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ScienceDirect

Energy Procedia 113 (2017) 390 – 395

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2016, 12–14 October 2016, Riga, Latvia

# Biomass co-firing laboratory equipment

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**Abstract**

Biomass is plant origin organic waste that is used for energy production, generally as a fuel. Co-firing is a combustion technology where two or more fuels are burned at the same time. It is a source of interest for many, due to provided greenhouse gas reduction and controlled use of fossil fuels. This paper takes a closer look at biomass co-firing equipment in the Riga Technical University (RTU). It offers a literature review on co-firing technologies, characteristics and implementation experiences. The paper includes a description of the laboratory equipment, possible experiment plan and the design of three factor experiment for an example of $CO_2$ emissions. Calculations for determining necessary fuel proportions are made. It was determined that the most appropriate amount of biomass used for co-firing in the existing equipment is between 60 and 70 % of mass proportions.

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Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".

*Keywords:* co-firing; natural gas; biomass; $CO_2$ emissions; fuel proportions

## 1. Introduction

It is important to switch from fossil fuels to renewable fuels, as they are a key element to decrease effects of climate change.

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Peer-review under responsibility of the scientific committee of the International Scientific Conference "Environmental and Climate Technologies".
doi:10.1016/j.egypro.2017.04.019

The potential of co-firing equipment is similar to that of combined heat and power generation plants. Two different types of fuels are used, they have low maintenance costs and are easy to install. Both of these methods are dependent on biomass characteristics, costs of biomass and emissions produced from the combustion process [1, 2].

The available wood biomass stock accounts for around 631 million $m^3$, with yearly consumption of about 12 million $m^3$. Harvesting and processing costs leave the biggest effect on biomass price. Therefore, different combustion technologies should be considered [3]. One of the most recent technologies for biomass combustion is co-firing. It is used in over 200 installations in 80 countries over the world with different fuel blends. Coal and biomass is commonly used, but in some cases coal is replaced with natural gas [4]. This technology can be applied to waste fuels. So far, successful demonstrations of waste and fossil fuel co-firing have been made in several experimental furnaces in Finland [5].

Biomass is a flexible fuel, due to the fact, that there are different types and forms of it available for combustion. It can be applied using several methods, therefore, it is available for use in a variety of furnaces [6].

The laboratory equipment located in the Institute of Energy Systems and Environment of the Riga Technical University (IESE RTU) can be used for pulverized biomass co-firing with natural gas. So far, there is only one co-firing furnace in Latvia using a blend of coal and biomass [7]. Co-firing of biomass and propane has been studied several times with laboratory equipment operating in the University of Latvia [8–11]. This is a fairly new technology in Latvia, therefore further research and experiments in the field are necessary [12].

**Nomenclature**

| | | | |
|---|---|---|---|
| A | ash content, % | a | furnace operating mode (load), % |
| $b_0$ | free coefficient of an equation | b | consumed air flow, $m^3/h$ |
| $b_1$, $b_2$, $b_3$ | calculated coefficients for each variable | $B_b$ | biomass feed rate, t/h |
| $B_g$ | gas feed rate, 1000 $Nm^3/h$ | C | carbon |
| $CO_2$ | carbon dioxide | $E_g$ | $CO_2$ emission factor for gas, $tCO_2/MWh$ |
| LHV | lowest heating value | $NO_x$ | nitrogen oxides |
| $O_2$ | oxygen | p | significance value |
| $r_{b/g}$ | fuel proportion, amount of biomass thermal energy/gas thermal energy | $S_b$ | biomass substitutions on thermal basis, % |
| W | water content, % | $x_1$, $x_2$, $x_3$ | independent variables (with known minimum and maximum values) |
| y | dependent variable that has to be calculated | | |
| ε | random error | | |

## 2. Methodology

The aim of this paper is to research the specifics of biomass co-firing and introduce possible experiment plan and methodology for biomass co-firing laboratory equipment in RTU. Methods include literature review on co-firing technologies, description of the laboratory equipment and possible methodology for experiments, the plan for three factor experiment for co-firing system in IESE RTU, in an example for changes in $CO_2$ emissions. Calculations are made for determining necessary biomass and gas proportions for co-firing in the IESE RTU laboratory equipment.

### *2.1. Literature review*

Three general methods of co-firing can be separated. They are direct, indirect and parallel co-firing. Each of them has its own requirements, depending on furnace parameters, amount, type and quality of biomass used in the combustion process [13].

Direct co-firing is widely used due to its easy application in already operating boilers and low costs. In this method, both biomass and fossil fuel are blended and burned together in the same furnace. It is mostly used in grate firing boilers for pulverized fuel combustion. There, fuels are shredded to a size of 6 mm, before combustion [13].

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