Resource-efficient fuel additives for reducing ash related operational problems in waste wood combustion

Acronym: REFAWOOD

Coordinator:
RISE Research Institute of Sweden (S)

Partners:

- Umeå University (S)
- Luleå University of Technology (S)
- ENA Energy AB (S)
- Gips Recycling AB (S)
- Bioenergy 2020+ GmbH, (A)
- FRITZ EGGER GmbH & Co. OG (A)
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- Dekra (D)
- Cuijk (D)
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- Hotel ARŁAMÓW (PL)

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Contact: RISE Research Institute of Sweden

Introduction

Today, waste wood combustion in dedicated plants or in co-combustion with forest wood chips has become common practice in many EU Member States. Wood waste fuels arises via a variety of post-consumer waste and in different fractions, ranging from untreated, pre-consumer off-cuts to treated wood as demolition wood. Depending on the source, waste wood contains more or less elements that increase the risk to get ash-related problems in the boiler during combustion. Alkali chlorides formed from the critical elements released from biomass combustion may lead to severe ash deposition and corrosion problems in biomass-fired boilers. The majority of biomass and wood waste-fired power plant in Europe reports more or less extensive corrosion problems in the superheater as well as on furnace walls that cause unacceptably short life times. One of the measures to reduce the alkali chloride-related problems in biomass combustion is to use additives. Fuel additives can increase the reliability of biomass combined heat and power plants and develop skills to extend the use of different types of biomass fuels, which ultimately may mean that the energy supply of conventional fuels with higher environmental impact can be reduced. The overall objective of REFAWOOD was to improve economic and environmental conditions for the use of wood waste fuels in combined heat and power plants by using resource efficient additives during combustion.

Results

The project has investigated the influence of new cheap and resource efficient fuel additives as recycled gypsum, iron sulphide (sulphide ore waste material), and the aluminosilicate additives halloysite and coal fly ash on important ash transformation processes in thermal conversion of wood waste. The additives provide different strategies that may be suited for different processes. Recycled gypsum contains calcium that can increase the melting temperature of formed ash particles in the temperature range typically associated with woody waste combustion. Additionally, the gypsum provides sulphur that can outcompete chlorine in the formation of deposits and thereby reduce the risk of corrosion problems. Similarly, the iron(II)sulphide can provide sulphur to reduce chloride formation in fouling and deposits but iron is not generally considered to reduced slagging issues. Finally, the aluminosilicate- containing additives halloysite and coal fly ash can act as reactants to capture the alkali components potassium and sodium in compounds with high melting temperatures.

WASTE WOOD POWER PLANTS

	A	B	C	D
Installed capacity, MW	22 MW_e , 45 MW_{th}	1.2 MW_e, 5.5 MW_{th}	10 MW_e, 40 MW_{th}	0.8 MW_{th}
Fuel blends, in % primary energy	forest residues 9%; waste wood 91%	Wood chips (forest) 100,0%	Bark 7%; Chips and sawdust 3%; Sunflower shells 5%; Screening dust from production 40%; Wood chips (forest) 45%	Forest residues 100%
Tested additives	1 wt% gypsum	1 wt% gypsum 1 wt% halloysite	1 wt% gypsum 3 wt% coal fly ash	1 wt% gypsum 3 wt% halloysite

Table 1. The 4 different waste wood power plants.

To demonstrate the fuel additive design concepts, full-scale combustion trials have been performed in wood waste fired combined heat and power plants of different sizes (8-70 MW) and with different technologies. Additives can be blended with the fuels at a terminal, dosed directly on the fuel at the augers upstream of the furnace or added to the fuel in the boiler by fuel injectors. Fuel admixing worked similarly well regardless of strategy, but the additive dosing system needs to be adjusted to different fuel feeding systems and to each specific combustion system.

Gypsum as an additive for simultaneous addition of Ca and S to problematic wood waste streams shows potential. The results from the project show that the underlying chemical reactions work as intended. Alkali capture in Ca-sulphate particles was readily observed which indicates good potential to reduce chloride formation. Increased flue gas concentrations of HCl in combination with elevated SO2 concentrations shows a reduction of chloride formation. However, power plant capabilities for handling of total particulate matter concentrations in cyclone or filters as well as flue gas cleaning must be considered if gypsum is used as an additive.

In order to understand the environmental consequences of using low-cost additives for waste wood combustion, the environmental profiles of four different power plants were investigated through a life cycle assessment (LCA). Such assessment allowed to explore the contribution of different parameters (e.g. additives strategies, combustion emissions or wood fuel composition) to the total life cycle environmental impacts of producing heat and electricity in a combined heat and power plant.

In conclusion, the use of low-cost additives have the potential to slightly reduce the environmental impacts of producing energy with waste wood, especially in the case of medium to big scale power plants using pre-treated waste wood as feedstock. However, impacts on acidification may increase under the absence of appropriate flue gas cleaning systems (desulphurization and NOx reduction). Halloysite was the additive presenting the highest benefits.

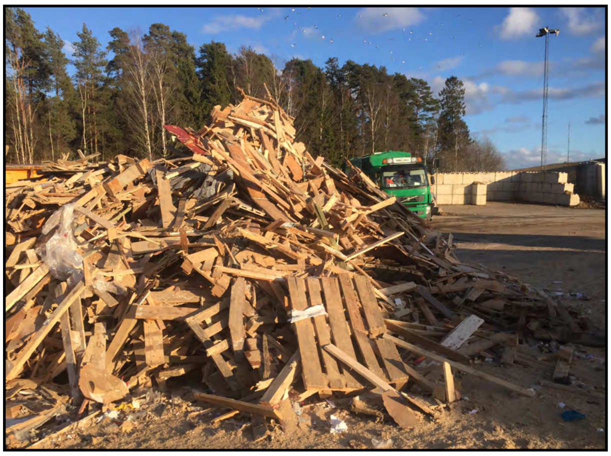

Figure 1. Fuel admixing.

Figure 2. ENA CHP-plant, Sweden.

The project has analysed whether or not the use of additives within the fuel mix will result in reduced operational and maintenance costs. These reduced costs could be caused due to an increase in boiler performance and operational hours, and a decreased amount of maintenance. This was done by performing a cost benefit analysis (CBA) of four different power plants. The economic effects, a yearly cost reduction (before interest and corporate tax) range (low scenario – high scenario), was calculated for all the additives that were tested in each power plant. A yearly cost reduction between €134,000 and €334,000 could be realized by applying 1 wt% gypsum within the fuel mix for a plant with the size 22 MWe/45 MWth. For a smaller plant a cost reduction between €29,000 and €60,000 could be realized (1,2 MWe/5,5 MWth).

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