Development Fly Ash Utilization in Turkey and Contribution of ISKEN to the Market

Dr. Sirri Uyanik*, Mehmet Topeli

* Iskenderun Enerji Üretim ve Ticaret A.Ş.

Budak Sokak No:4 06700 Gaziosmanpaşa ANKARA – TÜRKIYE

phone: +90(312) 455 2 455

fax: +90(312) 455 2 456

e-mail: isken@isken.com.tr
mehmet.topeli@isken.com.tr

Keywords: Turkey, Fly Ash, ISKEN, Cement Industry,

Abstract

Turkey is demonstrating a sustainable economic growth, and has already become the 16th largest economy in the world (Turkey at a Glance > Facts and Figures > Economic Outlook). Turkey's power consumption per capita also exceeded the world average with an average growth rate of around 8%. In order to satisfy this increasing demand, the installed capacity is amounted to 53.000 MW and approximately 12.000 MW of this amount is based on lignite and imported hard coal. Consequently, around 24 million tons of fly ash is produced per year, which is an opportunity for supply. However, fly ash utilization has not reached to satisfactory levels yet. But, as being the largest cement manufacturer in Europe, the country has started appreciating the value of the product and finally it is accepted as a by-product, not anymore a waste. Our company (ISKEN) is the pioneer in Turkey in terms of fly ash marketing and certification.

ISKEN Sugözü PP, which is an imported coal-fired power plant with an installed capacity of 2 x 660 MW, has been in operation since November 2003. Nearly 350.000 tons of fly ash is being handled per year resulting from 3,3 million tons of imported hard coal consumption. ISKEN is not only the first imported coal-fired power plant but also a pioneer in the area of by-product utilization in Turkey. The fly ash of ISKEN has been certified according to EN 450 since 2005. The quality of the fly ash and efforts of ISKEN to maintain it are highly appreciated by the customers and nearly 100% of the production has been taken by them.

This article shall provide an overview about the development of fly ash market in Turkey and the contribution of ISKEN to that market. Turkey has a great interest in coal for power production in an economical and environmentally friendly way. Consequently, utilization of coal combustion products (CCP) will continue to be important in the future.

Introduction

In the early 1930's, efforts were made to find a use for increasing amounts of fly ash produced when firing coal in large power plants in the construction materials industry in Europe and America. At first, in 1937, the term "fly ash" appeared in literature in the Proceedings of the American Concrete Institute. (The Coal Ash Resources Research Consortium). In the USA, fly ash was replaced by 35% of the Portland cement in about 3 million cubic meters of concrete during construction of the Hungry Horse Dam in Montana in 1948. In Germany, fly ash began to be used in significant amounts in the 1960's and, owing to the increasing amounts being produced, became an economic and ecological necessity from the mid- 1970s onwards. Since the mid 1990's, almost 100% of the fly ash generated in hard-coal-fired power plants has been used in the production of building materials. (Lutze & vom Berg, 2010)

In Turkey fly ash was first used at the Porsuk and Gökçekaya Dams construction in 1960's. In the following years some amount of fly ash was used in the road and bridge construction mainly for testing purposes. It took years to convince the potential users, developing the necessary logistics infrastructure and opening up the market for fly ash. One of the initial problems was, there wasn't any standard for determining the quality of the fly ash and no regulation to use it. In 1975, TS 639 was issued by Turkish Standards Institute. This standard was specifying the classification, properties, sampling, testing and marking of fly ash for concrete. It was replaced by TS EN 450 and TS EN 197-1 at 1998 and these standards are updated as soon as their European twins are updated. The past of fly ash usage in Turkey was more or less coinciding with the USA or Europe, however, the development of the usage was not as prosperous as them. There are no reliable statistics about the fly ash usage, but in between 2003-2006 the coal combustion products increased from 12M to 16M tons. On the other hand, only 10% of the total could have been used by the cement/construction industry. The rest was landfilled. In 2011 the CCP amount increased to around 19M tons. (Turkish Statistical Institute, 2012) By 2010 around 64M tons of lignite/hard coal was burned in Turkish thermal power plants and it is expected that the amount will increase by 30% by 2020..Consequently, the fly ash that has to be handled by that ratio will end up around 25M tons (Turkish Electricity

Transmission Company, 2011). Fortunately the usage of fly ash in the cement/concrete industry increased in the last years and this leads to positive expectations for the coming challenging years from CCP utilization perspective.

Main Characteristics of Fly Ash Production in Turkey

Turkey has a great interest in coal for power production in an economical and environmentally friendly way. 22 percent of the total primary energy consumption in Turkey is derived from coal. Only one-half of the coal used is produced domestically in Turkey which makes Turkey's coal market dependent on imports. The coal market is largely considered to be a monopoly operated by Turkish Coal Works (TKI) and Turkish Hard Coal Enterprises (TTK). Although minor parts of production, processing and distribution activities are contracted to the private sector. (Deloitte, 2010)

Table 1: The summary of coal-fired power plants in Turkey in 2012

Power Plant	Total Power	Coal Consumption	Ash Production
Imported Coal	3.085MW	8.300.000 ton	830.000 ton
Lignite	8.081MW	69.400.000 ton	22.030.000 ton
Hard Coal	480MW	2.600.000 ton	1.000.000 ton
Grand Total	**11.646MW**	**80.300.000 ton**	**23.860.000 ton**

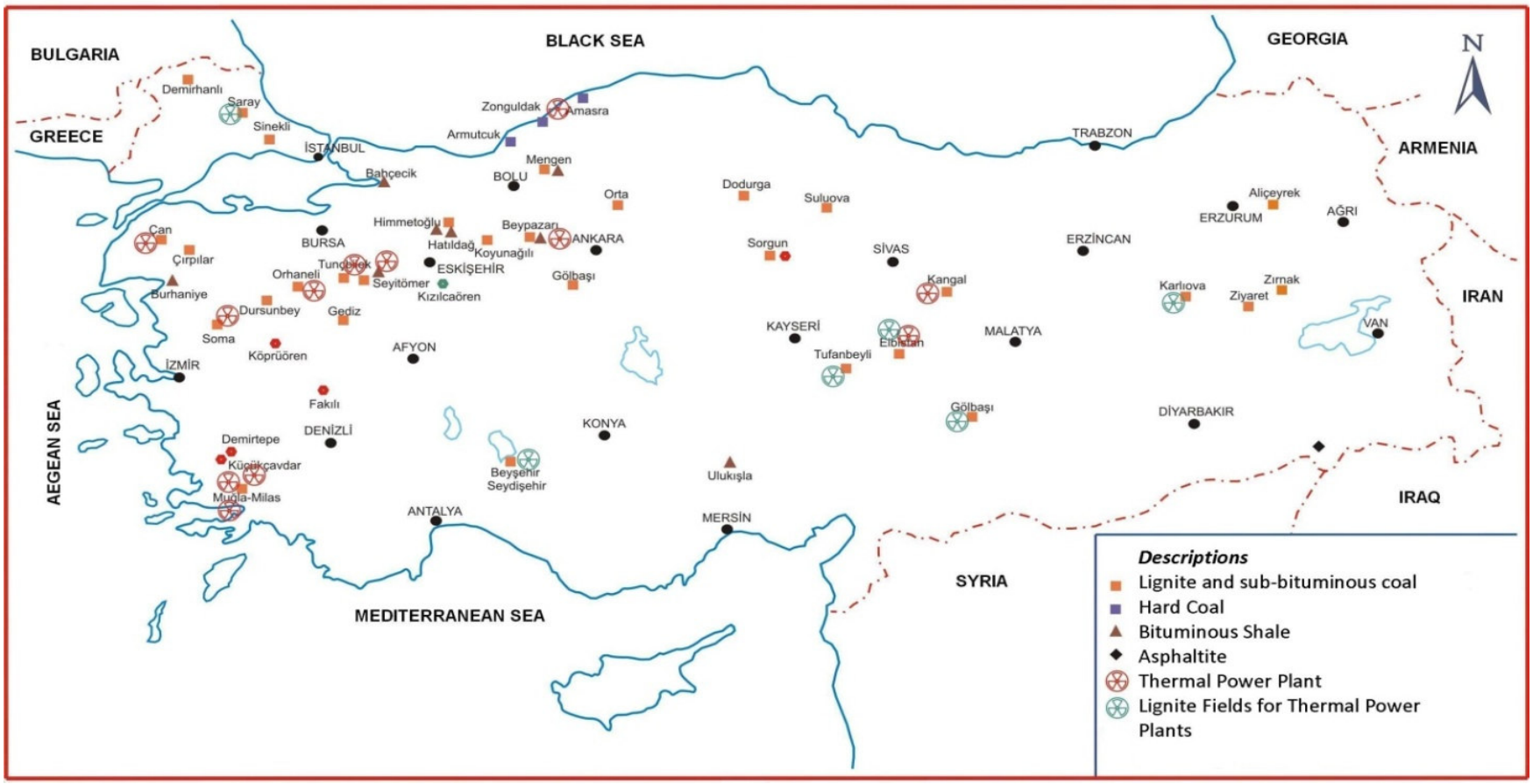


Figure 1: Lignite Reserve Fields in Turkey

Ash, the residue of coal combustion, is the critical issue to be resolved for the sustainability of thermal power production. In the literature, there are many ways for ash utilization. However the most important issue is the quality and the properties of the ash. The coal source is the main factor in determining the quality of the fly ash, that can be classified either by EN 197-1 or ASTM C 618 according to the chemical composition. ASTM C 618, mainly classifies fly ash depending on the coal properties, and has two classes F and C.

a) F type ash is produced from bituminous coal and the sum of SiO_2, Al_2O_3, Fe_2O_3 is larger than 70%. This kind of ash has a low reactive lime content ($CaO<10\%$) and a high reactive SiO_2 content. They are known as siliceous fly ash and have a pozzolanic effect.

b) C type ash is resulted from sub-bituminous coal and/or lignite. The sum of SiO_2, Al_2O_3, Fe_2O_3 is larger than 50%. Meanwhile, the CaO is larger than 10%, therefore this ash is called calcareous fly ash.

According to EN 197-1, there are two types of fly ash; either siliceous fly ash V type or calcareous fly ash W type.

a) V type fly ash is mainly composed of SiO_2 (silica) and Al_2O_3 (alumina) and the rest is Fe_2O_3 (iron oxide) and the others. In this type of fly ash reactive lime content should be less than 10% and silica should be more than 25%.

b) W type fly ash is mainly composed of reactive lime silica and alumina. The rest is iron oxide and the others. In this type of fly ash, reactive lime and silica contents should be more than 10% and 25% respectively. (Turker, Erdogan, Katnas, & Yeginobalı, 2009)

EN 450 classifies the fly ash according to the size distribution into S and N types as well. But this is excluded in the article while it is only a physical characteristic and can be improved, by separation techniques if necessary.

Table 2: The coal-fired power plants in Turkey and their fly ash types

Power Plant	Fuel Type	Total Power (MW)	Burning Type	Operation Year	Coal Cons. (ton)	Ash Prod. (ton)	ASTM C 618		TS-EN 197-1	
							F	C	V	W
Sugözü	Imp. Coal	1320	Pulverized	2003	3.400.000	340.000	X		X	
Eren	Imp. Coal	1360	Fluidized Bed	2010	3.500.000	350.000	X		X	
			Pulverized	2010						
Içdaş	Imp. Coal	405	Fluidized Bed	2005 - 2009	1.400.000	140.000		X		X
Afşin-Elbistan A	Lignite	1355	Pulverized	1984	8.300.000	1.700.000		X		X
	Lignite									
Afşin-Elbistan B	Lignite	1440	Pulverized	2004	19.200.000	4.300.000		X		X
Çan	Lignite	320	Fluidized Bed	2004	2.300.000	730.000		X		X
Çayırhan Park	Lignite	620	Pulverized	2000	2.500.000	1.450.000	X		X	
				1987						
Kangal	Lignite	457	Pulverized	2000	8.000.000	1.600.000		X		X
				1989						
Kemerköy	Lignite	630	Pulverized	1993-1995	5.500.000	2.200.000		X		X
Orhaneli	Lignite	210	Pulverized	1992	1.000.000	350.000	X		X	
Seyitömer	Lignite	600	Pulverized	1973 - 1989	3.000.000	1.000.000	X		X	
Soma A	Lignite	44	Pulverized	1957	8.300.000	4.400.000		X		X
Soma B	Lignite	990	Pulverized	1981 - 1992				X		X
Tunçbilek A	Lignite	65	Pulverized	1956	1.400.000	500.000	X		X	
Tunçbilek B	Lignite	300	Pulverized	1978			X		X	
Yatağan	Lignite	630	Pulverized	1982 - 1986	5.500.000	2.200.000		X		X
Yeniköy	Lignite	420	Pulverized	1986 - 1987	4.400.000	1.600.000		X		X
Çatalağzı	Hard Coal	300	Pulverized	1991	1.600.000	600.000	X		X	
Çolakoğlu 2	Hard Coal	180	Pulverized	N/A	1.000.000	400.000	X		X	

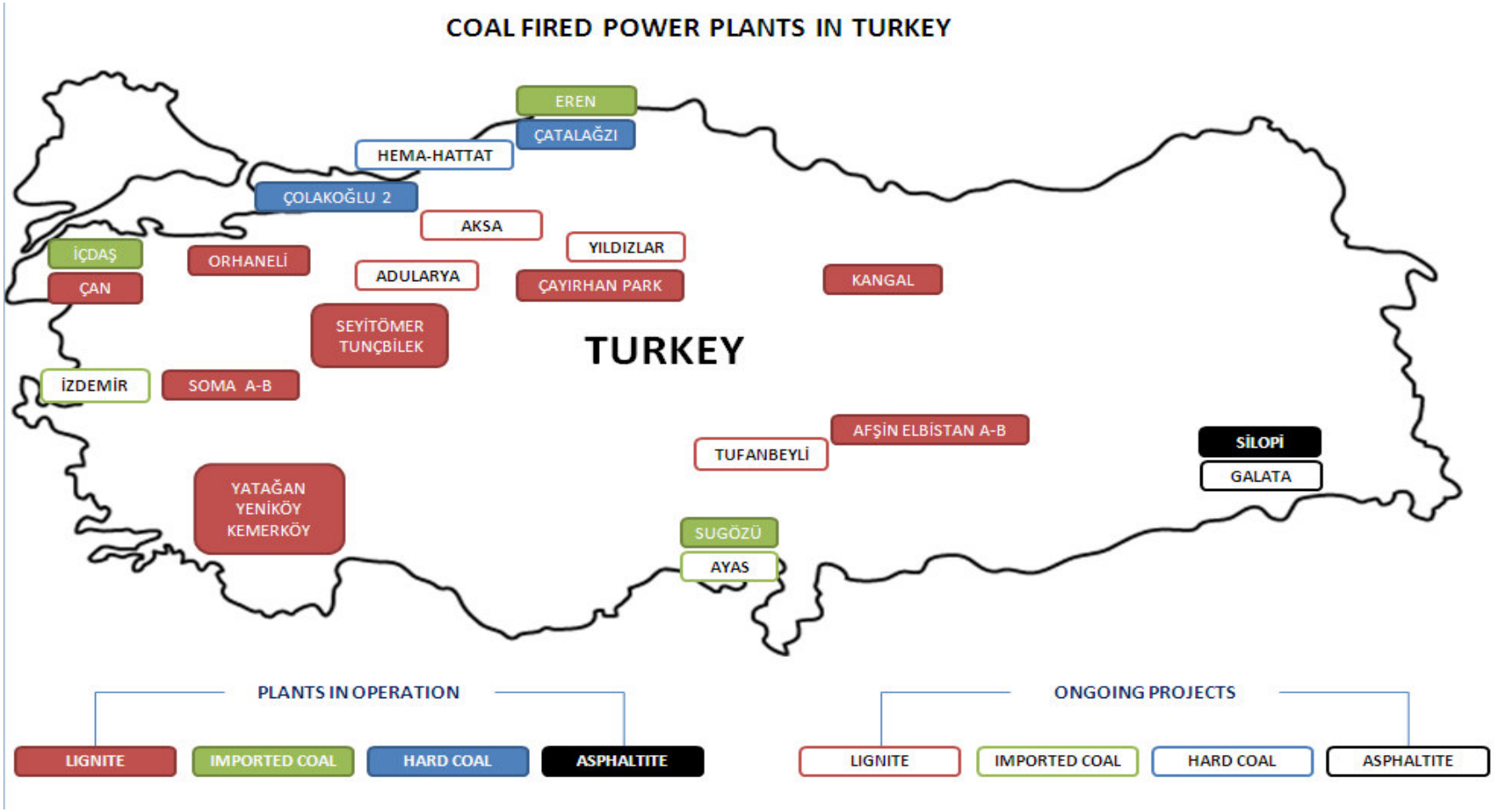


Figure 2: The coal-fired power plants in Turkey and ongoing projects

As it can be seen from Table 2, nearly half of the fly ash produced in Turkey is calcareous fly ash. According to EN 450, this type of fly ash can be used as a concrete addition. However, that can be used as a main constituent in the production of fly ash cement CEM II/A-W or CEM II/B-W (Lutze & vom Berg, 2010). Turkey is the biggest cement manufacturer in Europe and a lot of cement factories are still under construction. Turkey's cement producers have already surpassed their European peers in terms of output and turnover, according to Turkey's Cement Manufacturers' Association (TCMA). The increase in production also lifted Turkey up to 4th place in the world after China, India and the USA. Turkey's century-old cement production sector has grown 15 percent to a capacity of 50 million tons in 2010 setting the industry's 2011 target at a growth rate of 6-8 percent, depending on the housing and infrastructure investments in Turkey. (Ignebekcili, 10.01.2011)

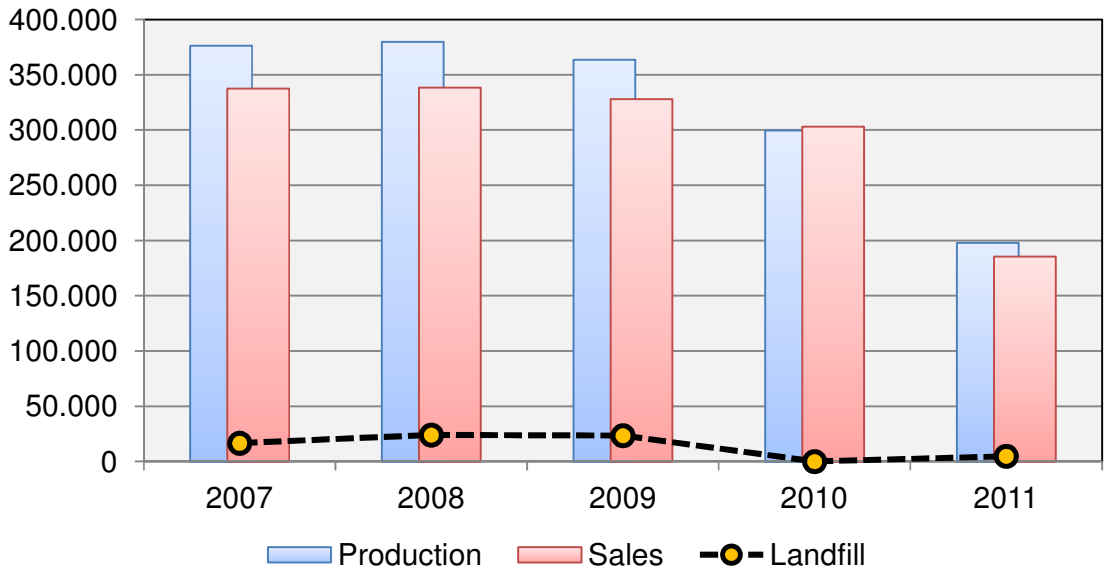
Moreover, according to the statistics of Turkish Cement Manufacturer's Association, by 2011, 90% of the clinker capacity and 65% of the cement capacity have already been reached (Turkish Cement Manufacturers' Association (TCMA)). Therefore, the cement factories will need additional clinker capacity, or that can be replaced by fly ash.

The more prosperous development was noticed at the ready-mixed concrete consumption in Turkey, which was 1,5M cubic meters in 1998 and increased to 80,0M in 2010. In parallel, the importance of the fly ash is understood by the sector and demand to fly ash is increased as well. (Turkish Ready Mixed Concrete Association). The partnerships of Turkish cement manufacturers' with European companies also have a contribution in the development of fly ash usage. One other significant indication of the development is there wasn't any notified body in Turkey up to 2006. First Turkish Cement Manufacturers Association-Council for Quality and Environment (TCMA-CQE) and then Turkish Ready-mixed Concrete Manufacturers Association are notified by NANDO in 2006 and 2008 respectively.

There are also few commercialized projects, like cobblestone production by fly ash addition, and the number of these kinds of projects is increasing, however the amount is still less when compared with cement/concrete addition.

A Success Story: ISKEN Sugözü Power Plant

ISKEN Sugözü PP is located in the southern part of Turkey at the west coast of Iskenderun Bay. It has been on the grid since November 2003 and producing around 9 billion kWh electrical energy per year. The power plant consumes 3,3M tons of coal per year, that is coming mainly from Colombia and partly from South Africa in a 80-20% proportion respectively. The yearly ash production is around 350K tons. Starting from commercial operation date up to end of 2011, 2,8M tons of ash has been produced and 2,6M tons were sent to cement/concrete manufacturers. Around 90% utilization is far above Turkish average and even above fly ash utilization in EU.



Graph 1: ISKEN Sugözü PP Yearly Fly Ash Production vs. Sales

It was not even easy for ISKEN to create a market for the fly ash. The difficulties which were valid for the fly ash producers were also valid for ISKEN. The first difficulty was, the product ash was not well known and accepted by the cement/concrete industry. At the beginning, the expertise of Steag, the major shareholder of ISKEN, was used to develop a market and marketing strategy in Turkey. At that time there was not any notified body to certify our product quality. Therefore we asked Technical University of Munich (TUM) to certify our product. At that time EN 450 was not valid therefore our initial certifications were made according to DIN EN 450 : 1995-01 in 2005 and revised according to EN 450-1:2005-02 in 2007 The geographical distance between the PP and the notified body had increased the

certification costs and moreover TUM is not well known in Turkey. Therefore we have switched to Turkish Cement Manufacturers Association-Council for Quality and Environment (TCMA-CQE) as soon as they have been notified by NANDO (NB 1784). The fly ash of ISKEN Sugözü PP was the first certified fly ash as a power plant in Turkey.

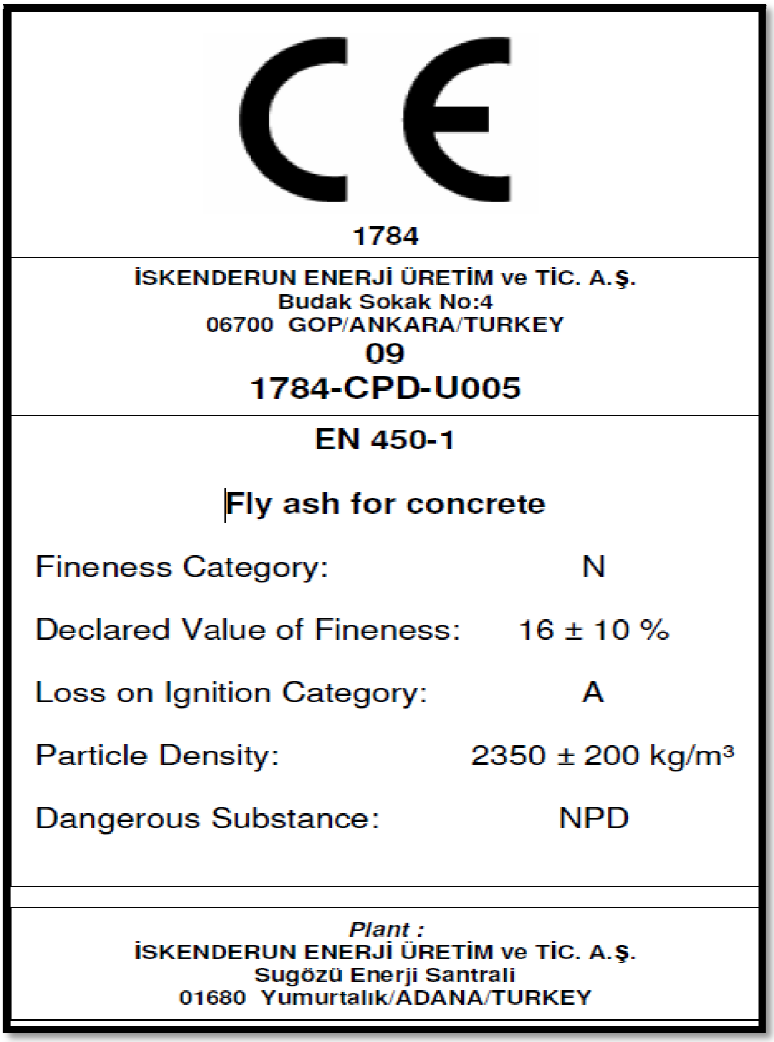


Figure 3: The tag of fly-ash of Isken Sugozu PP

One other major difficulty has been the logistics of the CCPs which is done by highway transportation, the most expensive way of shipping goods. Luckily in the vicinity of Sugözü PP there are two major cement factories and some ready-mix concrete stations, which do help us to cope with transportation costs, especially in

the sky-rocketing fuel price era. Additionally, between 2003-2007, around 100K tons of fly ash was delivered to the construction of the Al Wahda Dam, on the Yarmouk River on the border between Syria and Jordan, which does serve Jordan with water for both human consumption and agriculture, while boosting power supplies to Syria (Al Wahda Dam).

The last but not the least, it was also difficult to convince the authorities to allow us to deliver fly ash to the industries while fly ash has had always treated as a waste in Turkey, except for a few of successful cases. Taking this bad reputation into account ISKEN Sugözü PP has been built with its own landfill, specially designed for hazardous and normal wastes. It has been the first licensed landfill of Turkey in the power production sector. Under normal conditions, the first phase of the landfill was designed for 8 years of operation. However due to the successful marketing efforts of ISKEN, it wasn't fully occupied yet and it is calculated to be in service for 15 more years without additional landfill investment. The operation of the landfill is continuously being monitored by the authorities and there is not any changes/contaminations in the underwater in the vicinity of the PP.

Figure 4: The picture of Sugözü PP's Landfill

ISKEN Sugözü PP voluntarily set EU environmental limits that are stricter than the valid ones in Turkey and therefore became the pioneer in the sector. Authorities asked the same standards at minimum for the projects that were realized after ISKEN Sugözü PP. Meanwhile, the new PP's in Turkey are more or less ready for the EU regulations before being a member of the union.

Opportunities and Threats for CCP in the Turkish Territory

Turkey has been demonstrating a sustainable economic growth (4.8 percent annual average for the last 8 years) and a promising economy, having a population of 74 million people and half of that population is under the age of 30. Obviously, the power demand will rise in parallel. Therefore, Turkey plans to construct additional 18.500 MW sized power plants in the local coal basins by 2023 and there are also some imported coal-fired power plant projects in the pipe-line, in addition to the already installed 12.000MW. According to the 2011 figures the ash production in Turkey is around 24M tons and by 2023 it is estimated to be doubled. The past performance of fly ash utilization in Turkey was poor. Between 2003-2006 approximately 42M tons of CCP's were produced in Turkey. Unfortunately 10% could have been recycled in the relevant industries. 90% is disposed, either in waste ash dams/dry ash or as in one example ash is left to the nature in an uncontrolled way. (Gorhan, Kahraman, Baspinar, & Demir, 2008)

Below, the devastating effects of coal ash pollution can be seen.

Figure 5: Small size canals for transportation of the mixture and the waste discharging point. (Yıldırım)

Figure 6: The floating materials on the marine environment. (Yıldırım)

However it is not necessary to be pessimistic for the future. The CCP sector has two major advantages: a strong start to the 21st century and the skilled labor force that Turkey offers. Moreover, the integration of Turkey with the EU catalyses the development and more stricter rules are already valid for Turkey which do force the power plant operators to find a proper way for CCP recycling.

It is obvious that the major potential usage of ash in the future will continue to be usage in cement and ready-mixed concrete. Turkey is the number one cement manufacturer in Europe and because of the strong local and export demand, it won't be seeming change in the near or midterm. The geographical location of Turkey does also allow utilization of CCP's not only within the Turkish borders but also in the MENA region. For example, ISKEN Sugözü PP had already delivered 100K tons of ash to a dam construction in Jordan and 370K tons of gypsum to Knauf-Israel with an ongoing contract and there is an increasing demand.

Moreover the worldwide decrease of natural resources, increasing energy costs and environmental concerns are forcing people to innovations. There are some studies and even commercialized projects in Turkey to use fly ash as an aggregate material, to manufacture brick and/or Autoclaved Aerated Concrete (AAC), to be used for soil stabilization, to manufacture composite materials by mixing with a variety of other products and etc.

Conclusion

Turkey is a developing country and will continue to have a great energy demand. In the future energy portfolio coal will keep its share, even in an increasing ratio. Due to the circumstances it will be inevitable to use our own lignite and coal resources which have low calorific value, high sulfur, moisture and ash content. However the state of the art and promising technologies make it possible to burn coal in an environmentally friendly way. In a coal-fired power plant, the slag and fly ash management is one of the main environmental problems, unless a successful CCP management system is formed. The major issue in CCP management system is the quality control of the product, starting with coal quality. If it were inevitable to use poor quality coal, then utmost efforts has to be shown to recycle the CCP's in an appropriate way and at the worst case scenario land filling of CCP's has to be considered in an environmentally friendly way.

These are not utopian thoughts or very expensive precautions. ISKEN Sugözü PP has planned and established a proper CCP's management system from the design phase until to the end of economic life of the power plant. In the past 9 years of successful operation, the ash and gypsum recycling were around 90% and 100% respectively, which is far beyond the expectations in the newly formed CCP market in Turkey. The benefits of the successful CCP management system are already noticed. First, due to the successful marketing of the CCP's, it doesn't become necessary to extend our licensed landfill, that was designed for the first 8 years of operation. And the second one is CCP's are already become commercial goods and and has a positive contribution to the revenue of the company in contradiction to the first years of operation when these items were booked as disposal costs!

The last but not the least, our major motivation for establishing a proper CCP management system is to save the environment and to be a model in the Turkey. The past performance is a strong indication for the better future from CCP utilization perspective in Turkey, that is the motivating us to work with enthusiasm.

Works Cited

(n.d.). Retrieved 4 4, 2012, from Al Wahda Dam: http://en.wikipedia.org/wiki/Al_Wahda_Dam

Deloitte. (2010). *TURKISH ENERGY INDUSTRY REPORT.* Ankara: REPUBLIC OF TURKEY PRIME MINISTRY - Investment Support and Promotion Agency of Turkey.

Gorhan, G., Kahraman, E., Baspinar, S. M., & Demir, I. (2008). Fly Ash I: Production, Classifying and Utilisation Opportunities. *Technological Investigations* , 85-94.

Ignebekcili, T. B. (10.01.2011). Turkey leads Europe in cement production. *Hurriyet* , http://www.invest.gov.tr/en-US/infocenter/news/Pages/100111-turkey-cement-production-leading-europe.aspx.

Lutze, D., & vom Berg, W. (2010). *Handbook on fly ash in concrete.* Duesseldorf: Verlag Bau+Technik.

The Coal Ash Resources Research Consortium. (n.d.). *Historical Timeline*. Retrieved April 5, 2012, from University of North Dakota Energy & Environmental Research Center: http://www.undeerc.org

Turker, P., Erdogan, B., Katnas, F., & Yeginobalı, A. (2009). *Properties and Classifying of Fly Ash in Turkey* . Ankara: Turkish Cement Manufacturers' Association.

Turkey at a Glance > Facts and Figures > Economic Outlook. (n.d.). Retrieved 02 11, 2012, from Invest in Turkey- Investment Support and Promotion Agency of Turkey: http://www.invest.gov.tr/en-US/TURKEY/FACTSANDFIGURES/Pages/Economy.aspx

Turkish Cement Manufacturers' Association (TCMA). (n.d.). Retrieved 4 9, 2012, from http://www.tcma.org.tr/

Turkish Electricity Transmission Company. (2011). *Turkish Power Production Capacity Prjection (2011-2020).* ANKARA: TEİAS APK.

Turkish Ready Mixed Concrete Association. (n.d.). Retrieved 3 19, 2012, from Industry Datas in 2010 : http://www.thbb.org/Files/File/2010.pdf

Turkish Statistical Institute. (2012). *2010 Thermal Power Plants Water, Wastewater and Waste Statistics.* Ankara: Turkish Statistical Institute.

Yıldırım, Y. B. (n.d.). *AN INVESTIGATION OF INDUSTRIAL PLANT POLLUTION USING SATELLITE IMAGERY AS A TOOL IN ZONGULDAK COSTS, TURKEY.* Retrieved 4 10, 2012, from http://www.isprs.org/proceedings/XXXVI/1-W41/makaleler/Yildirim_Plant_Pollution.pdf