# Grass Pellet Combustion – Summary of NYS Studies

**Purpose**: The purpose of this publication is to summarize the results of using stoves and hydronic heaters to burn grass pellets.

### Where was Testing Done?

Testing of appliances was carried out in NYS at Cornell University, at SUNY-Canton, and in the NYC Watershed area. There was almost no appliance model overlap across the three sites. Research was funded by NYS Energy Research & Development Authority, the Catskill Watershed Corporation, Delaware County Cooperative Extension, and Cornell University. A wide range of appliances were tested using high ash mature, mixed grass pellets, and in some cases lower ash switchgrass or big bluestem pellets.

### Grass Biomass Composition is Critical

The range in grass composition, from warm-season to cool-season grasses, and from mature fall harvested to over wintered grasses, is shown in Table 1.

Table 1. Range in composition of grass sampled in NYS over 4 years and many sites. All were mature grass samples.

| Variable | Minimum | Maximum |
|---|---|---|
| Ash, % | 1.8 | 33.4 |
| Cl, % | 0.01 | 0.90 |
| K, % | 0.04 | 2.47 |
| N, % | 0.35 | 1.73 |
| S, % | 0.01 | 0.32 |
| P, % | 0.01 | 0.39 |
| Ca, % | 0.16 | 0.98 |
| Na, ppm | 34 | 1175 |
| NDF, % | 53 | 95 |
| Lignin, % | 5.1 | 12.4 |
| BTU, per lb | 5645 | 8460 |

Grass composition changes greatly as grass matures, all samples collected were mature grass. Grass composition can also be greatly impacted by allowing mowed grass to remain in the field and be subjected to rainfall and leaching.

The primary concern over combustion of grass is emissions of elements such as Cl, N, and S. Chlorine, N and S emissions will be directly correlated to the feedstock content of these elements. Chlorine is considered the most undesirable element (Cherney and Verma, 2013). Chlorine content of mature grass varied 90-fold, from unacceptably high values to values as low as that found in wood pellets. Through species selection and management, it is possible to produce grass biomass with acceptable levels of the primary undesirable elements. Samples in Table 1 very high in ash and very low in energy content are the result of soil contamination.

### Cornell Studies

A number of pellet stoves and hydronic heaters were evaluated at Cornell's testing facility and at a variety of public installations in eastern NY (Bioenergy Information Sheets #21-29). Prior to emission testing of appliances burning grass pellets, attempts were made to optimize control settings to grass combustion. Almost all appliances are only optimized for wood combustion. For some appliances, adjusting control settings differently than for wood pellets had a significant impact on emissions. Since some of these appliances have many parameters that can be adjusted, it is likely that there is some combination of settings not found that would result in increased efficiency.

Table 2. CO emissions (ppm) at near optimal feed rate (typically nominal rate for boilers and moderate rate for stoves).

| S = Stove<br>B = Boiler | Wood | Grass, low ash | Grass, high ash |
|---|---|---|---|
| Quadrafire, S | 98 | 44 | - |
| Europa, S | 50 | 56 | 90 |
| Harman P43, S | 233 | - | 119 |
| EnviroMaxxM, S | 535 | - | 1437 |
| Woodpecker, B | 34 | 23 | 178 |
| LEI BB100, B | 105 | 48 | 94 |
| Skanden(Reka), B | 46 | 34 | 73 |
| Woodmaster, B | 1162 | - | 2990 |
| LEI BB500, B | 585 | - | 1547 |

Concentrations of Cl, N, and S compounds in emissions are highly correlated to their concentrations in the feedstocks. Emissions containing these elements are best minimized by agronomic management of the feedstock. Combustion efficiency, estimated by CO emissions, was extremely variable over appliances. Typically pellet stoves have combustion optimized at a moderate fuel feed level, while hydronic heaters tend to be optimized at a nominal feed rate. Few appliances, such as the Reka boiler, are designed for non-wood combustion, and have recommended settings for non-woody fuels.

### Clarkson/SUNY-Canton Studies

Several boilers were recently thoroughly evaluated for emissions, using grass and wood pellet fuels (Chandrasekaran et al.). For multiple load settings and all types of grass pellets tested, particulate emissions ($P_{10}$ and $P_{2.5}$) were found to be higher for grasses than wood pellets. CO emissions were also higher for grass than wood, for all boiler/load combinations, indicating an incomplete combustion for grass. CO emissions were positively correlated with particulate and organic compound emissions.

All appliances were optimized for wood. No attempts were made to optimize settings for grass. A boiler that is not specifically optimized for a particular non-wood biomass fuel will most likely burn that fuel inefficiently. Inefficient combustion will result in high CO emissions and higher emissions of particulates and specific compounds.

### European Studies

Verma et al. (2012) evaluated wood and grass pellets in a 40 kW multi-fuel boiler under optimized conditions for each fuel. CO emissions were higher for reed canarygrass at a reduced load, but higher for wood at a nominal load. Particulate emissions were 1.7 and 2 times higher for wood than grass at nominal and reduced loads. The authors concluded that "Optimization of the combustion process is essential, not only for each type of pellet but also at each operational load." Boilers that allow for control of many different combustion parameters have dozens of possible combinations of settings. It can be difficult to optimize a particular load/non-woody fuel setting without any previous data.

### Conclusions

Combustion will be highly dependent on grass composition, and whether it is possible to optimize a particular appliance for non-wood combustion. Almost all biomass combustion appliances are designed for wood combustion, and most are unsuitable for grass pellet combustion. The Skanden (Reka) boiler is an example of an appliance that has been designed to burn wood or non-wood biomass fuels, and has suggested settings for non-wood fuels.

The higher the concentration of problematic elements in a feedstock, the higher the concentration of those elements in emissions. It is possible through agronomic management of grass, to produce a feedstock with more acceptable concentrations of problematic elements.

### Additional Resources


Chandrasekaran, S.R. et al. 2013. Residential scale biomass boilers emissions and efficiency characterization for several fuels. Energy & Fuels 27:4840-4849.

Chandrasekaran, S.R. et al. 2013. Characterization of emissions from grass pellet combustion. Energy & Fuels 27:5298-5306.

Cherney, J.H. and V.K. Verma. 2013. Grass Pellet Quality Index: A tool to evaluate suitability of grass pellets for small scale combustion systems. Applied Energy 103:679-684.

Verma V.K., et al. 2012. Performance of a domestic pellet boiler as a function of operational loads: Part-2. Biomass Bioenergy 35:272-9.


### Acknowledgments


Testing was supported by NYS Energy Research & Development Authority, the Delaware County Cooperate Extension, the Catskill Watershed Corporation, and the Cornell University Agricultural Experiment Station.


For more information

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