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An evaluation of biomass co-firing in Europe

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ABSTRACT

Reduction of the emissions of greenhouses gases, increasing the share of renewable energy sources (RES) in the energy balance, increasing electricity production from renewable energy sources and decreasing energy dependency represent the main goals of all current strategies in Europe. Biomass co-firing in large coal-based thermal power plants provides a considerable opportunity to increase the share of RES in the primary energy balance and the share of electricity from RES in gross electricity consumption in a country. Biomass-coal co-firing means reducing CO_2 and SO_2, emissions and it may also reduce NO_x emissions, and also represents a near-term, low-risk, low-cost and sustainable energy development. Biomass-coal co-firing is the most effective measure to reduce CO_2 emissions, because it substitutes coal, which has the most intensive CO_2 emissions per kWh electricity production, by biomass, with a zero net emission of CO_2. Biomass co-firing experience worldwide are reviewed in this paper. Biomass co-firing has been successfully demonstrated in over 150 installations worldwide for most combinations of fuels and boiler types in the range of 50–700 MWe, although a number of very small plants have also been involved. More than a hundred of these have been in Europe. A key indicator for the assessment of biomass co-firing is intrduced and used to evaluate all available biomass co-firing technologies.

1. Introduction

Environmental protection represents one of the major strategic objectives for all countries. The obligations of the Kyoto Protocol to reduce greenhouse gases (GHG) by 8% by 2012, relative to the base year 1990, and its high energy dependency (more than 50% [1]) is forcing the EU to achieve a doubling of the share of renewable energy sources by 2010 (from 6% of total consumption in 1996 to 12% in 2010) as the target of the EU strategy [2] and the Directive adopted to increase the share of electricity production from RES in its electricity consumption [3]. The European Commission has been finding that the share of renewable energy is unlikely to exceed 10% by 2010 and proposes in its Renewable Energy Roadmap [4] a binding target of increasing the level of renewable energy in the EU overall mix from less than 7% today to 20% by 2020 [4,5].

The Directive on renewable energy in electricity generation provides the framework for electricity from biomass and the Biomass Action Plan [6] states that electricity can be generated from all types of biomass. Several reliable technologies are available. These technologies can be used to ''co-fire'' biomass, by mixing it with coal or natural gas, or to run free-standing power stations.

Biomass-coal co-firing means reducing CO_2 and SO_2 emissions and it may also reduce NO_x emissions [7,8] and represents a near-term, low-risk, low-cost and sustainable energy development. Biomass-coal co-firing is the most effective measure to reduce CO_2 emissions, because it is the

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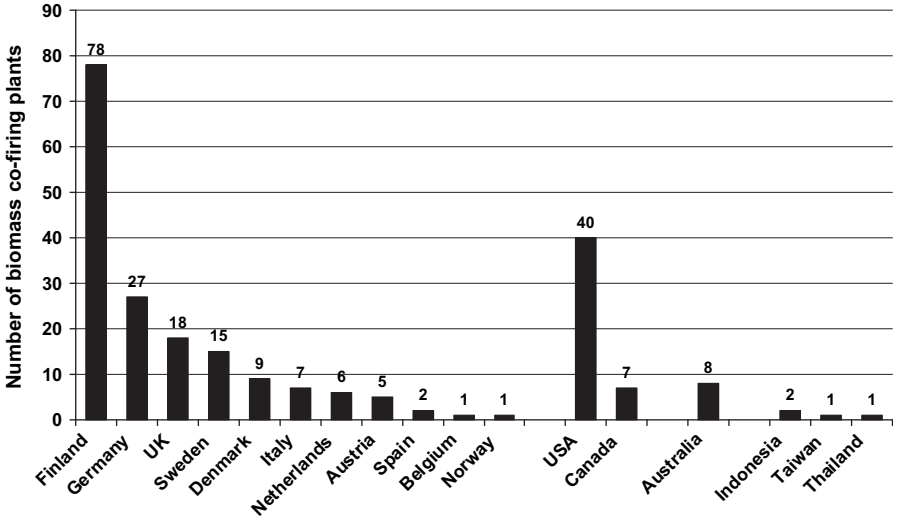

Fig. 1 – Distribution biomass power plants worldwide [12].

substitution of coal (which represents the most intensive CO_2 emissions per kWh of electricity production) by biomass with zero net emission of CO_2.

One of the research activities on biomass co-firing is the NETBIOCOF project, co-funded by the European Commission under the 6th Framework Programme. The objective of the NETBIOCOF [9] (Integrated European Network for Biomass Co-firing) project is to promote biomass co-firing and to foster the uptake of innovative technologies to expand the use of biomass co-firing in new and existing power plants in EU member countries. One of the activities of the project is to review (state of the arts) the co-firing of biomass with fossil fuels [10] and the identification of best practices in biomass co-firing in Europe [11]. This paper is based on the results of both documents (reports).

2. Biomass co-firing plants in Europe: state of the arts and geographical distribution

Co-combustion is practised with different types and amounts of biomass wastes in different combustion and gasification technologies, configurations and plant sizes. Currently, direct co-firing is the most commonly applied configuration. The typical configuration applied in Finland is a fluidised bed combustion installation within the range of about 20 to 310 MW where different biomass wastes from the wood industry are directly co-fired, eventually with recycled refuse fuel (REF), refuse derived fuel (RDF), coal or oil. Here, the installations need to be fuel flexible, one reason for this being that sparsely populated countries make specialized mass burning installations uneconomic. In Sweden, there are a large number of grate fired boilers in the range 1–30 MW which are operated for district heating (mostly firing "biomass" only, but it often means co-combustion of different types of residues). In the paper and pulp industries, there are both fluidised and grate furnaces that burn mixtures of bark, sludge, wood residues, oil and some coal.

Worldwide, the current installed capacity of coal fired power plants amounts to some 800 GWe. Thus, each percentage of coal that could be substituted by biomass in all coal fired power plants would result in a biomass capacity of 8 GWe, and a reduction of approx. 60 Mton of CO_2. At a typical co-firing ratio of 5% on an energy basis, this would correspond to a global potential of approx. 40 GWe, leading to an emission reduction of around 300 Mton CO_2/year. About 200 million tons of biomass would be needed to fulfil this demand.

Co-firing biomass with coal in traditional coal-fired boilers is becoming increasingly popular, as it capitalizes on the large investment and infrastructure associated with the existing fossil-fuel-based power systems while traditional pollutants (SO_x, NO_x, etc.) and the net greenhouse gas (CO2, CH4, etc.) emissions are decreased.

The co-firing of biomass with coal in traditional coal-fired boilers makes use of the large investment and extensive infrastructure associated with the existing fossil-fuel-based power systems, while requiring only a relatively modest capital investment, typically up to $50–$300 per kW of biomass capacity. These costs compare very favourably with any other available renewable energy option.

Power plant operating costs are, in most cases, higher for biomass than for coal, due to the higher delivered cost of the fuel, particularly if energy crops are used. Even when the biomass is nominally free at the point of production, for instance in the case of some dry agricultural residues, the costs associated with collection, transportation, preparation, and on-site handling can increase the cost per unit heat input to the boiler to a point where it rivals, and often exceeds, the cost of coal. When compared to alternative renewable energy sources, however, biomass co-firing is normally significantly cheaper, and co-firing has the advantage that it can be implemented relatively quickly.

For most coal-fired power plants, the conversion efficiencies are commonly in the range 30–38% (higher heating value basis). These efficiency levels are much higher than those associated with smaller, conventional, dedicated biomass power-only systems and rival or exceed the estimated