WELL BURNED MEANS CLEANLY BURNED

Wood heating is making a growing contribution to the substitution of fossil fuels and is thus contributing to a sustainable energy supply. Wood burning is CO_2-neutral, but produces dust that is potentially unhealthly. Aerosols can now be controlled with appropriate equipment and correct behavior—an international conference in mid-June at ETH Zurich made that clear.

Investigation in a wood-buring stove in the laboratory at the University of Lucerne - Engineering and Architecture. Photo: HSLU

Particulate matter has many sources. Tiny particles in the micro and nanometer scale (PM10) are produced during combustion of oil or coal to generate heat and electricity in power plants, industrial enterprises or residential buildings. Fine dust additionally arises from diesel engines in road and rail transport, in agriculture, forestry and construction sites (combustion processes, abrasion). Also when fires are blazing in cozy domestic wood stoves, fine dust is produced that can be inhaled by humans and that can attack the lungs. Particulate matter is a complex mixture to which secondary particles

A technical report about the 20th Conference on Combustion Generated Nanoparticles (June 14th 2016), focussing on the conference module of ‹IEA Bioenergy Task 32› about biomass combustion. The report has been published in ‹Kommunalmagazin› (issue October 2016).

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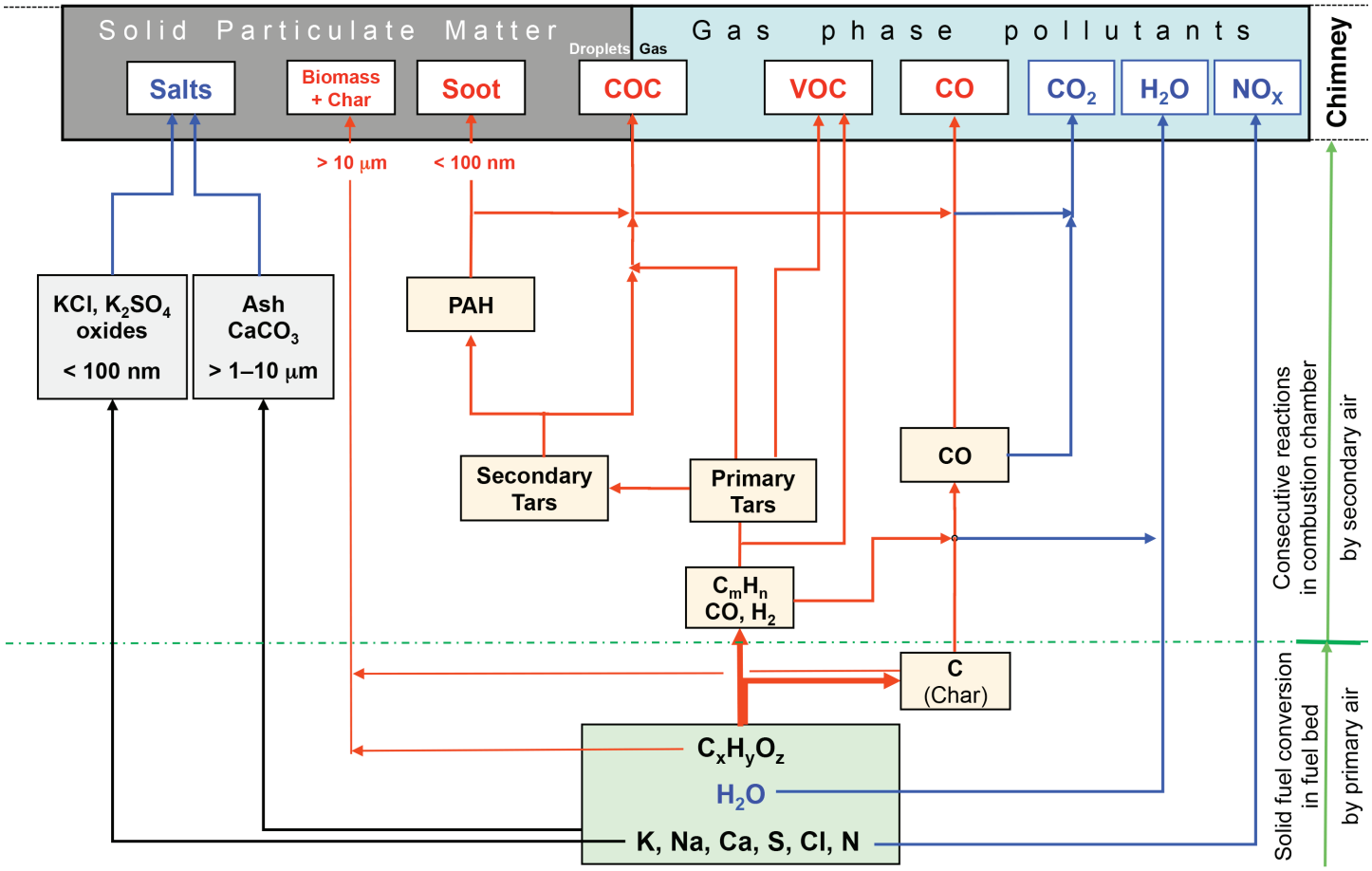


Overview of the products that are formed during the combustion of wood in furnaces and discharged as waste gas through chimneys into the environment: wood (green rectangle) consists of organic elements (carbon / C, hydrogen / H, oxygen / O) inorganic elements (particularly potassium / K, sodium / Na, calcium / Ca, sulfur / S, chlorine / Cl, nitrogen / N) and water. After complete combustion, salt, carbon dioxide / CO_2 and water / H_2O and a small concentration of nitrogen oxides / NO_X are left (blue). In reality, however, combustion is incomplete and produces a number of other combustion byproducts (red): entrained biomass and coke particles, soot, condensable organic compounds / COC (also called 'tar' hereinafter), volatile organic compounds / VOC and carbon monoxide / CO. Additionally in the atmosphere (not shown on the graph) secondary organic aerosols / SOA are formed from COC and VOC, and NO_X, which leads to secondary inorganic aerosols / SIA. Salts, primary organic aerosols / POA, SOA and SIA cause dust / PM10 in the atmosphere. Graphic: Nussbaumer 2016

that are formed only subsequently in the air from gaseous precursors, also contribute.

In recent years and decades, the international community has responded to the danger of exposure to particulate matter with various measures. For trucks and diesel cars a particulate filter is now compulsory in Switzerland and many other countries. Anyone who operates a wood heater that emits particulate matter must, among other things, comply with limits that were introduced in 1985 as part of the Ordinance on Air Pollution Control (OAPC). From 2008, the tightening of the OAPC resulted in widespread use of fine particle filters in automatic wood furnaces operating above 500 kW. Since 2012 there are also now regulations for furnaces operating above 70 kW. "Switzerland has made enormous progress in the fight against fine dust in the past two decades and today in international comparisons has first-class air quality. The current review of the OAPC will bring further improvements," says Daniel Binggeli, SFOE expert on bioenergy.

Fine Dust from Small Wood Furnaces

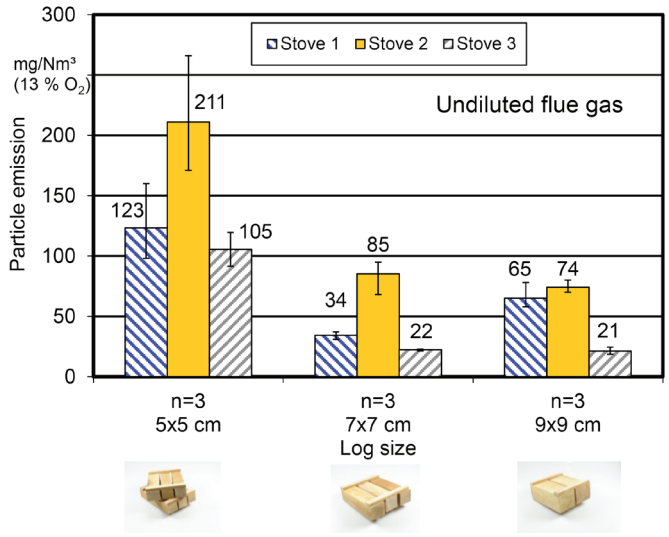
The burning of wood and other types of biomass has growing importance—it contributes to a sustainable energy supply, since the combustion of renewable resources is CO_2 neutral. Wood heating, however, contrubtes approximately 10 to 30% to annual man-made particulate matter pollution, depending on the location. Automatically operated wood chips furnaces today operate relatively cleanly thanks to the

use of high combustion temperatures. Although particualte matter is formed during this high-termperature combustion processes too, it is in the form of inorganic ash that in large furnaces is retained by separators.

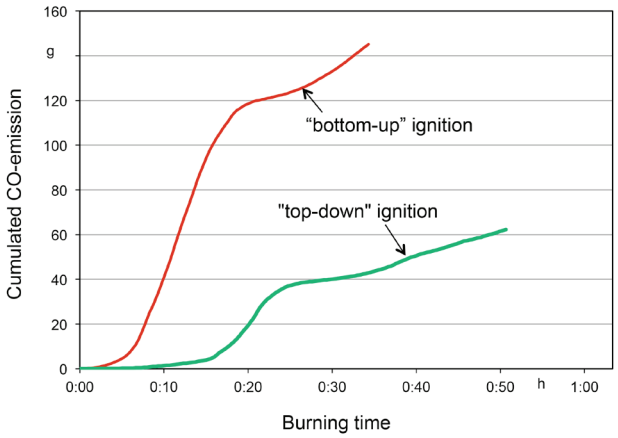
In addition to the approximately 8,000 such modern wood furnaces in Switzerland, there are still 56,000 wood-fired central heating systems and 539,000 fireplaces and wood stoves in operation. Many of them release more fine dust into the environment as some operators think. "In many small wood-fired systems, the wood is not burned completely, thereby collecting soot and other forms of particulate matter with sizes measuring less than 10 microns (PM10) too," says Prof. Thomas Nussbaumer, combustion expert at the University of Lucerne and owner of the consulting firm Verenum (Zurich). "We must focus technical improvements on allowing complete combustion of wood. In addition, operators must be trained and the particulate emissions be subject to consistent control," said Nussbaumer.

International Exchange of Experience

In mid-June 2016, Nussbaumer was a keynote speaker at the 20th Conference on 'Combustion Generated Nanoparticles' at ETH Zurich, helping engineers and physicians find new solutions for the fine dust problem. The conference module on biomass combustion was co-organized by '32 IEA Bioenergy Task', a working group of experts from 14 countries under the umbrella of the International Energy Agency (IEA) that is concerned with technical and economic aspects of biomass combustion (see p. 5). The panel enables Switzerland – represented by the Swiss Federal Office of Energy – to exchange ideas with neighboring countries Germany, Austria, Italy and Scandinavian countries such as Sweden and Norway, which like Switzerland have high standards for combustion technology and strict limits.



Scientists at the Bavarian TFZ-Kompetenzzentrum für nachwachsende Rohstoffe selected three wood-buring stoves for particular study since log size (diameter) affects particulate matter emissions. Conclusion: If logs are too small (cross section 5 x 5 cm) when burned, emissions are much higher in the furnaces investigated. The optimal size is medium logs with a diameter of 7 x 7 cm. Graphic: TFZ



Igniting fireplaces from below produces significantly more carbon emissions than igniting a fire from above the wood stack. This is confirmed by measurements from the Bavarian TFZ-Kompetenzzentrum für nachwachsende Rohstoffe. Graphic: TFZ

This international exchange in Zurich was shown by Dr. Hans Hartmann from TFZ Competence Centre for Renewable Row Materials (TFZ-Kompetenzzentrum für nachwachsende Rohstoffe) in Straubing near Munich. Hartmann reported his findings of small wood-burning stoves and fireplaces: In order to minimize emissions, the wood must not be too moist, but also not completely dry. Also important is to correctly load the furnace and to light the fire from above and not from below, as is still practiced by many fireplace-friends. The diameter of wood logs also has a significant impact on dust production: If the the diameter is too small, the level of particulate dust can be three times higher than if the wood is optimally sized. "The user actually has a greater impact on the particulate matter load than the technology used" concluded Hartmann at the conference.

Novel Test Methods

Other speakers in Zurich addressed the chemical and physical properties of fine dust particulate matter and also the procedures and standards that are used to detect particulate matter and other emissions from wood combustion. Becau-

		Pellet Boiler 1		Pellet Boiler 2		Pellet Boiler 3	
Parameter	Unit	Load cycle	Real life	Load cycle	Real life	Load cycle	Real life
CO	[mg/m3STP]	272	343	434	358	415	447
NOx	[mg/m3STP]	110	135	158	151	128	120
OGC	[mg/m3STP]	9	7	24	7	3	5
Dust	[mg/m3STP]	37	25	30	32	27	18
Efficiency	%	78,2	75	75,2	83,6	81,1	83,2
Annual Efficiency	%	-	72,4	-	78,8	-	81,4

Bioenergy 2020+ GmbH, an Austrian competence center for bioenergy research, studies, among other things, how emissions from wood combustion can be as realistically as possible depicted in the laboratory. This can be accomplished, for example, by a bench test that detects the load cycle of a furnace during eight hours of testing. The table compares the measured values(load cycle) during this load cycle test for carbon monoxide (CO), nitrogen oxides (NOx), organic gaseous hydrocarbons (OGC, commonly also known as volatile organic compounds (VOC)) and total dust (Dust) with "in a field" (real life) measured test values), for three wood-pellet buring furnaces (STP is Standard conditions for Temperature and Pressure). The trained eye will recognize that the load cycle test is in relatively good agreement with the field test values – much better than with the classical bench test measurements that use unrealistic values. Table: Bioenergie2020 +

se of the "Diesel scandal" at VW and other carmakers, the reliability of existing test methods is a hotly debated today. For example, Dr. Christoph Schmidl of the Austrian Bioenergy 2020+ presented in Zurich a test method that is able to depict the emission behavior of wood heating by simulating comparatively realistic load cycles.

- The **conference contributions** to "Session 2: Biomass Combustion (co-organized by task 32 of IEA Bioenergy)" are available through the following link: http://www.nanoparticles.ch/2016_ETH-NPC-20.html

- Information on **IEA Bioenergy Task 32** and the conference theme wood-fired emissions are available from Dr. Sandra Hermle (sandra.hermle[at]bfe.admin.ch), head of the SFOE-research program bioenergy.

- **Technical papers** on research, pilot, demonstration and flagship projects in bioenergy are available here: www.bfe.admin.ch/CT/biomasse.

INTERNATIONALLY CONNECTED

Working groups ("Tasks") of the International Energy Agency (IEA) are an important tool with which Switzerland promotes international exchanges in the field of energy technologies. The IEA currently has 39 programs ('Technology Collaboration Programs' / TCP) that are each dedicated to a specific energy area—Switzerland participates in 20 of these programs. To concretely implement international cooperation, each program has a number of Tasks in which experts from various countries work on a specific theme.

One of the IEA programs with Swiss participation is Bioenergy. Under this program, ten working groups are active and Switzerland participates in three: Task 32 (Biomass Combustion), Task 33 (Gasification) and Task 37 (Fermentation). Each working group will work on specific questions that will be defined during a three-year program under the strategic guidelines that were previously formulated by the Executive Committee of the program. Switzerland is represented in all relevant Executive Commitees of the IEA programs with an expert from the SFOE.

"The experts within the Tasks prepare scientific publications that give each country an important impetus for the development and use of particular energy sources," says Dr. Sandra Hermle, who represents Switzerland in the Executive Committee of the Bioenergy Program of IEA. "The working groups serve for mutual exchange and thus provide the framework to determine, in collaboration with professionals from other countries, specific energy technologies that will address future national issues." BV

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