ASH MANAGEMENT AT BIOMASS HEATING PLANTS IN SOUTHERN GERMANY

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ABSTRACT: Little is known about how biomass heating plants in South Germany actually dispose or recycle their ashes, about the costs that are incurred and about the obstacles to a material use of the ashes from an operator's point of view. This paper summarizes survey results mapping the current situation of ash disposal in Bavaria and sheds light on a poorly researched aspect of heat and power generation from solid biomass. The high participation in the survey (32 %) shows the interest of the plant operators in ash management. With regard to the installed thermal power, the survey can be considered representative. Following main obstacles for ash recycling have been identified: Small amounts of ash per plant, uncertainty about the legal situation of ash recycling, low economic benefits due to high analytical costs and inefficient logistics, fluctuating ash quality and too high contents of Chromium VI or other heavy metals in the ashes, difficult handling of the ashes (dust), low number of ash recyclers and small market for fertilizer based on wood ashes. To reach the goal to increase the recycling rate for bottom ash the first approach in Southern Germany should focus on plants within the power range from 2.5 and 15 MW. Due to their relatively high volumes of bottom ash the costs for analyzing and transport per ton of ash should be rather low for these plants. The survey results will be used within the research project "AshUse" to develop strategies for an increased material use of biomass ashes in Bavaria.
Keywords: Ashes, recycling, solid biofuel, district heating, biobased economy

1 INTRODUCTION

Combustion of solid biofuels in biomass heat (and power) plants produces ashes. On the one hand, these ashes have properties that suggest utilization, e.g. as fertilizers or building materials. On the other hand, the ashes may be contaminated with environmental pollutants such as heavy metals which may limit material use and may require disposal in landfills or even below ground. Shortage of landfill space, the changed legal situation (e.g. German Waste Management and Product Recycling Act, landfill regulations, European Waste Framework Directive, European Fertilizer legislation) as well as bio-economical demands to close natural cycles makes the material use of wood ashes increasingly attractive. Various research groups have been working on new ways to increase the material use of ashes [1, 2, 3]. However, little is known about how German biomass heat (and power) plants actually dispose or recycle their ashes, about what costs are incurred and the challenges of a material use of the ashes from an operator's point of view. Moreover, utilization of ashes for material use requires knowledge on their amount, quality and regional distribution. Thus, the aim of this study is to record the current "status quo" of handling biomass ashes in German biomass heat (and power) plants. This knowledge will be used to develop strategies on plant level and on a general level for an increased material use of biomass ashes.

2 MATERIAL & METHODS

The data collection is based on an online survey. In total, 351 biomass heat (and power) plants were invited to participate. The area of investigation is the federal state of Bavaria in Southeast Germany with a very high density of plants. The survey contains questions about plant engineering, fuel quality and quantity, the disposal and recycling of the different ash fractions and the willingness of the operators to recycle the ashes. At the plant level, the data collection comprises quality and quantity of the fuels, the operation of the plant and technical details on the type of furnace, on particle removal from the exhaust fumes and on the processing of the different ash fractions. Another set of questions addresses the existing disposal routes and recycling pathways and the economic conditions for ash handling. Current problems with ash disposal are inquired as well as the readiness of the operators to recycle ashes in the future rather than to dispose them. The final part of the survey investigates existing quality assurance measures at the plant. These measures form an important prerequisite to produce quality-assured ashes for material use.

3 RESULTS & DISCUSSION

The survey provides detailed information on the ash management of Bavarian biomass heat (and power) plants. The results show a high participation in the survey. A high share of 32% (114) answered the questionnaire. Those plants started to operate between the 1990ies and 2018. Between 2006 and 2011 the yearly increase of plants was highest (**Figure 1**).

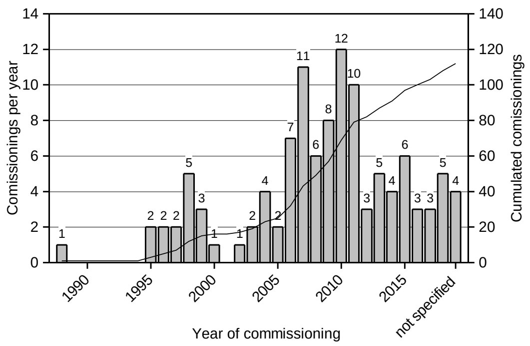

Figure 1: Year of commissioning of the biomass heat (and power) plants that participated in the survey on ash management.

3.1 Technical details of the heating plants

Three quarters of the plants have an installed thermal power of less than 1 MW (**Figure 2**), 16% of the plants have a thermal power between 1 and 2.5 MW and 9% range from 2.5 MW up to 50 MW.

With only a few exceptions the installations operate with a fixed bed furnace and a dry deashing. Concerning flue gas treatment 71% of the plants stated that they are equipped with a cyclone and 29% use an additional electrostatic precipitator to remove particles.

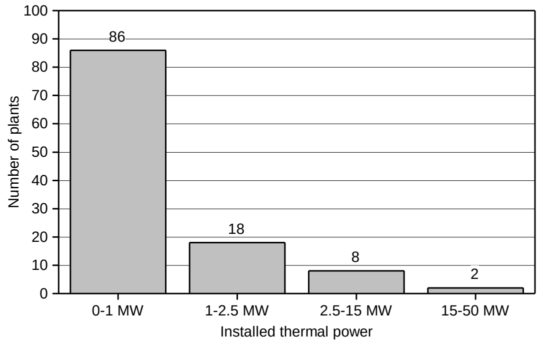

Figure 2: Categorization of the heating plants according to their installed thermal power

3.2 Representativeness of the answers

To gain information on the representativeness of the answers the distribution of the installed thermal power was compared between the returned surveys and the actual distribution among all plants (**Figure 3**). Overall a good correspondence of the distribution of the installed thermal power can be stated. In the survey the higher power classes are slightly higher represented. That is because of for larger plants, ash disposal is a more relevant topic.

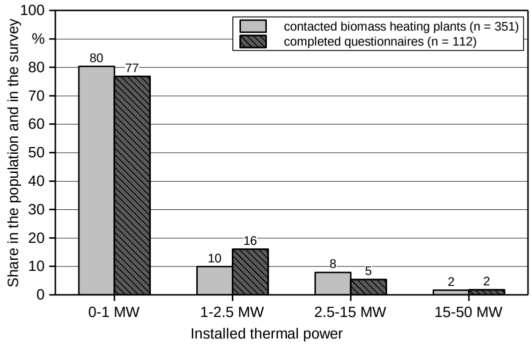

Figure 3: Distribution of the installed thermal power of all contacted plants compared to those that completed the questionnaire

3.3 Fuels and ashes

The average fuel quality that is typically combusted in the plants varies between the power classes. Whereas woodchips from softwood, sawmill by-products (without bark), woodchips from hardwood and pellets dominate the lower power classes (0–1 MW, 1–2.5 MW), residues from landscape maintenance is the dominant fuel for the plants with a thermal power higher than 2.5 MW (**Figure 4**). Pure bark is not combusted in plants below 1 MW.

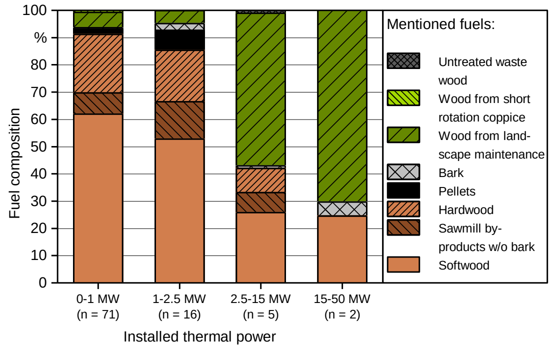

Figure 4: Mean fuel composition within the categories of thermal output

Half of the plants produce less than 10 tons of bottom ash (dry matter) per year while 10% of the plants generate more than 60 t per year (**Figure 5**). Regarding the total volume of ash reported via the survey the 10% largest plants generate 90% of the ashes.

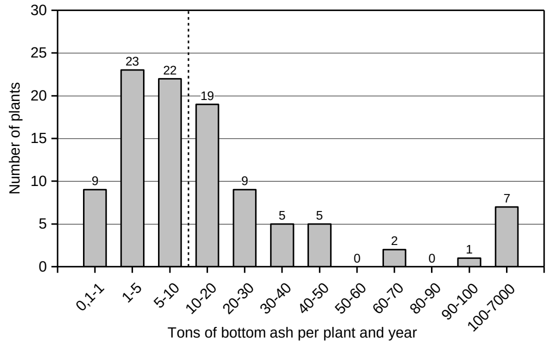

Figure 5: Amount of dry bottom ash per year illustrated as frequency of weight categories

3.4 Ash management

Figure 6 sums up different measures that are used from plant operators to ensure an ash quality that is suitable for the use as a fertilizer. For instance 41% of the plant operators reported to store different ash qualities (bottom, cyclone and fly ash) separately. This results in a lower content of heavy metals in the bottom ash, as certain heavy metal contents in the cyclone and filter ashes are increased. Further measures include retaining samples, documentation and analysis of the ashes and traceability back to the fuel.

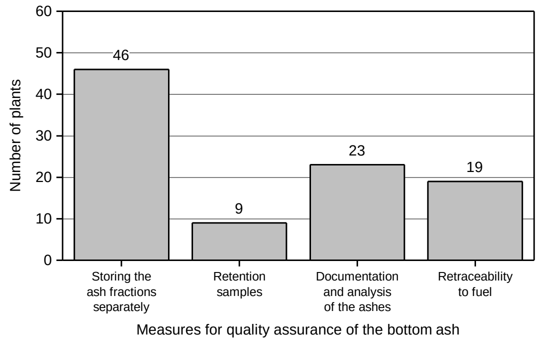

Figure 6: Quality measures that potentially contribute to a higher bottom ash quality

Few plants do not store their bottom ash (13%) whereas many plants store it up to a month (39%). Smaller installations, however, do often store their bottom ashes up to 6 months or even longer (**Figure 7**).

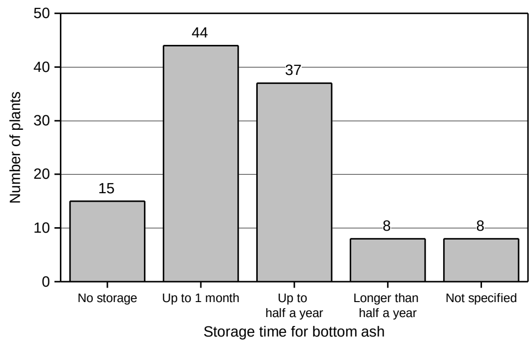

Figure 7: Storage time of the bottom ashes

Even though the plants from the survey burn untreated wood, the content of heavy metal in the bottom ash or in the mixture of bottom ash and cyclone ash can exceed the limits of the (German) bio waste / fertilizer regulations. Landfills also have limit values for certain components of wood ashes. Therefore, for both pathways i.e. recycling or dumping, the ash quality has to be analyzed. This analysis is done with variable intensity at the plants. Most plant operators did not answer the question according to which legal requirements the ashes are analyzed (**Figure 8**) while 11% of the plants analyze their bottom ash according to waste legislation, i.e. a requisite to deposit the ashes. Only 7% analyze their ashes according to fertilizer / bio waste legislation and aim therefore at using the ashes for fertilizing or as a source material for fertilizers. Approx. 11% of the plants did state, that they analyze the ashes but without additional information. The high share of 68% that gave no answer may encompass concepts that include the disposal company to analyze the ashes to determine the possible recycling or disposal path.

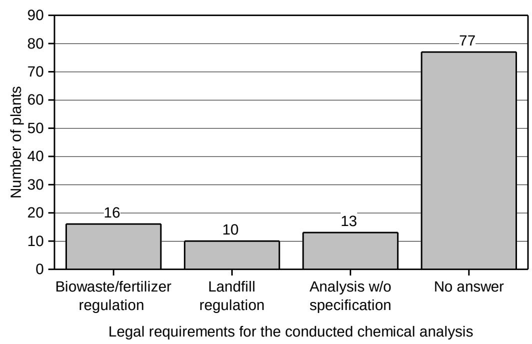

Figure 8: Legal requirements for the conducted chemical analysis of the bottom ash

In a comment field in the survey the plant operators had the possibility to describe common problems with ash handling. Several operators reported that too high heavy metal concentrations (most often Chrome-VI) are the main reason that prevents ash recycling as fertilizer. and some operators stated that the ash handling at their plant is unfavorable due to non-standardized ash containers. The necessary transfer of the ashes in other containers for transportation creates huge amounts of dust.

3.5 Ash disposal paths and costs

Detailed information on the costs of the ash management was only given in a few cases. Most likely many plant operators do not know exactly their cost allocation of the ash disposal. **Figure 9** gives four examples on the costs of reported ash disposal pathways of individual plants.

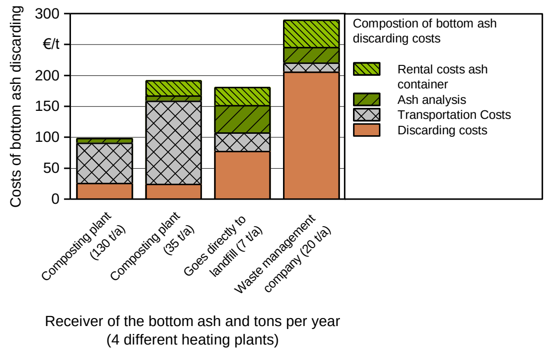

Figure 9: Detailed costs for ash discarding of four individual plants

The first and second column in **Figure 9** illustrate the costs for ash recycling as aggregate to compost. Whereas the disposal fee is more or less equal, the transportation costs per ton of bottom ash vary greatly. Smaller plants often have problems to establish effective logistic concepts due to only relatively small amounts of ash. The disposal fees for landfill or for engaging a certified waste management company are in general higher than for ash recycling and can vary in a wide range as shown by column 3 and 4.

Figure 10 shows how the bottom ashes are treated in the different thermal power classes. The share of ash recycling increases with installed thermal power from about one third in the lower classes to a 100% recycling rate of 100% for the plants greater than 15 MW.

Application on their own agricultural or forested areas and handing over the ashes to the fuel supplier is often practiced by plants smaller than 2.5 MW. Recycling in composting facility is common in all groups. Mixing with limestone only occurred in few cases smaller than 1 MW. Both recycling paths increase with installed thermal power. For plants up to 15 MW the share of bottom ash that is handed over to waste management companies increases up to 50%. In most cases, those companies send the ashes to landfills. In particular cases also recycling might occur without knowledge of the plant operator.

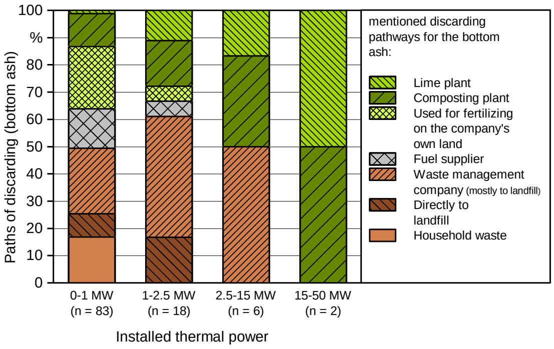

Figure 10: Ash discarding pathways according to the categories of thermal output

Although the attitude towards a quality certification of the bottom ash as a fertilizer or as a base material for fertilizers is either positive (28%) or neutral (59%), many operators fear a high effort and costs with little added value, especially if the bottom ash only amounts to a few tons per year. Some operators expect an improved public image and cost savings from ash recycling.

4 CONCLUSIONS

The high participation in the survey shows the interest of the plant operators in ash management.

Concerning the installed thermal power, the survey is representative. The thermal power correlates directly with the amount of ash a plant generates. Therefore, the survey should also be representative of many parameters that depend on the size of the plant.

As main obstacles for ash recycling have been identified:

- Small amounts of ash
- Uncertainty about the legal situation of ash recycling
- Low economic benefits due to high analytical costs and inefficient logistics
- Fluctuating ash quality and too high contents of Chromium VI and other pollutants in the ashes
- difficult handling of the ashes (dust)
- low number of ash recyclers and small market for fertilizer based on wood ashes

Recycling fees for bottom ash often are lower than disposal costs but increased transport costs can eat away this benefit. Many small plants with small amounts of ash have difficulties to recycle, since extensive analyzes are necessary and transport is rather expensive. In those cases, the ash recycling does not offer a financial benefit. To reach the overall goal of this study, i.e. to increase the recycling rate for bottom ash in Bavaria, the first approach should therefore focus on plants within the power range from 2.5 and 15 MW. In this category, ash disposal apparently is wide spread. Due to high volumes of bottom ash, the costs for analyzing and transport per ton of ash should be low.

Ash recycling as a whole would reach more supporters, if cheaper heavy-metal analysis would be available.

The survey is part of the project “AshUse”. As continuation of the survey the bottom ashes of plants that showed interest in recycling will be sampled and analyzed according to the German fertilizer legislation. Further work includes experiments on plant availability of relevant nutrients in the ashes to gain information on its value as a fertilizer. An important part of the project is to build a network between scientists, authorities, plant operators and disposal / recycling companies and other institutions to promote the reuse of ashes. Legally sound alternatives to dumping the ashes into landfills often are unknown. Therefore, the project will also give information to clarify the current legal situation to the operators of the biomass heating plants.

5 REFERENCES

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7 LOGO

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