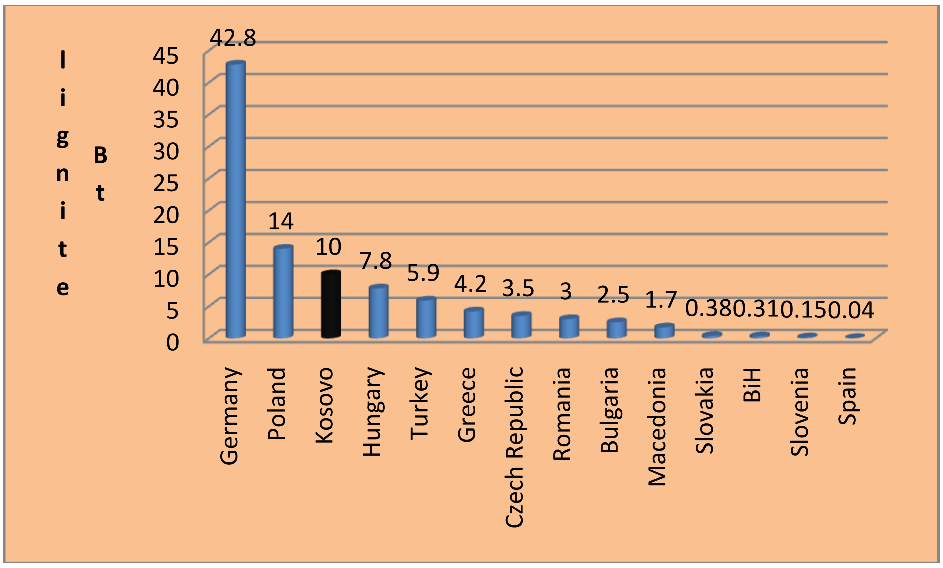

Figure 2: Lignite reserves of Kosovo comparing to European countries

Annually the lignite consumption from TPP Kosova A and TPP Kosova B is 7-8 Mt/a. The Table V below shows the annual lignite consumption for a period from 2002 to 2012.

Table V: The overall lignite consumption in TPP Kosova A and Kosova B [3][5].

	Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Lignite consumption	**Mt**	5.23	5.64	5.59	6.27	6.35	7.11	7.46	8.41	9.34	9.11	9.35

Note: The calculations for 2009, 2010, 2011 and 2012 are done from specific average of coal consumption for Kosova A 1.83 t/MWh, and Kosova B 1.4t/MWh , taking the specific average for both Kosova A and Kosovo B as 1.6 t/MWh.

In the Table VI there are presented some parameters and characteristic to feature the lignite as the main fuel used in the process of generation of electricity in Kosovo TPP

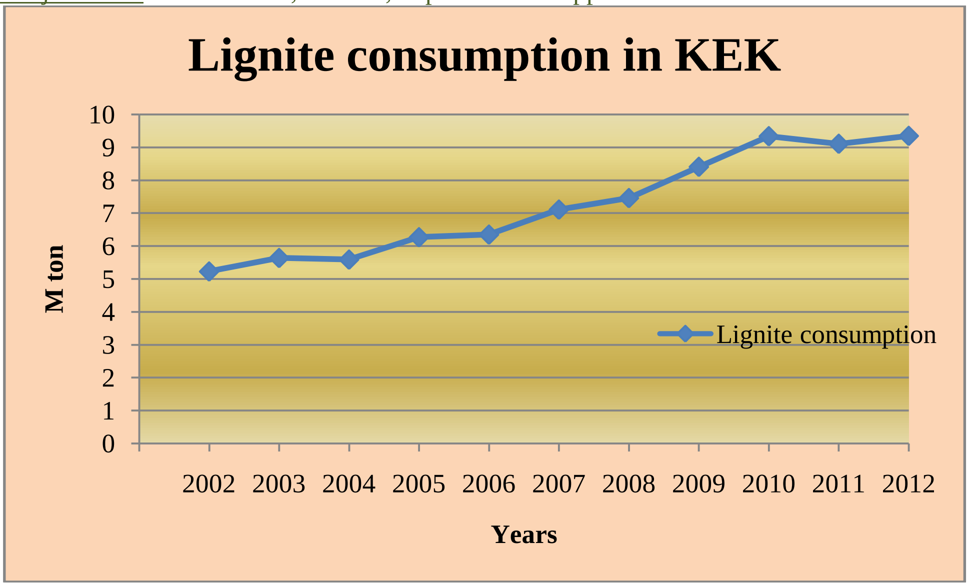

Figure 3: Total Lignite consumption in TPP Kosova A and Kosova B

Table VI: Kosovo lignite quality and parameters [6]

Ash content	12-21%. The average values 14-17%		
Moisture content	35-50%		
Heating values	Bardh -Mirash	7800 KJ/kg	
	Sibovc	8100 KJ/kg	
	Total reserves	29%	> 8.4 MJ/kg
		43%	7.7-8.4 MJ/kg
		25%	5.8-7.7 MJ/kg
Sulfur content	1 %. In all deposits/mines. The average content of combustible sulfur is 0.35%		
Lime	The concentration of lime is sufficient to absorb the SO_x gas emitted during combustion- no need for desulfurization of flue gases		

IV. FLY ASH AS LIGNITE COMBUSTION BYPRODUCT AT TPP KOSOVA A AND KOSOVA B

Lignite, after extraction from the deposits, is transported through a system of conveyers to the TPP. There it undergoes a drying process; grinding-pulverization up to baking flour sized particles and sprayed to the combustion chamber of the TPP. The pulverized lignite combustion process heats up the water steam that is beneficial for pressure steam turbine rotation and finally the generation of electrical energy in generators, which are connected to the transmission system. This is advantage and benefit of usage of lignite.

The combustion process is associated, apart from energy release, with the emission of some other combustion byproducts:

- gaseous products: carbon dioxide (CO_2), sulfur oxides (SO_X), nitrogen oxides (NO_X),
- lignite ash (particulate matter-PM): fly ash, bottom ash

The aim of this study is lignite ash that is a mineral residue from the combustion process of lignite in Kosova TPPs. The coal ash from lignite fired power plants depends from the ash content of lignite and boiler operation. The emission of PM for the coal with high ash content depends more on the coal ash than combustion efficiency [8], whilst the coal, lignite in this case, with low ash content depends more on the combustion efficiency.

Bottom ash, which represents 10-15% [9] of the overall coal ash, is a coarse granular ash almost sand like material. It is the noncombustible residue of lignite combustion. It is called bottom ash because during the high temperature combustion, some of the ash melts and accumulates on the boilers walls and steam tubes and then it is collected from the bottom of the boiler where the combustion takes place.

Fly ash is also a noncombustible residue from the combustion of lignite in the TPP. It is the finest of coal ash particles which constitutes 85-90% of the overall ash. [9]

The control of dust (PM) in most lignite fired TPP is done through Electrostatic precipitators (ESP). The designed efficiency of ESP in TPP B is 99.14 %, for TPP 98% [10]. The fly ash is carried together with other flue gases (this why it is called "**fly**") and before exiting the stack it is collected by ESP.

Fly ash features cementitious (property of a material to harden when mixed with water) and pozzolanic (the property of material that in the presence water reacts with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. The definition of fly ash in EN 450-1[11], which is the European standard for Fly ash in Concrete, is:

"Fine powder of manly spherical, glassy particles derived from burning of pulverized coal, with or without co-combustion materials, which has pozzolanic properties and consists essentially of SiO_2 and Al_2O_3" [11].
The properties of fly ash resulting from its chemical composition and reaction make it of a great use either in concrete production as cement substitute or aggregate.
As it is known that in the world, the cement is the second most consumed substance after water [12][13], and during the cement production a great quantity of CO_2 is emitted, approximately from 900 kgCO2/t- 935 kgCO2/t of cement. This means that for 1kg of cement replaced by 1kg Fly ash, we have 1kg less CO2 released in our air we breath, i.e. less green house gas, less global warming [14].
Many countries in the world utilize Fly ash (and bottom ash as aggregate substitute) as cement replacement in concrete production and as additive in concrete to archive specific properties in construction sector; as fill material in road construction; industry as filler in plastic, paint sealing material etc. But in Kosovo, the Fly ash is literally only a waste with health and environmental consequences.
The core part of this paper is to classify and standardize this waste to a product conform other international recognized standards, specifically European and American standards. If we standardize this waste to a construction product, then the utilization of Fly ash from KEK TPP would be of a great importance, economically and environmentally, for Kosovo industry and environment. Up to now, there is no evidence of its utilization in Kosovo, i.e. our Fly ash is only a threatening waste that waits for exploitation.

V. FLY ASH OF KOSOVA B TPP

Fly ash as a residue of combustion of lignite for generating electrical energy comprises of fine particles that rise with flue gases, but these particle (Particulate matter) before exiting the stack get captured by ESP or electro-filters, and then can be carried to storage or silos. In Kosovo none of these, the fly ash is stockpiled ore better said dumped.

The sample for analyses are taken from Kosovo B TPP and the chemical, physical and mineralogical analyses were conducted at laboratory **ZAG, Department of materials, Laboratory for cement, mortar and ceramics, Lubljana, Slovenia**. The analyses were conducted in conformity with European Standards SIST EN 450-1:2005 5.2 and 5.3 [11].

Conform EN 450-1 the fly ash is defined as Fine powder of mainly spherical, glassy particles derived from burning of pulverized coal, with or without co-combustion material, which has pozzolanic properties and consists essentially of SIO_2 and Al_2O_3.

According to ASTM C618 12a [15], Standard chemical requirements there are two classes of fly ash determined by the content by mass of lime:
- Class F: lime (CaO) content less than 20% by mass
- Class C: lime (CaO) content more than 20% by mass

5.1. Chemical composition of Kosovo Fly Ash

Table VII: Chemical composition of TPP Kosova B Fly Ash.

Constituent	% by mass	Requirements of SIST EN 450-1 cl.5.2	Test method
Loss on ignition	**2.09**	≤5.0%, A category	SIST EN 196-2 cl. 7
SiO_2 total	**29.7**	≥75%*	SIST EN 196-2 cl.13.6
SiO_2soluble	**0.27**		SIST EN 196-2 cl. 13.8
Al_2O_3	**10.65**		SIST EN 196-2 cl.13.11
Fe_2O_3	**6.18**		SIST EN 196-2 cl. 13.10
CaO	**32.92**	-	SIST EN 197-1 cl.3.1
MgO	**5.93**	≤4.0%	SIST EN 196-2 cl. 13.13
SO_3	**9.98**	≤3.0%	SIST EN 196-2 cl. 8
Na_2O	**0.74**	-	SIST EN 196-2 cl. 17
K_2O	**0.61**	-	SIST EN 196-2 cl. 17
Na_2O equivalent	**1.14**	≤5.0%	Calculated
Insoluble residue	**5.65**	-	SIST EN 196-2 cl. 10
CaO free	**6.49**	≤1.5%**	SIST EN 451-1
CaO reactive	**24.62**	≤10.0 %	
SiO_2 reactive	**26.30**		SIST EN 197-1 cl. 3.2
Cl^-	**0.019**	≤0.10 %	SIST EN 196-2 cl. 14
P_2O_5 soluble, mg/kg	**0.00**	≤0.100 mg/kg	
Added ml NaOH (1 mol/l)	**0.00**	-	SIST EN 450-1, Annex C

*for Siliceous fly ash (Class F), 50% for Calcareous fly ash class C
**≤1.5% with the SIST EN 450-1 New this is changed from ≤1.0% to 1.5% [24].

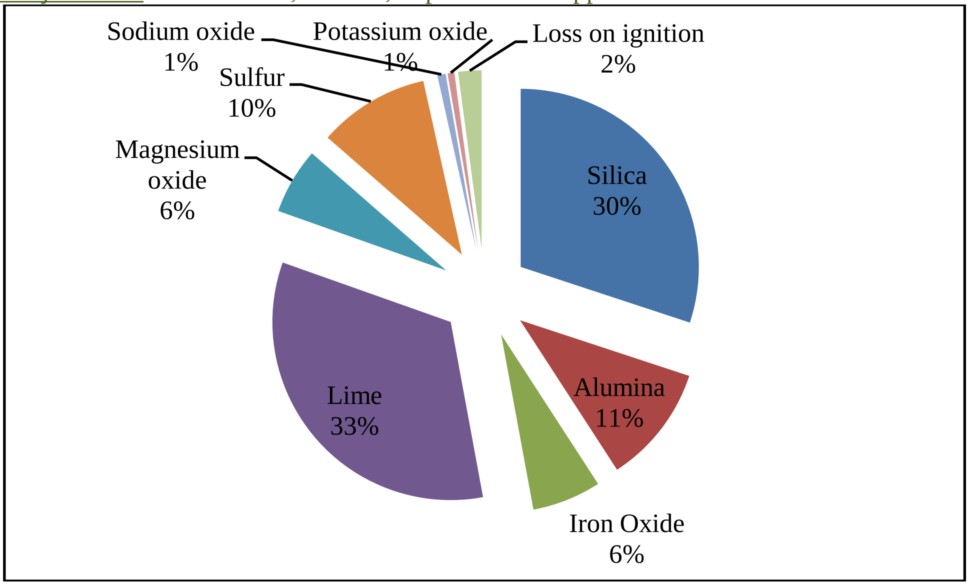

Figure 4: Chemical composition in %/weight of Kosovo Fly Ash

VI. CLASSIFICATION OF KOSOVO B TPP FLY ASH

Fly ash produced from the combustion of lignite generally is composed of silica, alumina, small quantities of oxides of magnesium, iron, calcium and some other elements. The percentage of its constituents depends. The general classification of Fly ash is done by the percentage content of CaO, which depends on the type of the fuel. This fly ash that is produced from burning lignite showed to have 32.92 % CaO (testing method SIST EN 197-1, clause 3.1) and conform this percentage value, the Kosovo B TPP Fly ash belongs to Class C**.** Class C Fly ash in addition of pozzolanic properties has also cementitious properties.

Cementitious property is the property of a material (in this case fly ash) that in the presence of water to harden, whilst the pozzolanic property is the property that in the presence of water and other activating agent (cement, quicklime, or hydrated lime) to react chemically and have cementitious properties.

These properties make Kosovo Fly ash very useful for utilization as substitute of cement in concrete production industry.

Note: the other Class F of Fly ash has less then 10% CaO and has only pozzolanic properties. This is produced when other types of fuel are burned.

VII. CHARACTERIZATION AND STANDARDIZATION OF FLY ASH OF TPP KOSOVA B

7.1. Loss on Ignition 2.09%

Loss on ignition indicates the content of unburned carbon in fly ash. This property of fly ash is very important because the carbon content has a significant influence on the effect of air-entraining admixtures that are used for the improvement of concrete to the freezing and thawing. Generally portland cement concrete has less than 3% entrapped air. The presence of fly ash in concrete lowers the content of air by 05.-1 % [16].

Carbon absorbs the air-entraining admixture, resulting with lower entrapped air in concrete, which directly affects the resistance to free-thaw cycles.

The SIST EN 450-1 cl.5.2 requirement is $\leq$5.0%, and the Loss on ignition determined conform SIST EN 196-2 cl. 7 of Kosovo fly ash is 2.09 that is absolutely compatible with European standard and American standard ASTM C618.

7.2. Calcium Oxide (CaO)

7.2.1. Total calcium oxide 33 %

From the analyses shown in the table and graph, the Kosovo Fly ash has high lime content (33%), which under the specification of American Standard ASTM **C618** this is greater than 20% by mass and is classified as calcareous fly ash-Class C. This lime content makes the Kosovo fly both pozzolanic and cementitious, and presents hydraulic properties [17].

7.2.2. Free calcium oxide 6.49 %

This is determined in conformity by the method prescribed by European Standard **SIST EN 451-1[**11], as stipulated in **EN 197-1:2000, cl. 3.1[**18]. The test result for Kosovo Fly ash is 6.49 % by mass. Here the test result shows a fluctuation of the result from the standard **SIST EN 450-1 cl.5.2.**requirement value of $\leq$1.0%. This implies that fly ash shall be tested for conformity to the requirements for soundness in 5.3.3 of the standard [11].

7.2.3. Reactive calcium oxide 24.62 %

This is determined conform **EN 197-1:200, Cl. 3.1,** which limits this not to exceed 10% by mass. This is greater than the standard requirement. This also implies that the fly ash should be tested for conformity, to the requirements for soundness in 5.3.3.

In our case the fly ash is Class C, i.e. calcareous fly ash, and the sum of silica, alumina and ferric oxide is almost 50%, the content of reactive calcium oxide should no be expected to be less than 10% [19].

7.3. Total content of Silica (SiO2), Alumina (Al2O3) and Iron oxide (Fe2O3) 46.53%

The sum of these oxides expressed as percentage by mass of fly ash has been determined conform SIST EN 196-2 cl.13.6, SIST EN 196-2 cl.13.11 and SIST EN 196-2 cl. 13.10 respectively. The requirement of SIST EN 450-1 cl.5.2 for the sum of all above three constituents of Fly ash is to be greater than 75%. But, in accordance with ASTM C618, for Class C fly ash, this sum shall be equal or greater than 50% by mass. This indicates that ASTM C618 for the content of three oxides requires the value of 70% for Class F of Fly ash. According to ASTM C618, Kosovo Fly ash is almost compatible with the standard's requirements. The Indian Standard, Bureau of Indian Standard (BIS), IS: 3812 part-1 2003 requires this value to be 50% too.

7.4. Reactive silicon dioxide 26.30%

Reactive silica is the key parameter for determining the pozzolanic ability of fly ash. This is the property that flies ash tends to react with available calcium hydroxide to form hydration products with binding properties [20].

According to EN 450-1+A1:2007, and the new revised EN 450-1: New, the content of reactive silica as described in SIST EN 197-1 cl. 3.2 must no be lees than 25 % by mass. The content of reactive silica of Kosovo Fly ash (26.30 %) is in compliance with this standard.

7.5. Alkalis content Na_2O-0.74%, K_2O-0.61%, Na_2O equivalent -1.14%

The present alkalis in fly ash (concrete) react with free silica of the aggregate and the result is the formation of alkali silica gel with properties of capturing the water and causing local expansion of concrete. This expansion causes the deterioration-cracking of concrete.

The alkalis content has been determined conform SIST EN 196-2 cl. 17 and calculated as Na_2O (equivalent). The requirement of SIST EN 450-1 cl.5.2 is less than 5%, and Kosovo fly ash is absolutely compatible with EN 450-1:2005+A1:2007.

7.6. Magnesium oxide 5.93%

The content of MgO has been determined in accordance with SIST EN 196-2 cl. 13.13 and the requirement of SIST EN 450-1 cl.5.2 is ≤4.0%. The Kosovo fly ash has a slight higher content of MgO, i.e. a little fluctuation from the European standard requirement. This excessive content of magnesium oxide may have some deleterious effect; can cause expansion of concrete. But for Class C fly ash this value is almost within the limits. In some countries this limit is up to 5% [21]. The testing method of ASTM C151-74 for detecting unsoundness caused by CaO and MgO, shows that the expansion of concrete affected by the presence of these two oxides is smaller than the actual expansion that can occur under field conditions [22].

7.7. Sulfur Trioxide (SO3) 9.98%

The requirement SIST EN 450-1 cl.5.2 for SO_3 in fly ash is less than 3%, which represents a high fluctuation. But, ASTM C 618 for both Class C and F limits this to 5% maximum. It is known that fly ash inhibits the ASR, and the content of SO_3 is known to be one of the factors of this inhibition. So, care must be taken for this value when fly ash with this content of SO_3 is used in concrete production as hydraulic material or blended cement [23].

7.8. Soluble phosphate (P2O5) 0.00%

The requirement of **SIST EN** 450-1 cl.5.2 for soluble phosphorous pentoxide in fly ash is 100 mg/kg, and Kosovo fly ash is fully compatible with European Standard.

The text of EN 450-1: New reads:

"The content of total phosphate (P_2O_5) shall be determined in accordance with EN 196-2 and shall not be grater than 5.0% by mass. Fly ash obtained from combustion of pulverized coal only shall be deemed to satisfy this requirement". Although there is no known effect of phosphate in concrete performance, it is stated that fly ash may contain up to 5% by mass of P_2O_5 [24].

7.9. Chloride (expressed as Cl^-) 0.019%

The content of chloride has been determined in accordance with SIST EN 196-2 cl. 14 and the obtained value of 0.019 % is lower than 0.10 % by mass, which in fact is the requirement of SIST EN 450-1 cl.5.2. Thus Kosovo fly ash with this content of chlorides is suitable for use in cement-concrete industry.

VII. CONCLUSIONS

Kosovo electrical energy is basically generated by TPP. This process produces a huge quantity of unprocessed waste-fly ash which has a very deleterious impact in environment especially in the central Kosovo where the TPPs are situated. The fly ash, since the beginning of TPP operation has been not utilized at all. Thus, due to its huge quantity produced every year it represents not only a waste that should be stockpiled it also represents an industrial pollutant of environment that must be considered seriously.

By this study, through the chemical analyzes this waste-fly ash can be turned to be a construction-industrial product either as direct substituent of cement in concrete industry or as admixture in concrete. The basics of Kosovo Fly ash, its chemical and mineralogical composition generally prove to be suitable for utilization in concrete industry. The composition of Kosovo Fly ash in many aspects is compatible with two basic standards referred in this paper: European Standard EN 450-1 and American Standard ASTM C 618 for use of fly ash in concrete.

The percentage by mass of three oxides SiO_2, Al_2O_3 and Fe_2O_3 according to standards classify Kosovo fly ash in the category of high lime content, which in terms of classification belongs to Class C fly ash. This class C fly ash is calcareous fly ash. The carbon content expressed as LOI, is one of the most important factor for the utilization of fly ash in concrete industry since the carbon content of fly ash affects many properties of concrete, and Kosovo fly ash meets the chemical requirements of standards regarding the LOI, i.e. carbon content.

The content of CaO, MgO and SO_3 represent some fluctuations from standards requirements. This excessive content of these three components may have some undesired effects in concrete-unsoundness. By considering this and testing the concrete for soundness, concrete produced with a specific percentage of fly ash as cement substituent, can make fly ash utilizable as construction material. The alkalis content of Kosovo fly ash is in complete accordance with the standards requirements showing that Kosovo fly ash represents no threat to possible alkali silica reaction that could cause cracking of concrete, i.e. unsoundness of concrete. Also, the chloride content that can affect the PH of concrete is in full accordance with requirements of standards that depict requirements of utilization of fly ash in cement-concrete industry.

This in-depth chemical analyze, compared to the requirements of standards, prove that Kosovo Fly ash could not be a threatening waste to Kosovo environment, but it can be very useful for utilization as cement substituent in certain percentage for producing concrete, or as concrete admixture. Finally, the Kosovo fly ash with these chemical properties can be used as cement substituent in concrete production industry.

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