

Summary of Environment and Climate Change Canada's (ECCC) Wood Burning Emissions Study

Objective

- Examine the impact of different parameters thought to influence emissions factors from Canadian wood burning appliances.

Methodology

- Emissions testing was completed by PFS-TECO. Statistical analysis of results was completed by the University of Sherbrooke.
- Three variables of interest were considered to study the connection between wood burning and emissions: moisture content of wood, draft, and type of fuel.¹
- 46 pollutants and two pollutant categories (Total VOC, Sum of PAHs) were examined.
- A variety of wood burning appliances were tested including an open fireplace, multiple wood stoves, a pellet stove, and a non-catalytic fireplace heater.
 - A combination of older and newer appliances was used to compare different EPA standards from 1990 to 2020.
- Statistical models were created for each pollutant. A Central Composite Design was used with univariate and multivariate analysis (least-squares regression) to measure correlations and statistical significance of results.
 - Coefficients from univariate models were more telling; multivariate models yielded few significant coefficients, presumably due to unknown variables.
 - Issues with sample contamination and instruments used during testing were suspected to be responsible for missing values, and out of range values were found throughout data. This led Sherbrooke team to implement data replacement method (PCA approach).

Key Findings

- Moisture, draft, and fuel type alone do not seem to fully explain emissions from wood burning. Results suggest that other, unknown variables are also influencing emission levels.
- **Moisture content was the only variable of interest that was found to have a statistically significant impact on emissions levels.**
 - In most cases, as moisture content in wood increased, emissions also increased.²
- EPA 2020 catalytic wood stove was significantly more efficient than other stoves tested.
- Appliances observed to have highest emissions were those without emissions controls.³

¹ Fuel types included hardwood, softwood, and a mixture of both. Draft was used as a proxy for outdoor ambient temperature (parameters used: 2.5, 8.8, 19.8, 30.8 and 37 Pa). Cordwood fuel moisture parameters used included 10, 15, 25, 35 and 40% w/w on a dry basis.

² Degree of increase varied by pollutant. See univariate analysis for more details.

³ Includes open fireplace, conventional wood stove, and the fireplace heater. However, fireplace heater has some emissions controls.

- **EPA 2020 catalytic stove and pellet stove had lowest emissions overall.** Both had emissions controls which led to reductions in emissions from select pollutants. In comparison to the conventional wood stove (pre-1988), results show an 85-86% reduction in PM_{2.5} and 88-90% reduction in organic & total carbon.
 - Pre-EPA 2020 and EPA 2020 non-catalytic wood stoves ranked better than the highest emitters, but worse than the EPA 2020 catalytic and pellet stoves.⁴
- Large number of correlations between fuel moisture content and emissions levels observed in results from open fireplaces and pre-EPA 2020 stoves.
 - Presumed to be caused by “uncontrolled nature of the burn cycle” in open fireplaces. Cause unknown in pre-EPA 2020 stoves.

Potential Outcomes

- Unknown factors
 - Those who question the validity of wood emissions testing could use this finding to their advantage and misrepresent the presence of unknown variables to mean that emissions testing is inaccurate.
 - Because of this observation, ECCC directly highlights the need for further research on the link between appliance use and pollutant emissions to contextualize the findings from this study.
- Due to observations around efficiency and reduced emissions from EPA 2020 catalytic stove in particular, ECCC anticipates that advancements in emissions control technology will influence emissions estimates over time.
- ECCC confirms that some of the average emissions factors observed in this study are similar to those used previously by ECCC, therefore reinforcing their validity.
- Concerns around level of certainty with measuring emissions from wood burning unfortunately cannot be completely satisfied with results from this study.

⁴ Pre EPA 2020 non-catalytic stove emissions were significantly close to those from EPA 2020 certified non-catalytic stove, especially with regards to PM_{2.5} and total carbon.