

# The Proposed Design of Co-Combustion Stoker for Şırnak Agricultural Biomass Waste and Şırnak Asphaltite in 35MW Electricity Production

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**Abstract**— The objective of this study is to determine and use the agricultural biomass potential in terms of the types, quantities and regional distribution with Şırnak asphaltite and lignite in Turkey for electricity. The calorific values of the selected agricultural wastes were investigated. It was found that the total calorific value of the studied waste of corn crop field was around 18 kJ /kg. There was 26 million ton total biomass waste production for the period of 2012- 2013 in Turkey. The major waste of crops that took place in the ratio of the total calorific value was corn (43.4 %), wheat (19.6 %), and cotton (16.1 %). The total calorific value of the fruit waste residue was 5 PJ/year. The fruit wastes were major peanut (55.8 %) and olive (25.9 %) in the total agricultural biomass source. The total calorific values for cow, sheep and poultry in Turkey were found to be wastes approximately 4.8, 0.3 and 0.7 PJ/year, respectively.

**Keywords**- *co-combustion, co-incineration, biomass, agricultural waste, co-electricity.*

## I. INTRODUCTION

The biofuels, agricultural resources, plant and animal waste and residues constitute an important potential. Evaluation of residues containing organic matter, pollution and clean energy production is significant. For this purpose, on the property for use in developing countries is the most common source of biomass. Approximately 15% of world energy consumption, the energy consumption in developing countries, is about 43% and %20 from biomass in USA and EU27 in 2009, respectively (Figure 1) [1,2,3]. Biomass is able to grow everywhere and contribute to environmental protection, power generation, chemicals and fuels, particularly for vehicles due to be considered as a strategic source of energy. Fuels of biological origin, one of the most effective methods for energy generation, combined heat and power production. From combined heat and power generation, process heat and steam for industrial applications could also be utilized for the power production. For many processes in the industrial sector as drying heat generation are needed. This requirement without district heating system with combined heat and power production can be met. In addition, small - scale combined heat and power plants obtained from the heat energy used for heating of public and industrial buildings. The purpose of this the study is the use of the biomass of agricultural origin in

Şırnak and Şırnak coals in Turkey. Those resources are environmentally sustainable by the following a method taking into account the economic and social benefits, in a controlled manner is to develop the possibilities of using new technologies. Scope of this work is to evaluate Şırnak's biomass for 35MW electricity production with the regional biomass waste and the primary energy source of Şırnak asphaltite. The co-combustion of biomass resources within the special stoker is designed and proposed providing legal and institutional economic and environmental impact assessment. However, the utilization of Şırnak biomass energy source improve technological coal combustion include solutions against pollution.

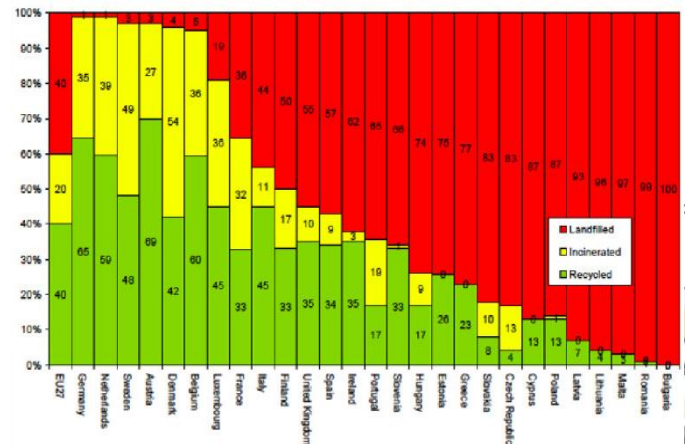


Figure 1. Waste incineration and recycling grew rather steadily in the EU. [2]

## II. AGRICULTURAL BIOMASS WASTE POTENTIAL OF TURKEY

In Turkey, the Ministry of Agriculture and Rural Affairs declared the statistics that the amount of waste generated from annual and perennial crops received from local authorities; the amount of production and acreage of each product is calculated using the data for 2002-2003. In our country, agricultural production waste is commonly left in the field. Cereal straw is used for various purposes, for example, used as animal feed , animal litter. The main waste from the production of

agricultural products, industrial plantations is allowed to rest. These kinds of waste cotton stalks, corn stalks, sunflower stalks, hay and tobacco stalks are waste, etc. Total amount of municipal waste products are divided into theoretical and actual values are given in the Table 1[3]. The total annual waste production of field crops in Şırnak and waste quantities are given in Table 2.

TABLE I. TOTAL AMOUNT OF MUNICIPAL WASTE PRODUCTS ARE DIVIDED INTO THEORETICAL AND ACTUAL VALUES IN TURKEY IN 2012. [3]

Waste Type	Waste Statistics		
	Heat Value,kJ/kg	Theoretic al, million ton/year	Actual, ton/year
Plastic	18200	0,6	0,4
Cardboard	17600	2,4	1,6
Animal Waste	13500	22	9
Total	18000	25	11

Total heat value of approximately 16,8 kJ/kg for corn stalk and 20,2 kJ/kg for peanut shell waste. According to the total thermal value, basic products are corn 33.4%, wheat 27.6% and cotton 16.1%, respectively. Regarding the total annual production of horticultural crop waste in Turkey, Its total thermal value is approximately 21.5kJ/kg and the total calorific value of the waste product is of the biggest 56.3% nut shell and olive seed 25.2%. According to the number of animal wastes in Şırnak, the calorific value of waste and the amount of animal waste are given in Table 2, for cows, sheep and poultry, and approximately the amount of annual waste capacity are 0.2, 0.1, 0.008 million tons, and about 13, 30 and 26,5 million in Turkey respectively. The total annual amount of forest, bush and wood waste, are 6, 0.6 and 0.49 million tones, respectively. The total available 65 % solids content of 3% and 99% values were determined by the availability of forest, bush and wood waste, respectively [4,5]. Thus, Şırnak's cows, sheep and poultry waste calorific value of the annual total was found to be of about 48, were 3 and 0.7 MJ, respectively.

TABLE II. THE TOTAL ANNUAL PRODUCTION OF FIELD CROPS WASTE IN ŞIRNAK AND WASTE QUANTITIES.

Waste Type	Waste Statistics		
	Heat Value,kJ/kg	Theoretic al, 1000ton/year	Actual, ton/year
Plastic	17200	2,1	1,3
Cardboard	17600	2,4	1,6
Cow, Sheep Waste	13400	20	11
Forest Waste	18600	60	33
Total	17000	84,5	46,9

Nowadays, renewable resources distribution in connection prioritizing and license fees are not taken, such as the Electricity Market Licensing Regulation and certain incentives were introduced 05.10.2005 dated and 5346 The "Renewable energy sources of electricity production for use" law on renewable energy sources derived from the power of the high-rates and in certain ratios, such as the need to purchase some incentives were introduced. The law also established and operated by the private sector of renewable energy projects specific permitting and provides incentives for such systems. Today in Şırnak, including biomass in terms of research and development in renewable energy incentive programs is improving finance mechanisms. A potential market instrument of state support is required to continue forever. They are sustaining investor confidence during the regional development and feasibility and profit state of the regional energy investments may be so important.

TABLE III. THE TOTAL ANNUAL PRODUCTION OF ANIMAL WASTE IN ŞIRNAK AND WASTE QUANTITIES.

Waste Type	Waste Statistics		
	Heat Value,kJ/kg	Theoretic al, 1000ton/year	Actual, ton/year
Cow	15200	25,4	12,3
Sheep	14600	2,3	1,6
Poultry	13700	0,7	0,4
Total	14200	28,4	14,2

Apart from dedicated waste incinerators, where exclusively waste is burn, the energetic content of MSW can also be recovered in industrial facilities, where waste acts as a substitute fuel, or in some cases as raw material, and is not the only feedstock present in the furnace[6,10]. The main limitations of co-incineration derive from the fact that "not every waste is appropriate for co-incineration" and to the "possible contamination with elements that can impact the quality of the industrial products".

Examples of practical co-incineration facilities include power and steam plants, cement and lime kilns, as well as steel works. In order to be able to co-incinerate waste in these industrial facilities it is necessary to detect which waste streams are able to adapt to the existing process[11,15]. The potential fuel substitution capacity of waste in power plants is approximately 5% in hard coal plants [16,17]and 10% in brown coal plants, while in cement and lime works the potential rises up to 50% [18,20]. Particularly cement producers not only utilize waste as a substitute fuel but also as a raw material as the mineral fraction of the waste is utilized for the clinker.

This study showed that state-of-the-art co-incineration practices contribute positively in the ecological impact of waste treatment and that co-incineration facilities can achieve similar ecological benefits as dedicated waste incinerators. The result also reported that the combination of both incinerator systems,

dedicated and industrial co-incinerators, can achieve optimal results in waste treatment.

### III. COMBUSTION ANALYSIS OF WASTE AND COAL

In the experiments, Şırnak asphaltite samples were used and the chemical analysis is given in Table 4. The combustion analysis was carried out in the tub furnace as shown in Figure 2. The decreasing combusted fractions of coal specimens were weighted continuously at the reactor by temperature increased over 900°C regarding time. Test results are shown in Figure 3 for biomass pellets and coal sample.

In the combustion experiments, effect of addition hydrated lime over desulfurization and emission was determined, reactor temperature changed between 500°C and 950°C and waste samples mixed only by %10 weight rate the MgO expanded clay pellet and hydrated lime as shown in Figure 4. Products received from combustion of coal specimens were subjected to analysis for sulfur hold-up determination. Experimental results are shown in Figure 5.

TABLE IV. THE CHEMICAL ANALYSIS OF ŞIRNAK ASPHALTITE.

Proximate analysis	Weight (%)	Sulfur distribution	Weight (%)	Elemental analysis	Weight (%)
Moisture	1.26	Total sulfur	6.89	Carbon	51.43
Ash	39.07	Pyritic sulfur	2.00	Nitrogen	0.91
Fixed carbon	25.08	Sulfate sulfur	0.29	Hydrogen	3.86
Volatile mater	34.59	Organic sulfur	4.60		
Heating value (kcal/kg <sup>-1</sup> )	5630.2				

The gravimetric change during combustion are calculated by the equations below.

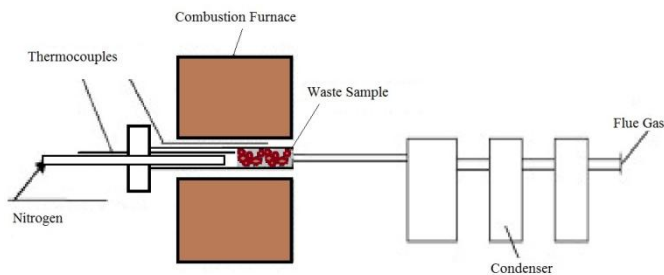


Figure 2. Comparison of desulfurization% 10 lime addition to combustion chamber with waste.

The waste combustion yield were calculated by the following expressions:

$$\text{Mass of combusted yield (\%)} = 100 - \frac{\text{wt of ash, g}}{\text{wt of waste, g (dry basis)}} \times 100 \quad (1)$$

$$\text{Conversion (\%)} = \frac{\text{wt of waste, g} - \text{wt of solid residue, g}}{\text{wt of waste, g (dry basis)}} \times 100 \quad (2)$$

$$\text{Gas losses (\%)} = 100 - (\text{solid residue} + \text{water yield}) \quad (3)$$

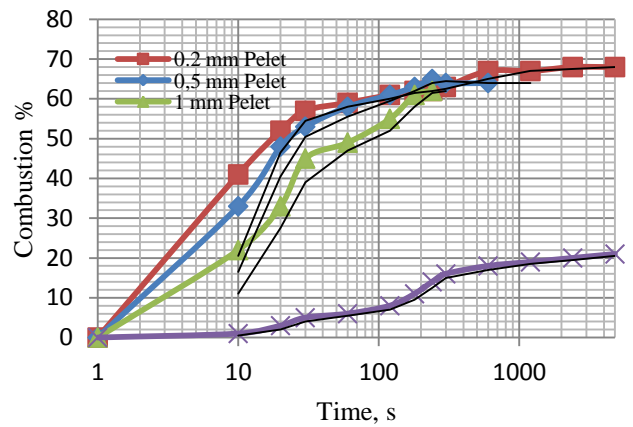


Figure 3. Combustion weight change of biomass pellets and coal sample with% 10 lime.

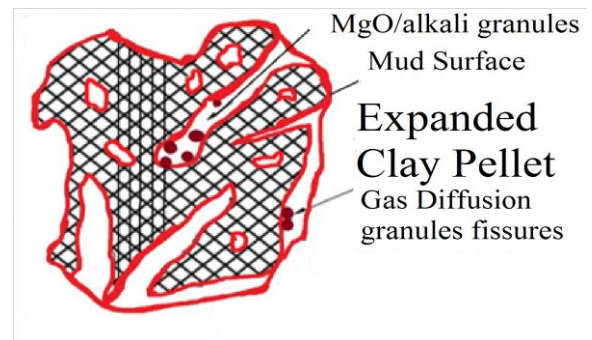


Figure 4. Section of biomass pellets and expanded clay sample with % 10 magnesia and lime addition

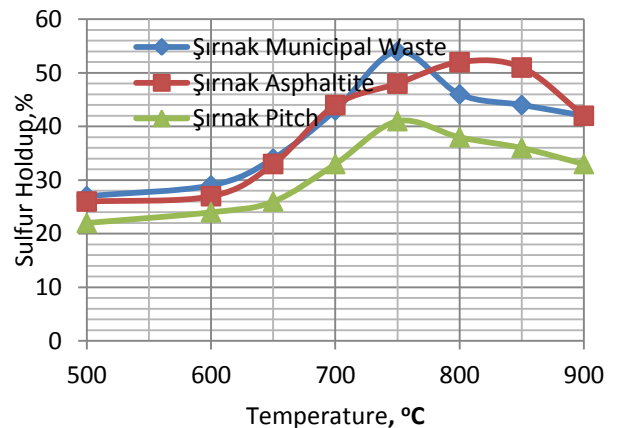


Figure 5. Comparison of desulfurization with % 10 MgO pellet-lime addition to combustion of waste and coal samples.

### IV. RESULTS AND DISCUSSIONS

In the combustion experiments, the stoker boiler was used as shown in Figure 6. The decreasing particle size fractions of coal specimens at stoker the combustion rates of Turkish lignites and Şırnak asphaltite and waste increased at the reactor temperature increased over 900°C regarding amount of mixing waste and asphaltite samples over MgO-lime pellets at 10% weight rate. The combustible yields in the mixed

specimens were determined and compared on yield amount base. Test results of those yields in combustion of the lignite, wastes and asphaltite are seen in Figure 7.

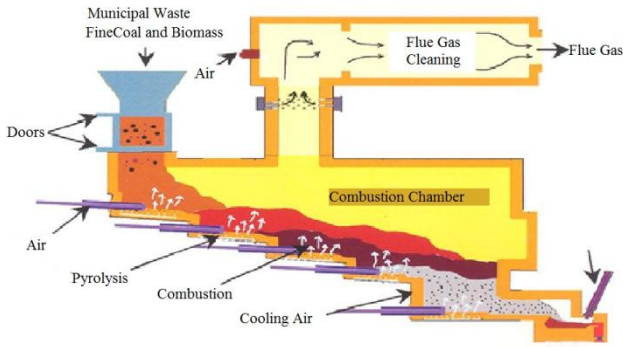


Figure 6. Stoker incinerator used for the Biomass Wastes and coal combustion process.

From the point of view of gasification experimentation, Şırnak asphaltite calorific value was significant. That combusted quantity in the chambers for biomass and coal samples were determined for different source evaluation and reduce the effect of ash content of coal samples in order to optimize combustion rate of mixture samples.

In the combustion experiments with different particle size fractions of coal specimens, at reactor temperature changed to 850°C and lignite samples mixed only by lime at 10% weight rate. Stack gas and soot yields in combustion of coal specimens were also determined and compared on yield amount base.

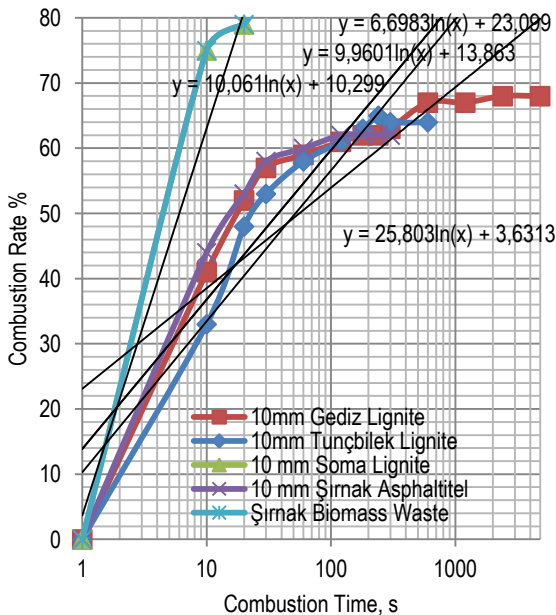


Figure 7. Comparison of combustion rate with % 10 MgO-lime addition to stoker chamber with the waste and coal at 850°C.

## V. ELECTRICITY PRODUCTION BY CO-COMBUSTION OF COAL AND BIOMASS

According to the proposed project studies over coal and municipal waste, it is calculated that at almost 40% thermic performance could be received in the site and oil collected at average near 2,7m<sup>3</sup>/ton for coal and municipal waste. Coal and municipal waste may reach to 20.000 m<sup>3</sup>/yr. Biomass production potential in Şırnak City and close local area is almost 5% of the oil produced from municipal waste. Hence optimized resource usage in co-combustion in optimized boilers can just be managed by high heat-oil boiler ORC plant. At projected capacity at 20.000 tons of coal and municipal waste per year can manage proposed 35MW electricity yield and can produce almost equivalent 50 million kWh/yr electricity. However, all the gaseous products are co-burned in internal combusting generator converting thermal heat. As given in gas and oil yields for lignite and coal, the biomass resources should be processed for toxic contents prior to combustion and regarding oil yield for coal. The proposed enthalpy yields of power generation in moving grate boiler system changed versus regarding combustion temperature is shown below in Figure 8.

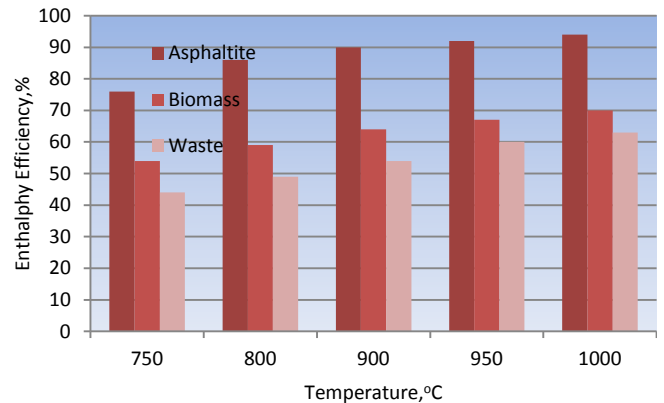


Figure 8. Effect of Combustion chamber Temperature over Entalpy Yield in moving grate boiler

## VI. CONCLUSION

In Turkey today, on a small scale in some industries from agricultural wastes are utilized. However, in Turkey biomass energy use in front of the financial and technical barriers, policy and market instruments inadequacy of reasons, such as biomass and solid waste operated energy facilities private sector, yet at a sufficient level has no interest. The development of an appropriate policy to mitigate the impact of expenses related issues can help. The proposed project plant is shown as seen from Figure 9.

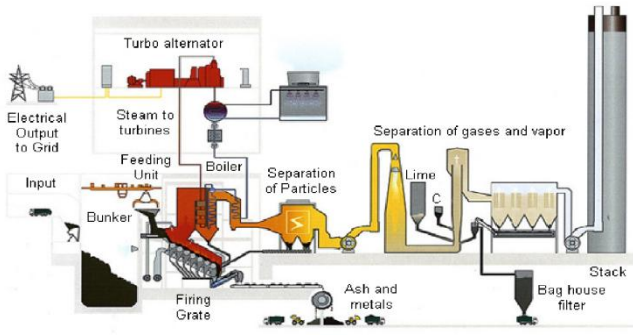


Figure 9. Moving grate type incinerator for Turkish Wastes used in coal combustion-pyrolysis process, of biomass and biowaste, prepared regarding that project work.

In order to reduce the risk of investment projects of the public sector will need to develop appropriate financial support. Suggested potential market instruments included:

- better utilization of agricultural by-products , which support financial incentives ( eg direct grants, loans and /or subsidies ) ;
- trash the place of agricultural wastes or agricultural waste to be stored in an environmentally friendly way using non- aversive environmental taxes and penalties ;
- electricity produced from biomass sources , heat and / or taxation of biofuels tax exemptions or reduction in the level of recognition ;
- private loans, subsidies first run facility and / or allowances as financial support mechanisms related to energy investments.

Suitable for utilization of agricultural waste in the implementation of policies formulated and the role of government is very important. Recommend specific policies and regulations, while the inter-ministerial (agriculture, energy and environment ministries of) the development of coordination and cooperation on these issues and it is also important to ensure efficiency and effectiveness. An important achievement in policy and practice to achieve results, can provide the necessary funds to mobilize private sector has the capacity development of biomass and other renewable energy sources should be encouraged participation.

Şırnak asphaltites should be cleaned and high ash content should be reduced prior to combustion. Benefaction from Şırnak biomass and asphaltites in the mid heat steam generation and low heat pentane ORC generation, many parameters may raise entalpy combustion efficiency in the parallel or serial hybrid systems. In order to receive clean energy from clean combustion gaseous products must be provided in power generated with low heat steam. It is also advised that the high amount of enthalpy receive of combustion will be managed at high combustion temperatures over 900 °C and emissions were more environmental friendly gaseous out puts. Stoker combustion carried out for Şırnak biomass waste and asphaltite below 10mm size distribution

showed sufficient combustion yields of 98% and 91% from biomass and the Şırnak asphaltite, respectively between to 800-850 °C and even other biomass sources showed similar trend, the higher combustion rates of 54-67 %/min at lower combustion temperatures.

In the research works production of clean energy with the design of the addition of high-quality coal biomass waste mixtures are processed and biomass fuels could be an alternative clean fuel sources. Clean energy sources may be supplied in South East Anatolian region in Turkey. Hence, those clean energy production from other renewable alternative resources will further enhance the industrial development in the region.

## ACKNOWLEDGMENT

The author would like kindly thanks to Alfa Kazan ve Makina A.Ş., ANKARA for providing great concerns and supports.

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