# Novel RES based Co-combustion Technology

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*Abstract:* The object of the paper focuses on a new technology of waste biomass co-firing with fossil coal that is a possibility to use existing national energy renewable resources and contribute to a clean energy production. The paper is based on experimental research and was supported by national and EU programs. The experiments conclude that the technology is cleaner, has as main advantage the possibility to reduce the exhausted $SO_2$, $CO_2$ and particulate from flue gases, in comparison to fossil fuel combustion, under comparable circumstances. Investments are reasonable and the technology has promising possibility to be included in the future energy cocktail of the EC, as it is supporting the main development objectives for 2020, concerning RES, efficiency and environmental protection targets.

*Key-Words:* Waste (residual) biomass, RES, Sawdust, Corncob, Pit coal, Lignite, Co-firing, Fluidized bed.

## 1 Foreword

Biomass has been widely used as a fuel for generating heat by direct combustion. Compared to traditional gaseous and liquid fossil fuels, bio-fuels, however, suffer drawbacks, such as lower storage density, lower calorific value, handling difficulties and wide variations in properties. These are the main reasons why bio-energy was not used more extensively in industrialized countries. Several studies, e.g. the White Paper by the Commission, have described biomass as the most important source of renewable energy for the future. In the long term, biomass will undoubtedly play a significant role in the supply of energy in many countries. Opportunities are available for improving the competitiveness of biomass by lowering the utilization cost. The two most important factors in this respect are (i) the cost of biomass fuel and (ii) the development of less costly biomass utilization techniques. These tendencies registered progress and have enabled knowledge to be accumulated on matters such as the technical obstacles that must be overcome before biomass can be expected to make a significant contribution to the total energy supply.

Biomass is a general term that describes fuels based on organic matter. Bio fuel includes a number of organic raw materials that are of varying significance in different countries. The term biomass used further thus covers all biological matter, including bio-waste. A number of fuels (including waste) may be included in this definition. Some of these are in regular traditional utilization (forest residues, straw, etc.), others are introduced more broadly (energy crops, etc.). Although forestry residues are the main biomass resource used so far, various types of waste products and a growing proportion of energy crops are also examples. Not exceptions are Municipal solid waste (MSW), contaminated wood, black liquor and liquid bio-fuels, for which special concern is paid for the processing through direct combustion or co-firing [1], [2].

Efficient and environmental friendly energy production technologies are strongly requested in the developing countries due to rapid economic growth. Especially for the south-eastern countries, biomass resources are abundant. Therefore, the developing countries need the support of biomass technologies to produce energy. This study contributes to constructing ecological energy production systems in the developing countries due to developing the biomass utilization. Exploiting of biomass, which is considered to produce no supplementary (net) $CO_2$ emissions in its life cycle, can reduce the effective $CO_2$ emissions of a coal-fired power generation system, when co-fired with the coal, but may also reduce system efficiency [4].

*Co-firing of biomass* is a promising short-term technology to use secondary fuels, consisting on the simultaneous combustion with a primary fuel (fossil i.e.) in plants, originally designed or retrofitted and optimized for the combustion of coal by taking advantage of the existing knows. Biomass co-firing represents, compared to other renewable sources, a technically feasible option, possessing potential of contributing to the EU energy supply meanwhile ensuring sustainable development. Co-firing of biomass with coal offers several advantages, such as (i) the utilization of large quantities at low combustion rates in the current combustion systems, (ii) lower investments and (iii) higher conversion efficiencies compared to systems fired exclusively with biomass. In spite of numerous successful experiences achieved in Europe, this technology still deserves attention in order to find solutions for technical problems as well to improve efficiency, reduce costs and emission levels [3].

The interest for co-firing and the use of this term sprung in the 80's in the U.S. and Europe, and referred specifically to the use of waste solid residues or biomass in coal power stations that were initially designed for combustion of coal, and attempted, because of existence of those new opportunity fuels, to carry out a combined combustion in order to increase benefit [4]. As a matter of fact, this interest on co-firing has grown in the last decade, mainly due to the increasing social concerns on global warming and greenhouse gas (GHG) emissions. Consequences of this concern are the new policies on energy and environment aiming at reducing emissions. Co-firing is regarded as a great opportunity for replacing coal used for power generation easily with renewable fuels with low costs and a direct repercussion in the decrease of greenhouse gas emissions. During the last decades research has provided very diverse solutions for co-firing biomass in coal power stations with a limited impact in efficiency, operation and lifespan [5], [6].

Other reasons counting for biomass co-firing in existing coal stations, are regarding also [7]:

- Tremendous need to cut pollutant emissions from power plants in the energy sector,
- The need to create an independence and equilibrium concerning imported fuels,
- The need to build up new facilities in accordance to novel green techniques, as most of them are at the end of their life time, representing no more EC standards,
- Existence of isolated places with no modern electricity supply, as the national grid is costly to be extended also difficult to reach places, such as in higher mountains, where bio energy is best suitable,
- Intensive development rate of the wood processing industries, agricultural and forestry sectors that are developing waste biomass, mostly not used properly.

## 2 Co-combustion pilot in stationary fluidized bed

The co-firing facility, presented in Figure 1, comprises several main parts and is based on original design [8], [9]:

(I) **The main burning subassembly** comprising the furnace, the air distributor, divided with grates for injection of the fluidization air and main combustion air, the fuel bunkers (biomass and coal), the starting combustion burner working with natural gas, an appropriate air feeding system including all necessary adaptors and diverse measuring instruments and observation gaps.

(II) **The heat transfer subassembly components** are mainly formed by the convective case and heat exchanger.

(III) **The flue gases de-dusting system components** are formed by a cyclone dust separator, a convective connection, flow measuring sockets, extracting tubes for flue gas analysis and powder/dust sampling, thermocouples, thermometers and manometers.

(IV) **The flue gases cleaning subassembly** is formed by a scrubbing tower, a neutralization reactor and the demister.

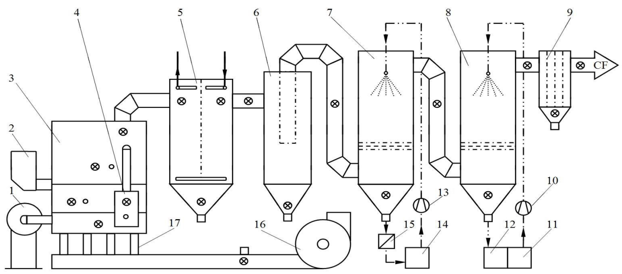

Fig.1. Co-firing fluidized bed facility
1-Start-up burner, 2-Fuel bunkers, 3-Stationary fluidized bed furnace, 4-Ash cooler, 5-Convective case, 6-Dust separator-cyclone, 7-Scrubbing tower, 8-Neutralization reactor, 9-Demister, 10, 13-Reagents circulation pumps, 11, 12, 14-Containers, 15-Filter, 16-Air feeding system, 17-Air distributor, CF-Chimney

The main characteristics of the co-firing facility are:

- Thermal energy output: 45 - 90 $kW_{th}$,
- Electrical power consumption: 2 - 4 $kWh_{el}$,
- Water flow (in heat transfer system): 2 - 4 $m^3/h$,
- Combustion / fluidization air flow: max. 270 $m^3/h$,
- Compressed air flow: 0.5 - 1 $m^3/h$,
- Coal mass flow: 25 - 50 kg/h,
- Biomass mass flow: 15 - 30 kg/h,
- Washing liquid flow: 0.2 - 0.6 $m^3/h$,
- Resulted ash mass flow: 10 - 20 kg/h.

## 3 Co-combustion fuels and potential emissions

According to the promising biomass potential available for heat and electricity production, based in Romania on the stock of wood and agriculture, researches have been developed, in order to utilize different qualities of available biomass as second fuel in the co-firing process, characterized by low price compared to coal, for a comparative energy offer [10]. During the tests, two different types of biomass (corncob Cc, respectively sawdust Sd) and coal (pit coal Pc from the Jiu Valley basin and lignite L from Oltenia basin) were used. After drying and milling, the secondary fuels were mixed externally with the basic fuel, before being fed to the combustion system. All other methods - as separate feeding - determined lack of stability and non-homogenous temperature levels, and the risks of thermal strength were raised, and were abandoned.

Table 1 gives the elementary analysis for in use coal and biomass qualities. Notable is the S content, as well the lower humidity of the *pit coal* in comparison to the used biomass. Also the N content in biomass is sensible reduced in comparison to that of the pit coal.

Table 1. Elementary proximate analysis for the used fuels, in reference to humid state (i)

| Characteristics/ Symbol | IS unit | Pit coal "Pc" | Lignite "L" | Sawdust "Sd" | Corncob "Cc" |
|---|---|---|---|---|---|
| Carbon $C^i$ | % | 58.84 | 23.48 | 35.97 | 43.62 |
| Hydrogen $H^i$ | % | 2.24 | 2.24 | 4.60 | 4.64 |
| Oxygen $O^i$ | % | 10.64 | 11.35 | 28.96 | 21.11 |
| Nitrogen $N^i$ | % | 2.26 | 0.59 | 0.35 | 0.44 |
| Sulphur $S^i$ | % | 1.80 | 0.85 | 0.01 | 0.01 |
| Humidity $W_t^i$ | % | 8.00 | 43.29 | 30.00 | 29.87 |
| Ash $A^i$ | % | 16.22 | 18.20 | 0.12 | 0.31 |
| LHV $H_i^i$ | kJ/kg | 21,089 | 8,035 | 13,023 | 16,516 |

Figure 2 presents four different mixtures, between waste biomass and coal, used in co-firing facility. The visual analysis indicates disperse-homogeneous, quite raw aspect and various grinding.

a) 15 % by mass corncob with 85 % lignite

b) 15 % by mass sawdust with 85 % pit coal

c) 30 % by mass sawdust with 70 % pit coal

d) 30 % by mass corncob with 70 % lignite

Fig.2. Mixtures of biomass with coal by mass

Based on the chemical composition of biomass compared to other solid fuels in a Van Krevelen diagram, the biomass fuels are high in the O/C - and H/C - ratios compared to peat and coals (Figure 3). These high ratios are responsible for the biomass fuels being more volatile than coals and peat, fact that determines a better stability in the ignition process. The O/C - ratios is responsible for the range of the lower heating values of the fuels.

Depending on the fuel composition, the design of the combustion chamber and the operation technology of the system, biomass combustion can lead to emissions of CO, HC, (VOC, UHC), PAH, tar, soot, particles, $NO_x$, $N_2O$, HC1, $SO_2$, salts, PCDD/F and heavy metals (Pb, Zn, Cd and others). Two main groups of pollutants from the combustion of the fuel combination (coal with waste biomass) are expected: *un-burnt pollutants* such as CO, HC, PAH and soot, and *oxidized pollutants* such as $NO_x$ $SO_2$ and $CO_2$.

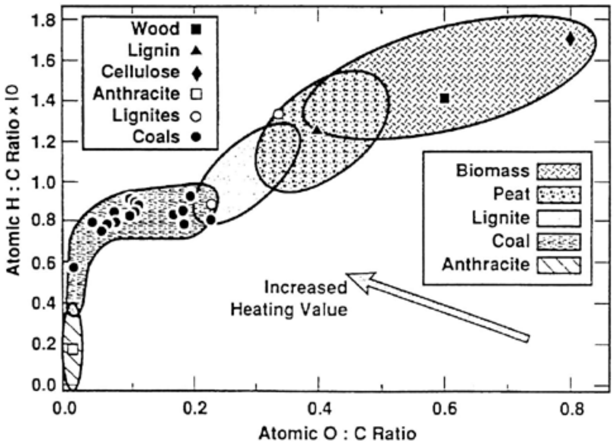


Fig.3. Van Krevelen diagram for various solid fuels, including bio fuels [12]

Further, additional pollutants can be emitted if biomass contains Cl, metals etc.

The emissions from biomass combustion are distinguished as:

- Emissions which are mainly influenced by the quality of the combustion process and operation of the convective system (un-burnt pollutants which can be avoided by complete combustion: CO, HC, PAH etc.).
- Emissions which mainly originate from the fuel properties (emissions which are formed from elements found in the waste and are not to the same extend dependent on the combustion process: $NO_x$ from N, HC1 from CI etc.).

Nitrogen compounds include NO (nitrogen oxide), $NO_2$ (nitrogen dioxide) usually summed up as $NO_x$ (nitrogen oxides) and $N_2O$ (nitrous oxide). While NO, formation and emissions have been widely investigated for many years, emissions of $N_2O$ have been in focus in the last years, due to its contribution to the greenhouse effect. Formation of $NO_x$ in combustion systems involves three main paths:

- Formation of thermal $NO_x$, which requires sufficiently high temperatures for dissociation of the atmospheric diatomic species $N_2$ and $O_2$.
- Formation of fuel $NO_x$, originating in the fuel bound N.
- Formation of prompt $NO_x$, involving fuel-bound hydrocarbon radicals and atmospheric $N_2$, forming HCN as the most important intermediate specie.

Nitric oxide emissions from small-scale waste biomass regular and fluidized bed co-combustion originate mainly from the fuel bound nitrogen, thermal $NO_x$ emissions are of less importance. However, some discussions on the role of thermal $NO_x$, as well as prompt $NO_x$, have been noticed in the literature regarding the contribution in fluidized bed systems, due to incomplete mixing giving possibilities of fuel rich zones and high temperature zones [9], [10], [11], and [12]. For large-scale suspension combustion and co-combustion, all mechanisms must be considered to be important.

Co-firing was the selected technology of the present research, and one measured experimental emissions of NO, $N_2O$, $SO_2$ and CO from combustion of mixtures of bituminous coal and wood in a SFB, in order to complete the information with peculiar aspects regarding Romanian biofuels and fuel. The rage of tests concludes that emissions from the combustion of mixtures depend on expected emissions behavior of the respective fuels. Results, scientific relevant explanations and theory are also revealed in [3], [9], and [12].

# 4 Conclusion

## 4.1 Experimental results

The tests have been achieved at a ratio of 15 - 30 % by mass of biomass, the rest being coal. These data are needed in order to depict the reference oxygen content for comparing the combustion results into the maximum admitted values for stack emissions. In Romania, the biomass combustion is referred to 10 % oxygen, the coal to 6 % oxygen, by volume.

The temperatures and pressures have been recorded during tests with a data acquisition system, on line, in several important points. All values were in the range of expected relevance: in the furnace 800 - 1200 $^oC$, in the convective part 300 - 1200 $^oC$, in the cyclone 150 - 300 $^oC$, in the scrubber 90 - 150 $^oC$, and in the neutralization reactor 70 - 90 $^oC$.

Main results representing average values obtained after achieving a steady state, in several points along the flue gases lay out, are given in Figures 4-9. The *Pit coal* (Pc) and *Lignite* (L) co-firing ratio with *Sawdust* (Sd), *Corncob* (Cc) are indicated. For basic comparison, the experiment with no biomass addition was used. Thus, as reference value, one considered the concentration of a species in stack without the biomass mixture. All figures were experimentally determined after the application of the proposed co-firing process. The higher the biomass support, the less $SO_2$ concentration in the flue gases is resulting. The explanation consists of the reduced S content of the used biomass sorts. The achieved desulphurization efficiency accomplished only by the biomass addition (Sd and respectively Cc), is between 15 and 31 %, compared to the reference, when no biomass was added.

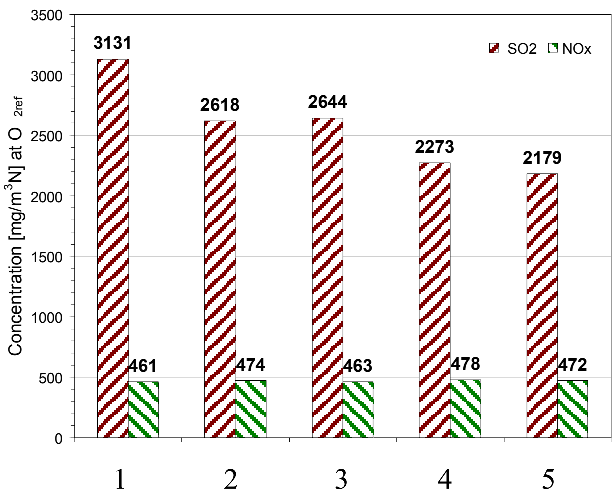


Fig.4. Average concentration of $SO_2$ and $NO_x$ in the case of pit coal - biomass co-firing, at different mass participation of the biomass in the mixture
1) Pit coal, 2) 15% Cc with 85% Pc,
3) 15% Sd with 85% Pc, 4) 30% Cc with 70% Pc,
5) 30% Sd with 70% Pc. % are by mass.

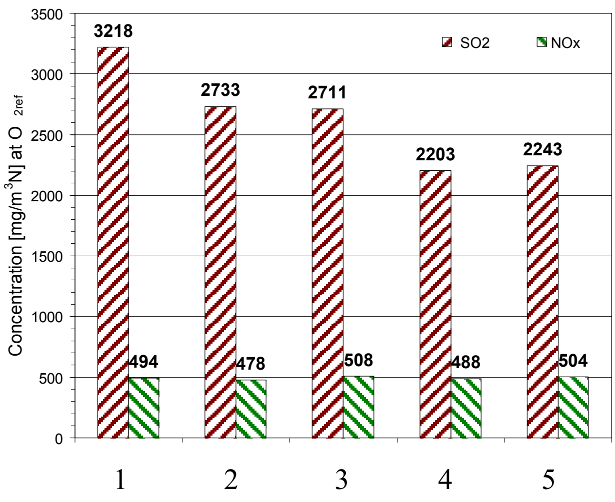


Fig.5. Average concentration of $SO_2$ and $NO_x$ in the case of lignite - biomass co-firing, at different mass participation of the biomass in the mixture
1) Lignite, 2) 15% Cc with 85% L,
3) 15% Sd with 85% L, 4) 30% Cc with 70% L,
5) 30% Sd with 70% L. % are by mass.

The results regarding $NO_x$ emissions from co-firing are comparable to those resulting from burning coal alone, as unique fuel. Nitrogen content of biomass is lower comparative to coal, fact that supposes to reduce the formation of $NO_x$. Nevertheless, the formation of thermal or proximate $NO_x$ is directly related to the operation techniques, as well, mainly the range of temperature levels covered and oxygen content in reaction zones. Thus one may conclude, that the N from the biomass and also the thermal mechanism of the $NO_x$ formation are not activated as expected, due to the fluidized system combustion that limits the temperature levels, and influences the residence time and the oxygen content, as well.

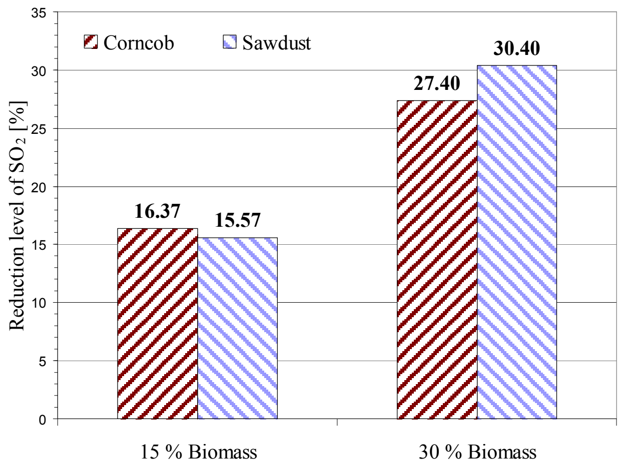


Fig.6. Desulphurization rate resulted from tests with corncob/sawdust - pit coal co-firing. % are by mass.

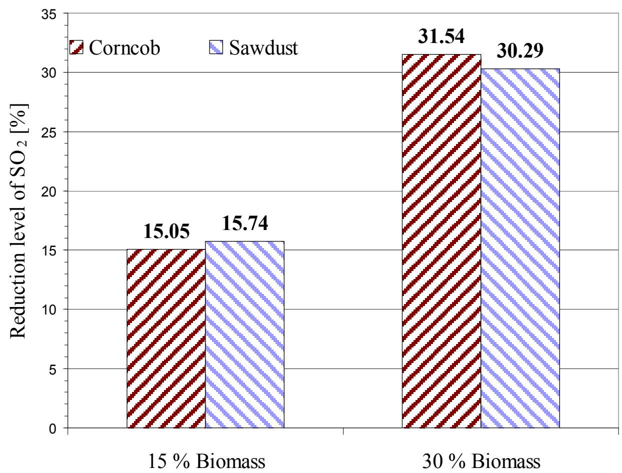


Fig.7. Desulphurization rate resulted from tests with corncob/sawdust - lignite co-firing. % are by mass.

Analyzing the particle concentration in the exhaust flue gases, one notes that the co-firing determines a reduction of the particles amount, explicable by the better combustion conditions, due to the higher volatile content of the biomass, which supports the stability of the ignition and combustion process. With the increasing of biomass mixture ratio the particles in the flue gases are reduced.

It is to mention that the different biomass input is causing a temperature increase, but, as the fluidized bed is a combustion system characterized by a enhanced heat exchange, the profiles of the temperatures are kept lower, as in case of pulverized combustion.

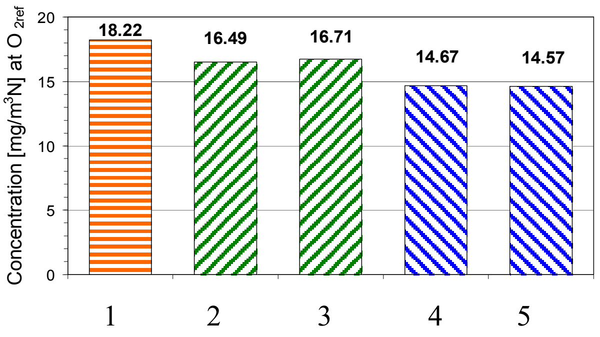


Fig.8. Mass concentration of dust in the flue gases resulted from co-firing of Corncob, respectively Sawdust, with Pit coal
1) Pit coal, 2) 15 % Cc with 8 5% Pc,
3) 15 % Sd with 85 % Pc, 4) 30% Cc with 70% Pc,
5) 30 % Sd with 70 % Pc. % are by mass.

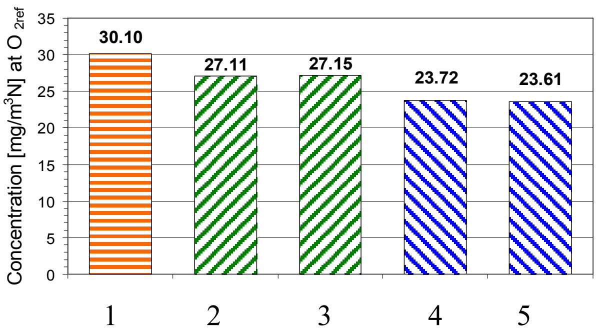


Fig.9. Mass concentration of dust in the flue gases resulted from co-firing of Corncob, respectively Sawdust, with Lignite
1) Lignite, 2) 15% Cc with 85% L,
3) 15% Sd with 85% L, 4) - 30% Cc with 70% L,
5) 30% Sd with 70% L. % are by mass.

The higher the share of biomass in the fuel mixture, the higher is the temperature at the top of the furnace. Because of the high volatile matter content in the biomass species, the release of volatiles and its subsequent combustion are enhanced, contributing to the stability of ignition and combustion, further.

Figures 10-17 review the stability of the process, as the measured values are quite constant and the variations are negligible, versus a mean value.
Increasing the share of biomass (from 15 to 30 % by mass) was found to lead to lower concentrations of $SO_2$, NO and $N_2O$ at the bed exit except CO. This is considered to be due to introduction of higher volatile matter with increasing biomass share.

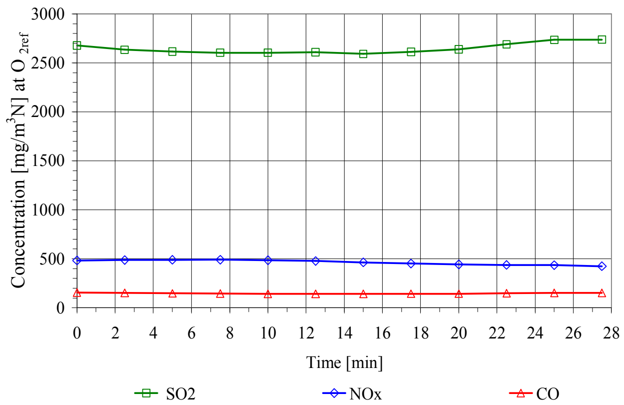


Fig.10. Time dependence of $SO_2$, $NO_x$ and CO concentration when co-firing 15 % by mass Sawdust with Pit coal.

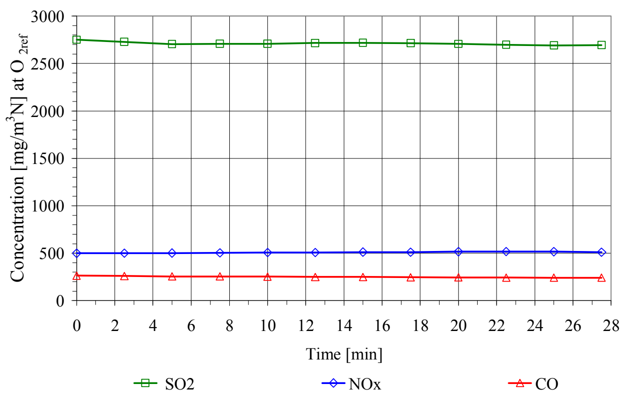


Fig.11. Time dependence of $SO_2$, NOx and CO concentration when co-firing 15 % by mass Sawdust with Lignite.

The measured $NO_x$, $SO_2$ and CO concentrations at stack are considered reasonable constant. Concerning the unburned C (CO), the amounts are considerable (between 100 and 350 $mg/m^3_N$ at $O_2$ reference) and thus, the efficiency due to un-burnt matter of the global co-firing process is reduced, in comparison to the basic case (only coal). This phenomenon suggests that the biomass addition can enhance the ignition of coal since volatile matter in biomass is easily evolved even at relatively low temperature, and because lack of oxygen, the CO is generated more intensively as if no biomass is added.

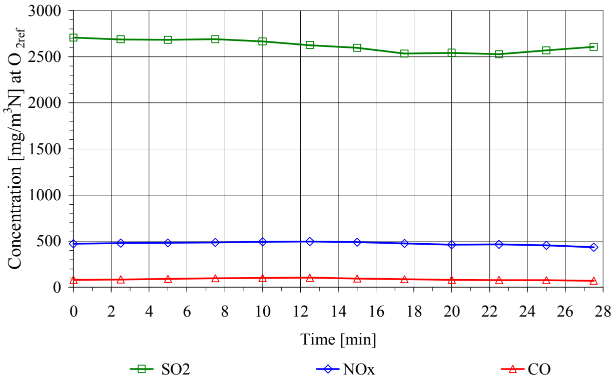


Fig.12. Time dependence of $SO_2$, $NO_x$ and CO concentration when co-firing 15 % by mass Corncob with Pit coal.

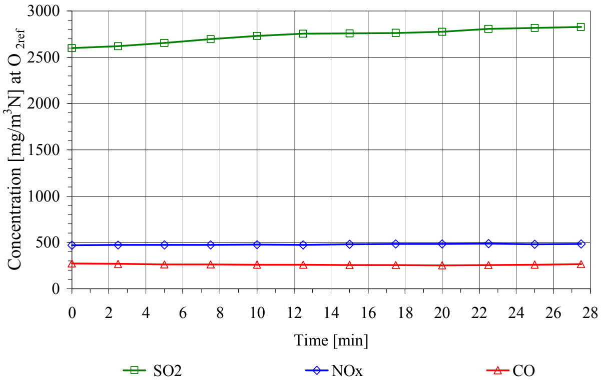


Fig.13. Time dependence of the $SO_2$, $NO_x$ and CO concentration when co-firing 15 % by mass Corncob with Lignite.

In general, when the volatile matter content is low the reactivity is low too and the combustion of this fuel is more difficult. The coal has in some cases a lower reactivity or comparative, in other even higher than the biomass specie. The presence of unburned particles in the ash is higher or less, resulting, in majority of cases, a decrease of the combustion efficiency. The high reactivity of the biomass species compared to that of coal char, results in a rapid burnout of the biomass particles in case such particles would have survived the passage through the combustion chamber to burn in the cyclone together with the combustible gases.
If the share of biomass is less than 5 % by mass, it was been demonstrated that there are no relevant CO increased values in the flue gases [12].

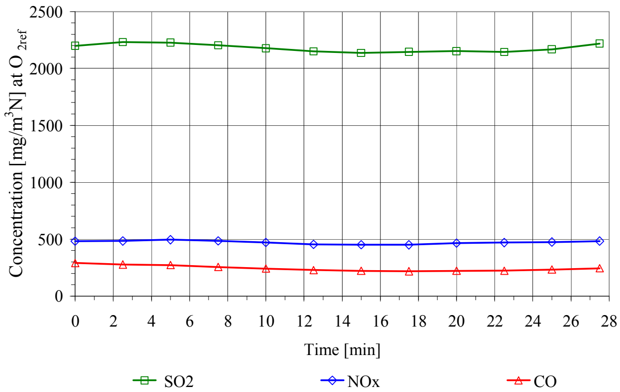


Fig.14. Time dependence of $SO_2$, $NO_x$ and CO concentration when co-firing 30 % by mass Sawdust with Pit coal.

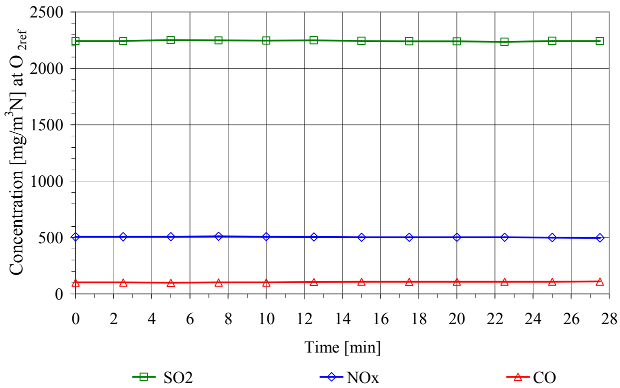


Fig.15. Time dependence of $SO_2$, $NO_x$ and CO concentration when co-firing 30 % by mass Sawdust with Lignite.

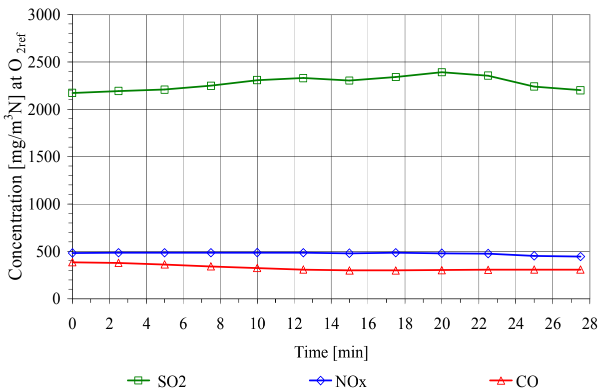


Fig.16. Time dependence of the $SO_2$, NOx and CO concentration when co-firing 30 % by mass Corncob with Pit coal.

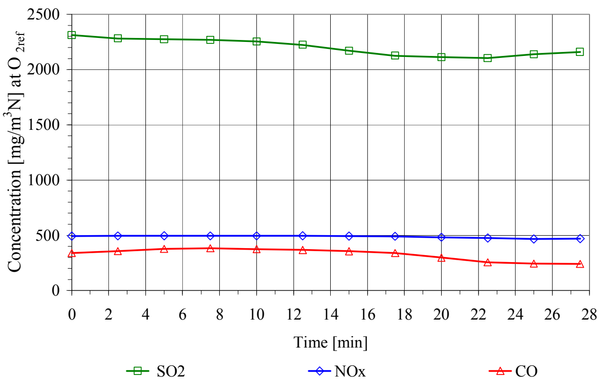


Fig.17. Time dependence of the $SO_2$, NOx and CO concentration when co-firing 30 % by mass Corncob with Lignite.

## 4.2 Specific conclusions

As specific comparative result, one indicates that between the two test series accomplished on co-firing of biomass species (sawdust and corncob) in addition to coal no major relevant differences resulted, despite the difference of heat value, determining higher temperatures, with all resulting benefits and disadvantages. Both species of waste biomass are appropriate to be used in co-firing with coal, in slightly retrofitted existing facilities, normally used for one fuel. The support of other fossil fuel is not needed. In order to improve the efficiency of the co-firing process, one suggest to continue the tests for reducing the unburned carbon (CO) values in the flue gases, that is the main reason for a lower thermal efficiency of the process, in comparison to the classic (fossil fuel) case. Also the CO amount is over the limits permitted for a clean combustion and permitted emission concentration in stack.

Important relevant experimental conclusions, compared to the unblended combustion tests, are noticed. They refer to:

- The fuel cost under the co-firing circumstances is, under the specific conditions from Romania, lower as in comparison to alone fossil fuel utilization,
- Reduction of the $SO_2$ concentration in the flue gases occurs, in accordance to the biomass ratio; there are theories that the composition of the biomass might act also in influencing this process, as well,
- Because the fluidized bed combustion, not notable $NO_x$ enhance in case of the co-firing was attested, due to the higher heating value of the biomass in comparison to the coal.
- No special deposit problems have been recorded; one reason might be the special outfit of the furnace, according to the design of the fluidized bed combustor.
- A reduction of the thermal efficiency (due to a higher unburned C in the flue gases) is caused by the presence of the biomass in the blended fuel,
- The particle concentration in the flue gases is reduced in the case of the co-firing, in accordance to the biomass content, the explanation is also connected to the reduced ash content in biomasses,
- In order to generate a total $CO_2$ lean global process, one suggests adding finally, a technology of capturing the $CO_2$ by absorption (through scrubbing with monomethanol-amine MEA). The $CO_2$ emission might be also reduced and controlled by paying the price for the supplementary technology.

As further plans one will study special emission such as HC, PAH and soot, HCl, PCDD/F and heavy metals (Pb, Zn, Cd, others). Attention should be paid also to the corrosion aspects, knowing that they are related to alkali metals and chlorine and might turn into a major problem. In addition, the utilization of the residues (ashes) is term of further and peculiar analysis and research.

Generally speaking, one concludes that, the technology of waste biomass co-firing with fossil coal is worth of being further tested further in order to be more optimized both ecologically as from the point of view of the data base formation (different ranges of biomass categories) and as automatics. The experimental results presented demonstrate that the co-firing technology, for Romania, represents a progress, and is worth to be applied in industrial environment also, taking into consideration the potential of local biomass availability. The technology is stable, is expected to be applied with a large share of waste biomass, and by applying flue gas cleaning technologies, the limits for the pollutants' concentration in stack might be respected.

## 4.3 General conclusions and outfit

Used as an energy raw material, biomass has a number of benefits compared to other energy raw materials based on C. The main benefit of the biomass and waste biomass in this context is the fact that they are carbon dioxide neutral. However, a number of circumstances, as entire life cycle chain of the bio energy, must be strictly evaluated from environmental aspect.

As final general conclusion, one insists about the fact that renewable energy sources have the potential to make a significant contribution to the sustainable energy future of the European Union.

*Co-combustion* is a useful technology, less costly and friendlier for the environment, especially when waste biomass is fired. In particular by using the energy content of the waste biomass one may contribute to reach the environmental goals of the EU - in particular with regard to the commitments under the Kyoto Protocol - , increase the security of supply by mitigating the dependence on imported fuels and increase social welfare by creating new employment opportunities. Finally the development of renewable energy sources contributes to the goal of the Lisbon process to reach sustainable economic growth and to improve the competitiveness of the European Union on a global scale by creating lead markets for innovative technologies. The challenge of increasing the share of renewable in each sector of the energy system has been recognized by the European Union and translated into a comprehensive regulatory framework.

In January 2008, the European Commission proposed (in comparison to the level from 1990) a Climate and Energy package to:

- reduce greenhouse gas emissions by 20 % by 2020;
- increase the share of renewable energy by 20 % by 2020;
- improve energy efficiency by 20 % by 2020.

The proposed technology of co-combustion of waste biomass with fossil fuel is a step towards this global goal. The existing EU legislation needs to be adopted into national legal and policy measures of member states [13], [14].

Biomass waste and waste utilization in general, as energy resource, according novel technologies, are supporting this tendency and represent also a solution for environmental protection, simultaneously, not adding other benefits legally connected to job creation, energy independence of regions, cost efficient closing loop in local communities (such as so called green villages) or slightly grower energy supply tendencies, for improving the RES cocktail in energy supply.

Energy from waste should not be seen as a one-step disposal process, but as an integrated strategy that incorporates several handling and treatment steps, such as waste separation, recycling, energy recovery and residue management. It is also an alternative source of energy, which, by displacing fossil-fuels, contributes to meet the renewable energy targets, and offers a solution concerning global warming, thus achieving the Kyoto Protocol commitments.

The availability and continuous subsidy of fossil resources are considered major obstacles to the deployment of RES, including waste, in Member States. On the other hand, phasing out the utilization of nuclear power and dependence on the external supplies of fossil energy sources as well as energy intensive industry can function as promoters of RES. In general, waste and waste biomass faces the implementation barriers as other sources of renewable electricity, two of the most critical being the grid access and administrative procedures. Insufficient and inadequate support systems as well as the lack of integration of various biomass-related policies are hindering growth. In order to enhance waste and waste biomass energy use, support schemes and policy refinements should be improved, to take into account biomass potentials at regional and national levels and turn this fact into a benefit (economic, social and environmental). Uncertainties related to the supply of biomass are included in the barriers specifically for bioelectricity.

The large capital investments do not occur unless there is a proof of reliable long-term income to attract private investors and presently biomass use is based on industrial by-products and wastes which build up only slowly. Uncertainty of future energy politics is seen by decision makers as a great risk: the risk for investor is that incentives can change before the investment has paid off [14].

Last but not least, one has to remind that the implementation of renewable energies into the world's energy supply and the substantial investments needed to do so, call for an integrated approach to utilize all different available technologies and resources as well as energy end use efficiency to minimize demand. No energy source alone can supply the future needs of mankind and even our conventional energy sources face the problem of fluctuating generation capacities. However, one has to keep in mind, that no alternative energy system will be available when it is needed it in the coming decades, if the start to renew the energy concept is delayed.

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