Proposal to revise the EMEP/EEA Guidebook methodology for Small-Scale Residential Wood Combustion

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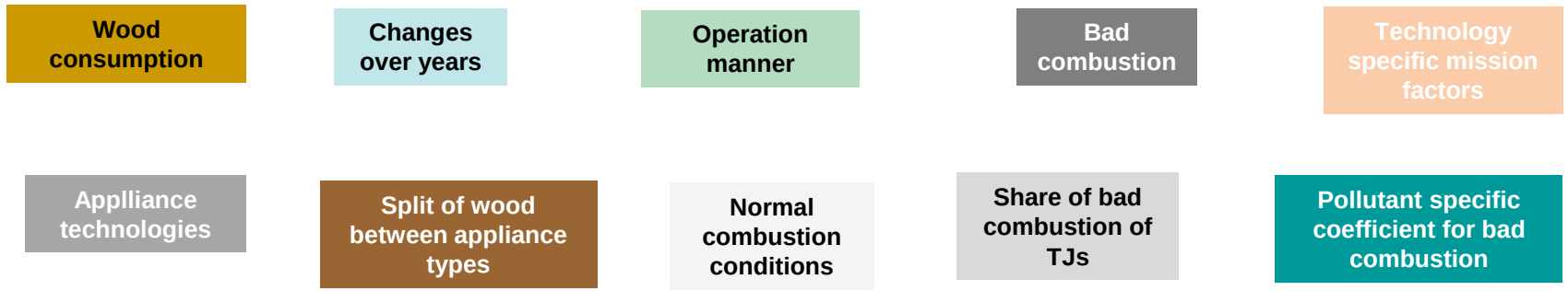
Introduction

- Small scale wood combustion in the residential sector is a major source of many pollutants
- Current Guidebook methodology for small scale wood combustion is under a chapter dedicated for all fuels and all appliances used in the Residential sector
- The current methodology is not fine-tuned to take into all factors that impact emissions from small scale wood combustion



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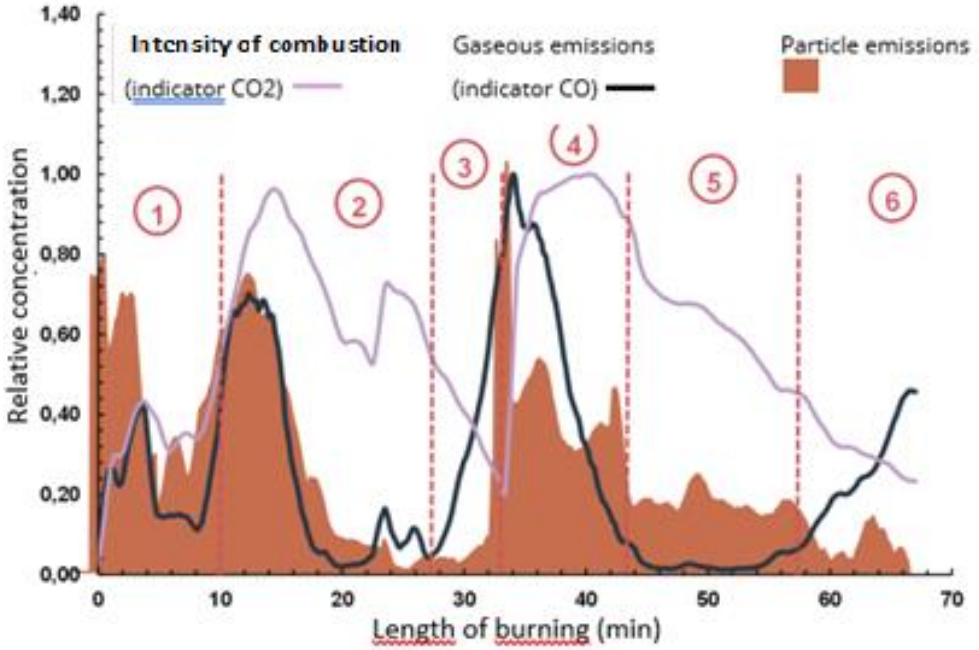
Chapter 1 - Real life emissions

- Combustion conditions vary depending on
  - appliance type, technology level, maintenance,
  - phase of combustion, air supply,
  - quality and quantity of the fuel
  - **operational practices**
- Complete combustion and efficiency
- The user has a significant impact on the combustion process in manually operated appliances
- Modern stoves with automated controls easier to operate, but even advanced appliances can be operated in a way that generate unnecessary high emissions
- Wider variability in emission levels in older appliances



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Chapter 2 - User-depended factors that impact emission levels

Issue	Detail
Fuel quality	Moisture content 12-20 weight-% (storage)
Fuel quantity	Optimal batch size and arrangement (appliance specific)
Combustion conditions	Ignition, start-up phase and addition of fuel Combustion phase End phase
Maintenance	Sweeping (chamber, channels, chimney)

- Note that **regional details** of these need to be assessed through regional studies

Chapter 3 - Significance of the user-depended factors

- The impacts of relevant factors should be assessed at regional or country level

- Boilers

Appliance	Issues that have an impact on emission levels	Detail of the issue
Overfire boiler	Boiler without accumulator/ small size accumulator ●●● (significant)	In these appliances the limited air supply leads to smoldering combustion at partial load. Wood should be combusted in small batches.
Double nest boiler	Boiler with small size accumulator in dual nest boilers ●●● (significant)	
Pellet/chip boiler	Combustion using continuous pilot-flame or at low power e.g. due to warm outdoor temperature to warm up water in pellet or chip boilers ●● (moderate)	The appliance controls drive the combustion into partial load. During warm periods/in warm climate an alternative water heating method should be used.
Modern/ Advanced boiler	Automated controls are not functioning ●●● (significant)	Air inlets are stuck.
Maintenance	Lack of maintenance ●● (moderate)	If the ash box is full or regular sweeping is neglected, the operation is not optimal.

Chapter 3 - Significance of the user-depended factors

- Stoves

Issue type	Issues that have an impact on emission levels	Detail of the issue
Fuel	Contaminated wood, waste or peat ●●● (significant)	The appliances are designed for combustion of clean wood only. Thus, the use of other fuels increases emissions. For instance, ashes clog air supply channels, chlorine containing fuel generates POP emissions, and heavy metal content increases heavy metals.
	Moist > 20 w-% ●●● (significant)	Combustion temperature remains low until moisture is evaporated thus increasing emissions, e.g. PM, VOC, PAH emissions to 2-3-fold. Wood needs to be stored prior to combustion and the storage needs to be protected from rain/snow. Note that ~30 w-% is hard to ignite and 50 w-% corresponds to fresh cut wood. Dry wood (6-10 w-%) may also generate excessive soot emissions.
	Arrangement of wood ● (mild)	In manually operated stoves the arrangement of wood logs impact emissions. Appliance specific instructions should be adhered.
Maintenance	Neglect of removal of ashes, sweeping and maintenance ●● (moderate)	The appliance does not function correctly. Particle emissions are increased due to a full ash pit or the combustion channels and chimney are not clean. Also, possible structural damages may have different impacts on emission levels. Removal of ashes and chimney sweeping should be carried out regularly.

Issue type	Issues that have an impact on emission levels	Detail of the issue
Operation	Ignition ● (mild)	If ignited from below, wood gasifies but the gases are not combusted at the beginning. Ignition should be carried out on the top of the pile using dry wood. Too slow ignition occurs when wood is not properly ignited and thus the combustion temperature remains too low. Dry small size wood should be used to ignite.
	Batch size ●●● (significant)	Over- or underloading increases emissions and is appliance specific. Large batch size increases gasification to a too high level. The appliance specific instructions should be adhered to. The general rule is to fill no more than half of the firebox.
	Log size ● (mild)	Small log size is better at the beginning of the combustion cycle or when using moist wood; large log size is better to use in the last batches or when the wood is dry.
	Addition of wood ●● (moderate)	Wood added too early, i.e. to a strongly flaming batch will be gasified too strongly and thus increase emissions. Wood added too late, i.e. to glowing embers does not ignite the logs immediately leading to increased emissions. Wood should be added just before the ember phase.
	Too low or too high power ●●● (significant)	Low power, i.e. limited air supply, generates smoldering combustion conditions where the temperature remains low and emission levels increase. In case of a hot firebox, no combustion air is left. High power, i.e. high air supply with large batch size /small logs, contributes to a too high level of gasification, no combustion air is left and gases are not combusted, thus emission levels increase. In both cases the decrease of the batch size and use of bigger log size helps. Adherence to appliance specific instructions.
Draught	Too low or too high draught ● (mild)	Too low draught causes combustion temperature to remain low. This can be corrected by using dry wood only and warming up the chimney before use. Too high draught either decreases or increases combustion. Limiting the air supply corrects the situation. Both cases increase emission levels.

Chapter 3 - Significance of the user-depended factors

- Outdoor appliances

Issues that have an impact on emission levels	Detail of the issue
Open fireplace, camp stove etc. ●●● (significant)	In case of a cold firebox and a longstanding combustion period dry small size logs should be used to avoid excess emissions.

Chapter 4 - How to include factors impacting emission levels into emissions inventories?

$$E_{ApplianceX} = AD_{ApplianceX} * (1-S_{ApplianceX}) * EF_{ApplianceX} + AD * S_{ApplianceX} * EF_{ApplianceX} * C_{ApplianceX}$$

where

E	"real life" emissions from a given appliance (incl. normal and bad combustion periods)
AD	amount of wood (kJ) combusted in the given appliance during the calendar year
S	share of wood (combusted in the appliance type) to be combusted under "bad" circumstances (***this could be appliance type specific or just a general value estimated for all appliances***)
EF	emission factor for "normal" combustion conditions
C	coefficient to multiply the "normal combustion" EF to represent emission level under bad combustion period

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Examples of typical "bad combustion : good combustion ratios" for the different small scale wood combustion technologies

		TSP, PM_{10}, $PM_{2.5}$	BC	CO	VOC	PAHs	NH_3
Boilers (wood log)	conventional	1	1	5	10	20	5
Boilers (e.g. pellet, chip)	modern	1	1	5	1	3-20	5
Stoves - slow heat releasing appliances	conventional	2-6	3	5	4	9	5
	modern	2-6	3	5	4	9	5
Stoves (inserts)	conventional	2-3	2	5	4	3	5
	modern	2-3	2	5	4	10	5
Outdoor appliances		2	2	5	4	3	5

Note that the ratio depends on issues listed in Table 2 (slide 5) and needs to be adjusted to regional conditions

Chapter 5 - Residential Wood Combustion Technologies

- Typical small combustion appliances used in European countries

  1) *Boilers,*
  2) *Stoves and*
  3) *Outdoor appliances*

- Same stove technology may include *conventional, modern* or *advanced* versions between which the emissions levels may differ significantly as the evolution generally includes features
  - The related EN standards, if available, provided (table 6)

- The appliances are categorized to enable common understanding of the appliance type (pictures to be included in the final version)

- Additional notes provided on features that impact emission levels

Chapter 5 - Residential Wood Combustion Technologies

- New classification of appliances (*boilers, stoves* and *outdoor appliances*)

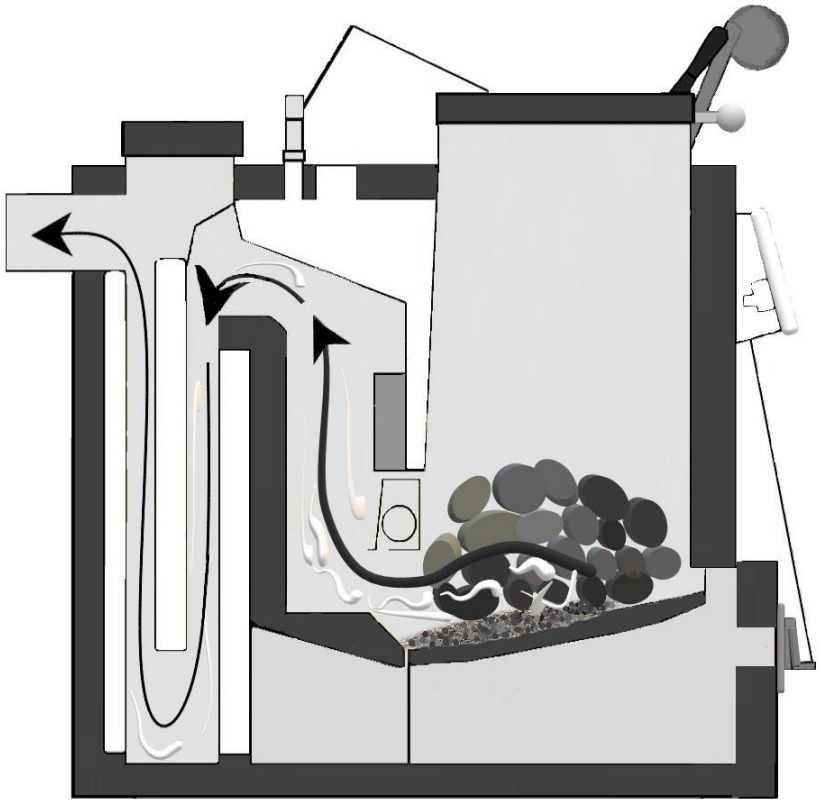
- Boilers (features separately for *conventional/modern/advanced*)
  - Wood log
  - Pellet
  - Wood chip

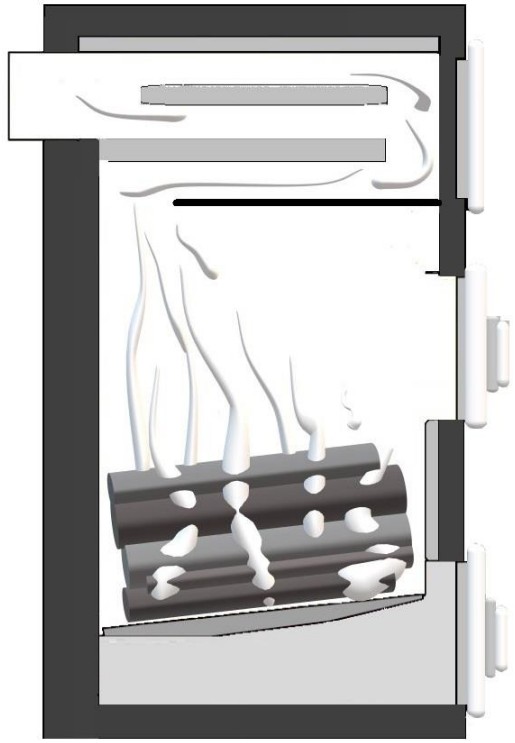
- Stoves (features separately for *conventional/modern/advanced*)
  - Slow heat releasing appliances
  - Room heaters
  - Inserts
  - Cookers
  - Sauna stoves
  - Open fireplaces

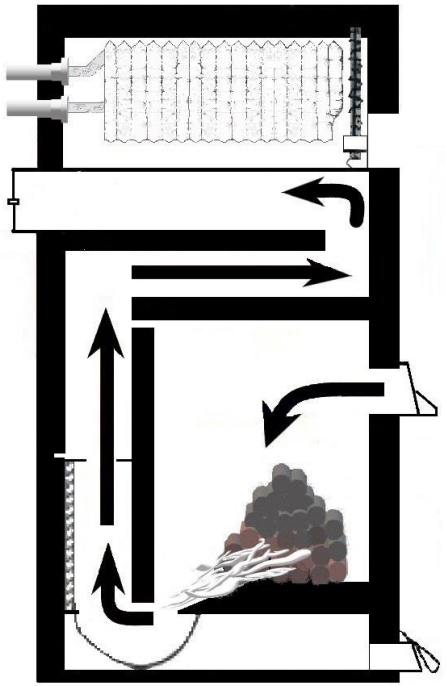
- Outdoor appliances
  - Bath tubes, cooking ovens, outdoor heaters, open fire

Chapter 5 - Residential Wood Combustion Technologies

- Examples of boilers (under-fire, over-fire, reverse fire)







Chapter 6 - Activity data

- Residential wood combustion is a key category for several air pollutants in most countries, therefore at least a Tier 2 method to quantify the emissions should be used

- National data collection
  - Activity data details needed for inventories
  - Organization of data collection
  - Proposals for surrogate data
  - Data sets from external information sources

Thank you for your attention!

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