5MW Hybrid Power Generation with Agriculture and Forestry Biomass Waste Co-Incineration in Stoker and Subsequent Solar Panel (CSP) ORC Station

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***Abstract*— As you know, our country has the world's leading bio-energy resources and a very advantageous position in terms of biomass energy; just as the earth's biomass region corresponding to the portion located between 7% and 12% in Europe in terms of biomass potential with this location first, and is ranked seventh in the world. When the use of biomass resources in our country, about 76% close of the heating application to the appropriate areas, according to other uses of the area around 13%, and the part about 7% appear to be economically viable to produce electricity. May 21, 2009 adopted the "Electricity Energy Market and Supply Security Strategy Document" in, has attributed particular importance to renewable energy sources and the use of the entire hydroelectric potential by 2023, wind power installed capacity of 20.000MW to, the installed 640 MW electricity of geothermal resources, 130MW of generating capacity from biomass sources. There are various objectives to make the necessary arrangements to increase the use of biomass and solar energy as the other device. Considering the known biomass area of the potential high forest fields in northern Anatolia and located in central and eastern Anatolia it is seen as having low to medium heat resources. As we have seen in our country there is a significant potential for biomass resources will be invested. The 5MW hybrid ORC electricity production for low heat sources with CSP will be great source for waste heat and co electricity production on 60-70 % thermal performances by co generation.**

Keywords- ORC, biomass, solar panel station, co-electricity production, CSP; biomass

I. INTRODUCTION

Biomass consumption in energy production is increasing in parallel with growing energy needs today. In terms of reserve and production quantities of high forest waste are limited. The significant amount of electricity is produced primarily from coal in the world [1, 2].

The almost 211TWh total electricity in 2011, Turkey were produced primarily from imported natural gas and domestic coal [3,4]. The total amount of asphaltite resource in reserves and production in Şırnak City are over 82 million tons of available asphaltite reserve and 400 thousand tons per year, respectively [5]. The most effective and cost-effective technologies are needed for clean coal products in today's modern technologies [5-9]. Turkish coal industry needs noble gasification technologies and high gasification performances at lower cost with various types of local coals regarding researches. The most effective and cost-effective technologies are needed for clean coal products in today's modern technologies [5-9]. Turkish coal industry needs specific tests in order to measure gasification performances of various types of local coals regarding standard qualification tests. There are lots of signs for the production of bio-masses and lignite in industrial many fields even using regular high capacity biomass of cellulosic wastes. Processing technologies using biomass should be under contribution to the fuel side [9]. On the nature and characteristics of the medium as base lignite are distinctly determined. In the view producing high value cleaned products, pyrolysis and gasification of wood and lignite are managed for this purpose.

Depending on advanced technological developments in energy production the low quality coals needed the most economical technologies and even in order to make it possible to produce coal-derived products. Compliance with environmental norms of wood and lignite pyrolysis or gasification of various types of coals, feasible combustion systems and energy production facilities are needed in today's modern technology, also enable the production of liquid and gaseous fuels [10]. However, raw materials and chemical nature of them requires a variety of adaptation methods. For this purpose, universities and industry needing to work together to provide the basic information required in pilot scale. Thus, the higher performance can be achieved by a certain mixture of solid fuel additives. A preferable advanced design in pyrolysis could produce clean wood fuels in the local site of the country so significant that needs to obtain the highest quality fuels.

It plays an important role during the combustion of fuel in the pyrolysis energy. The incineration usually needs to be controlled burning the municipal and industrial wastes, including hazardous and toxic gases. In this proposed work, the economically competitive and environmentally accepted, the pyrolysis technology and incineration options of agricultural and forest biomass from municipal waste for generation of electricity, fuel and chemicals production has been investigated. In order to pyrolysis and incineration Şırnak forest wood wastes, the stoker may incinerate wood and waste in design with heat carrier alkaline materials, coal ash keeps harmful components using a stoker furnace. Emissions are kept below the minimum allowable value. Pyrolysis oil yield varies from an average of about 17-18% as raw municipal biomass waste. The oil contained, 25-32%, low boiling volatiles. This method keeps phenol in polluted water with low concentrations of phenol. Water treatment is cheaper. Most remains in pyrolytic oil produced phenol type compounds and easily be removed by dewatering. Stoker furnace performed as steam boiler and the other top chamber is performed for emission control. Şırnak Province marl limestone, lime and other alkaline waste is used for cleaning and sulfur removal in exhaust gas emissions.

Agricultural waste into biofuels, plant and animal waste, and no longer poses a significant potential. Evaluation of the production of clean energy that is now possible with organic matter pollution. For this purpose, the use of biomass in developing countries is becoming widespread. Approximately 15% of world energy consumption, takes place in the developing countries and the energy consumption from biomass resources for the USA and the EU27 respectively in 2009, is approximately 43% and 20% (Figure 1) [1-4]. Biomass use is growing in all countries and in particular is considered a strategic energy source. Fuel for vehicles with these resources, environmental protection, energy production, production of chemical additives can be made to a variety of chemicals and fuels. Biological fuel for combined heat and power generation is one of the most effective methods for the production of energy. From a combined heat and power generation is used for the production of steam for process heat and industrial applications. The drying process is required for many processes in wood or biomass industry. It may hardly be performed without heating and combined heat and power production. In addition, the less use of biomass resources for the heating of buildings and public and industrial-scale combined heat and power plants with electricity generation can be performed[5-10]. The main purpose of this study is to improve the use of Şırnak forest biomass and agricultural waste biomass in Turkey and also to develop new technologies using these resources with environmental sustainability in a controlled manner by following a method in the feasible and social benefits. Şırnak forest wastes and other agricultural biomass wastes are the main resources for heating scope of this study to evaluate in the incinerator designed as 5MW hybrid power generation from biomass and CSP for direct heating (Figure 1). Legal and institutional, economic and environmental impact assessment of biomass stoker has been proven by local authorities and the burning plant has been designed and proposed. It also included many solutions to pollution. However, Şırnak coal combustion technology will be developed by biomass resources in thermal power stations.

II. WASTE INCINERATION

Few crowded cities performed incineration process in Turkey, but still requiring emission control. The main advantages of waste incineration are as defined below;

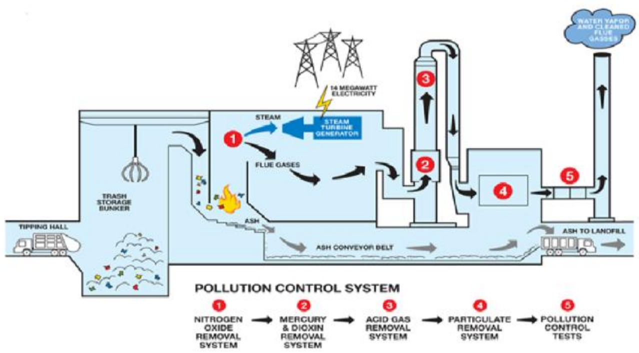

Figure 1. The Projected Incineration Plant of Biomass Waste and Municipal Waste.

This kind can go unwanted chemicals and waste storage is the only practical method of disposing of some waste such as contaminated material. Incineration is not available locally, such materials must be exported.

• Significantly must go storage and reduces the risk of contamination related sources.

• The reduce fossil fuel consumption and greenhouse gas (GHG) emissions resulting produce useful energy from waste.

• The costs of energy use and greenhouse gas emission may be lower than work related to transportation and recycling.

• Reduce emissions close to urban areas and the cost of transport of waste in waste incineration plants designed for waste treatment.

The Disadvantages of waste incineration;

• Evolution of harmful pollutants may cause hazard over the levels if operated incorrectly. Even the smooth operation of the fine particles and pollutants are released in small amounts. Technology evolves emission levels were significantly reduced - there were 2000 dioxin emissions from industrial and household waste in Germany in 1990 level of 1/1000th. If more than 1% of waste chlorine gas and stack gas considered hazardous waste must be raised 1100^{o}C for at least 2 seconds. Low chlorine level for household waste may need that 850oC oxy combustion for at least 2 seconds. But most of continuous measurements of dioxin emissions limits, furans and heavy metals are based on only six months of measurements [11-15].

• Municipal sludge waste (MSW) incineration should be thrown safe storage of fly ash (about 4% of the original waste by weight) produces a relatively large amount.

• Burning can reduce feedback in recycling. With all the components removed non-segregated recycled content of waste energy of waste much less. Incineration plants can compete with recycling for some materials.

• Combustion plants require a large initial capital cost and long-term contracts to be permanent. This may hamper the future more effective waste treatment technology.

III. ORGANIC RANKIN CYCLE WITH ELECTRICITY GENERATION TECHNOLOGIES

Heated electrical generating system based on an ORC technology (Figure 2), the evaporator (No. 1) in the organic working fluid (green line) uses the heat from the heat source to vaporize (red line in Figure 2). The selected working fluid or coolant silicone-based or hydrocarbon-based liquids may be used for low temperature fluid. The steam then to the turbines (No. 2) is sent and generates electricity when the generator combined. The steam is condensed in the condenser becomes liquid again (No. 3). Here or cooling tower (No. 5), or groundwater or river water (blue line) is used as a cooling medium. Air cooling system could alternatively be used. Then coolant pump (No. 4) pumps the working fluid to the evaporator again, and repeats this closed loop process. That the hot liquid is used as a fuel source [16].The almost fuel cost is zero. Also it realizes that no burning, no emissions into the atmosphere does not occur ORC energy systems. Hot sources are generally in the form of hot liquid or gas. Heat from such sources, depending on the characteristics of the waste heat sources or other limitations, the working fluid is transferred directly or indirectly through an intermediary ORC vehicle. The liquid waste heat sources are typically connected directly to ORC unit. The gaseous source of heat coupled indirectly:

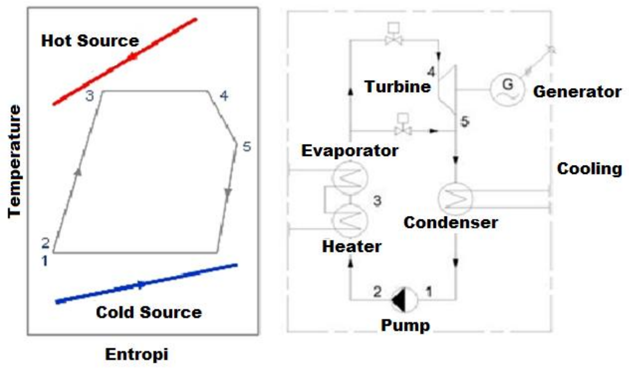

Figure 2. ORC Pentane System and thermodynamic cycle.

As seen from the ORC thermodynamic cycle, schematically, the left ring at the same time or TS Temperature-entropy diagram is called. Turbo generator uses the heat arising from the heat source toward the preheating and evaporating the appropriate organic working fluid in the evaporator (2 → 3 → 4). Organic liquid vapor, directly or speed reduction can be combined with the turbine provides energy to the electric power generator via gear (4 → 5). Steam is then condensed in the condenser cooled by water or air (5 → 1). The organic liquid is finally pumped to preheater and the evaporator (1 → 2); thus ends the series of transactions closed loop circuit [16].

ORC hybrid systems (Figure 3) could be evaluated with other renewable energy sources.There are many advantages of ORC rankin cycle in electricity power production as given below;

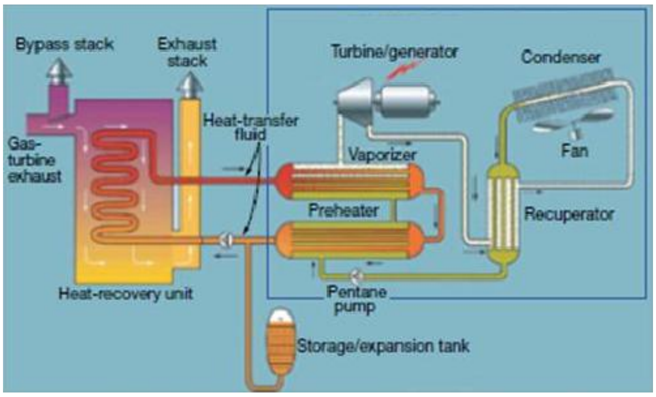

Figure 3. Low Heat Pentane Steam and ORC systems..

(1) is not in contact with the heat source in ORC turbine, there is no danger of damaging the turbine of pollutants that can be found in geothermal waters. Directly to the steam turbine due to the passage of flash steam geothermal resource is present in the danger steam turbine. Geothermal water is not clean can cause this damage. Of course causes damage to the turbine blades to a higher maintenance costs. Because of it is often necessary replacement of the blade. ORC in the operation of clean liquid vapor contacting the turbine blade because it is the steam turbine is not uncommon for more than 20 years of trouble free operation.

(2) Also, the organic working fluid is steam turbine high molecular weight substance. Small molecules of a high-speed steam turbine with high speed crash can cause the destruction of the blades. This turbine maintenance and replacement frequency and increases the total cost.

(3) ORC mechanical and thermal stress in components to operate at lower temperatures and pressures that is lower than the steam turbine. This increases the life of the component.

(4) ORC is no need for an operator working in the field because it works at lower temperatures and pressures. ORC be controlled remotely operated without staff. This reduces operating costs significantly. (5) Even in the partial load ORC as a major advantage of the 10% of the nominal power can operate a relatively high efficiency. This heat input of common motion made by Sun-thermal applications in some industrial applications and can operate for a longer period as compared to ORC steam turbine is particularly advantageous. Because the sun rises in the morning, starting to work in the early hours of this kind of applications can handle up to late in the evening as the sun sets.

(6) The working fluid is water / steam is used instead of the use of water is not necessary. Also in the steam system is generally no need for the necessary demineralized water or other auxiliary systems. Thus the entire system is easier to operate and control.

(7) ORC turbine, rotates at a lower compared to the steam turbine, which reduces mechanical strain. In addition, it allows establishing a link between the turbine generator through the speed reduction gear directly with the system and attached components in the vehicle.

(8) high turbine efficiency with ORC (even down to 85%) can be obtained.

(9) In addition, the ease of operation-stop operation, automatic / continuous ability to operate, safe and quiet operation, the field of high compliance (98% or more are not uncommon) and without serious care for the long life (20+ years) among other advantages.

(10) The energy generated in special cases where the low MW range is special economic advantage over the steam turbine ORC. In addition, because the steam turbine requires an environmental system; it is added to the system cost and small size which is not economically[17-20].

The investor Group, in the district of Şırnak Province are putting these biomass resources with using CSP water and waste incineration or burning coal for electricity generation have been targeted for the hybrid generation of electricity. The designed 5MW parallel two units are planned. The designed steam boilers for use in existing ORC technology (Figure 4) will perform co-incineration.

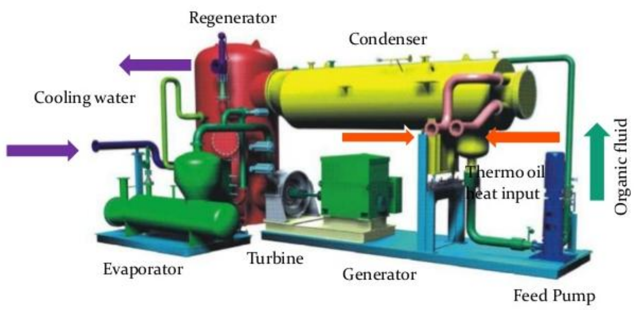

Figure 4. Turboden ORC system components, italy.

Agricultural and forest waste produced in the region will be evaluated together with coal in landfills. 1 Siemens Power Systems, SE-400 turbo-generators is planned to install in mid-June. Meanwhile, 100 pieces of pannier CSP parabolic mirror and central quartz pipe-laying will be done. Retrieving the decision to invest in the project, so the field is not enough data about the area and determined that it has not yet fully investigated. At the end of December 2016 projected, cooling towers and power plant equipment ordered and pilot studies have been initiated for inceneration.

• Overall plant investments in nature until the production phase "high uncertainty" system are characterized as.

• it states that this type of uncertainty in the investment pattern of the healthy "modular growth" is that it was decided.

• Modular growth model of the investment can be realized in a short time into smaller modules. The big advantage of this model is to avoid investing in capacity over the field.

• in the case of wells and temperature sufficient flow can be made such a system can produce energy over a period of approximately 3-4 months.

• Smaller modules generate cash after investments and starting system with less well able to create a support mechanism by possible treasure.

• installed a module while operating area of the identified potential problems can be solved. Observation and testing work will be carried out during operation, it may be decided to establish if a performance of other modules to allow for new investments. Modular growth may continue to the extent permitted by the field potential.

IV. EXPERIMENTAL WORK-COMBUSTION OF BIOMASS

A stove reactor (Figure 5) was used in waste and coal combustion heated till 900 ^{o}C with a rate 7-10^{o}C/min by fuel. The process was tested at a scale of 2–3 kg/h; collecting operational and design data to build an industrial installation. A technological diagram of the coal combustion process developed unit is made. Thermal destruction almost observed at temperature increase from 500°C to 900°C with a desulfurization rate of 64-72%. In stove kiln, where the average concentration of solids amounts to 0.2- 0.3 m3/m3, i.e. the conditions for residence time are long enough for the thermal decomposition of waste and coal and intensive gas mixing so enhancing mass and heat transfers. It is necessary to create conditions of internal circulation without the transported coal and waste in stove, 90-95% combustion yield were observed at the end of combustion. 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 33.4% for corn, wheat and cotton 16.1% and 27.6%, respectively. In Table 1, the total annual production of horticultural crops was in Turkey and is given. Its total thermal value is approximately 21.5 kJ / kg, respectively. Within the total calorific value of the product with the biggest nut shells and olive seed 56.3% 25.2%. According to the number of animals in Şırnak City Province, the calorific value of the amount of waste and animal waste are as given in Table 2, about 13, 30 and 26.5 million in Turkey for cows, sheep and poultry, and approximately in Şırnak City Province these amounts of annual waste capacity are 0.2, 0.1, 0.008 million tons, respectively. The total annual amount of forest, bush and wood waste, are 6, 0.6 and 0.49 million tones, respectively. The total available solids content of of forest, bush and wood waste are 65%, 3% and 99% as determined by the availability, respectively [5]. The calorific values of Şırnak's the annual total cows, sheep and poultry wastes were found to be of about 48, were 3 and 0.7 MJ, respectively.

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	***Theoretical, million ton/year***	***Actual, ton/year***
Plastic	18200	0,6	0,4
Cardboard	17600	2,4	1,6
Animal Waste	13500	22	9

Waste Type	Waste Statistics		
	Heat Value,kJ/kg	***Theoretical, million ton/year***	***Actual, ton/year***
Total	18000	25	11

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

Waste Type	Waste Statistics		
	Heat Value,kJ/kg	***Theoretical, 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

Establishing win incineration steam: Technical product is coal boilers to be increased to 20 bar of steam pressure, the burning of agricultural animals and forest waste with coal in the boiler, Stoker won this waste be developed for co-incineration with the establishment of the CSP solar panels; The concentrated solar parabolic solar panels in areas of high impact evaluation of the production of hot water. ORC 5MW and highly efficient hybrid two-cycle power plant to be set up: all this hot water is converted to steam to saturated steam at 220 ^{o}C for ORC co-generation of electricity.

10 tons/h waste and 20 tons/hour establishment of biomass combustion boilers: Waste incineration and development of biomass and coal combustion boiler technology with the minimum emissions CSP is the creation of 100/200 m2 of solar panels parabolic panels: electricity generation using solar energy Evaluation of CSP hot water: further evaluated by increasing the energy production of the boiler pressure boiler feed water using the hot water supply ORC 5MW of highly efficient two-cycle power plant to be established: the Hybrid electricity production from biomass waste and low-quality coal and CSPs can benefit from solar panels.

The design of the waste burning steam boiler: biomass waste can be burned together with coal modified steam boiler manufacturing, turbo filter also use lighting to ensure minimum emissions of ENA. And toxic metals such as sulfur dioxide and unburned hydrocarbon emissions of Hg in the adsorption, ash and soot dust control. The establishment of the CSP solar panels: Routing the panel according to the sun in the field of design and mounting of the sun's rays. ORC 5MW of highly efficient two-cycle power plant to be established: Siemens S-400 type of construction ORC cycle and waste boiler feed back as modifying the system of hot water generator.

V. RESULTS AND DISCUSSION

In the combustion experiments with addition hydrated lime, reactor temperature changed between 500^{o}C and 950^{o}C and biomass and asphaltite samples mixed only by %10 lime. Products received from chemical of the specimens were subjected to analysis for sulfur hold-up determination (Table 3). Test results of combustion by lime and other alkali at 850 ^{o}C are seen in Figure 6. Therefore it was supposed that porous coal layers, especially porous alkali and sorbents exhibit sufficient gas permeability at least for the gases of chemically inactive and sufficiently small in particle size.

From the point of view of combustion experimentation, the resulted different source evaluation and so we may reduce the effect of calorific value of waste samples in order to optimize combustion. As given in Figure 2 biomass waste type effected combustion time and coal samples were lower, combustion yield was lower for coal. In the combustion experiments with different particle size fractions of waste and coal specimens, at a constant reactor temperature changed to 850^{o}C showed that finer size caused higher rate of combustion subjected to analysis for yield determined between 37 and 40%.

TABLE III. PROXIMATE ANALYSIS OF TURKISH BIOMASS WASTE. (ADB:AIR DRIED BASE. DB:DRIED BASE, DAB:DRIED ASHLESS BASE).

Coal Type	Ash, % ADB	Moisture,% ADB	TotalS,% DB	Volatile Matter,% DAB
Şırnak Asphaltite	46.3	0.1	7.1	62.6
Şırnak Forest Biomass	1.3	48.1	0.1	78.6
Şırnak Animal Waste	2.2	21.7	0.6	62.7
Şırnak Corn Waste	0.8	24.0	0.2	77.4

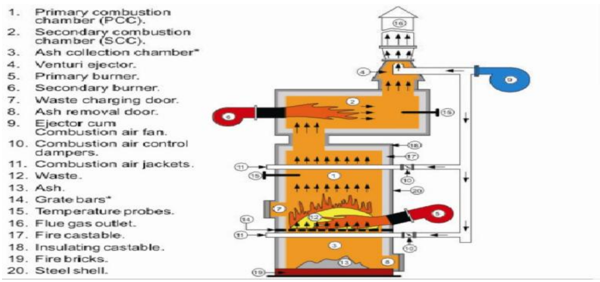

Figure 5. Stove type incenerator for Turkish Biomass Wastes used in coal combustion process.

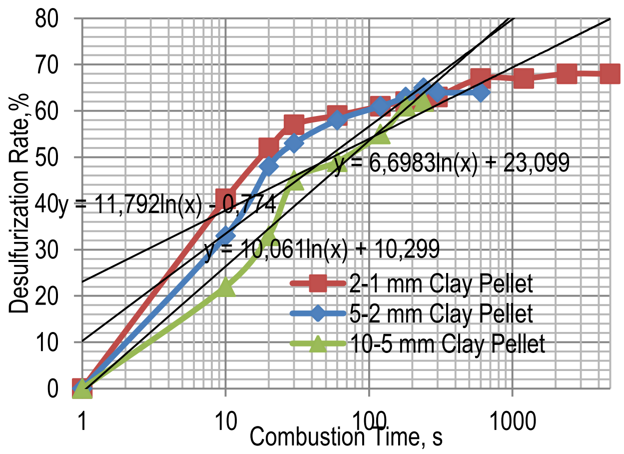

Figure 6. Comparison of desulfurization %10 lime addition at equal rates to combustion chamber with Şırnak waste and asphaltite.

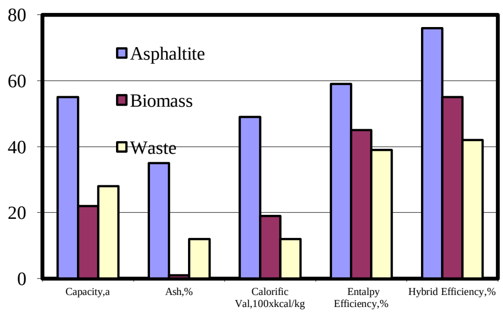

Figure 7. Comparison of use of biomass for combustion and power efficiencies of resources.

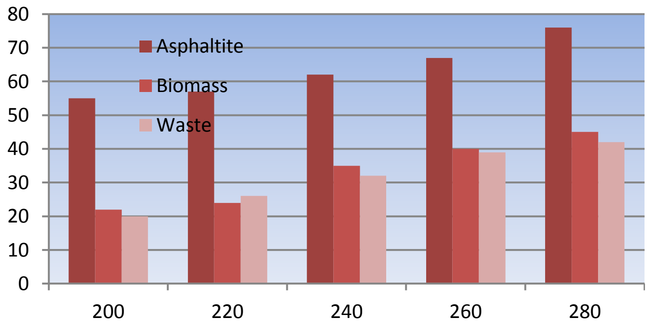

Figure 8. Effect of Solar Panel Temperature over Electricity Yield .

I. CONCLUSIONS

The calorific value of Şırnak asphaltite was significant for power generation showing high about 72% enthalpy efficiency with hybrid production. Furthermore, the results exhibited the higher enthalpy yields in using biomass waste and the biogas inlet 3lt/min.kg waste with the coal.

Combustion of different types of wastes was successfully processed in terms of desulfurization and even reduction of ash content. At higher rates of combustion rate of different types of Şırnak biomass wastes and, but, this rate was lower for asphaltite. The mid-heat steam was much beneficial in hybrid power generation from different types of Şırnak biomass wastes and municipal waste. Şırnak asphaltites should be cleaned and high ash content should be reduced prior to combustion by oil source in pyrolysis and gasification.

Benefaction from Sırnak 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 and high temperature of CSP. It is also advised that the high amount of enthalpy receive of combustion will be managed at high combustion temperatures over 800 oC 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 600-700 ^{o}C and even other biomass sources showed similar trend, the higher combustion rates of 44-57 %/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.

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