

Certified woodstoves emission factor (EF) analysis for the NEI.

Issue: How was the current PM_{2.5} EF for certified wood stoves derived and are there updated data to bolster or improve on the values in the short term?

The NEI 2017 uses the step 1 certified wood stove EFs derived in the “Emissions Memorandum” for the 2015 NSPS ([2015 NSPS Emissions Memorandum](#) supporting the Regulatory Impact Assessment). There are 2 certified stove EFs: one for certified catalytic (cat) wood stoves, and one for certified non-catalytic (non-cat) wood stoves.

The NSPS derives the step 1 values by multiplying the Phase II cat and non-cat EFs (from AP-42) by 0.6, where 0.6 is the ratio of the Washington (WA) state wood stove limits to the Phase II NSPS wood stove limits. It is assumed that step 1 stoves would meet the WA state limits. For non-cat stoves (where the WA state limit is identical to the step 1 limit), it is the ratio of 4.5 g/hr to 7.5 g/hr (i.e., $4.5/7.5=0.6$); for catalytic stoves, it is the ratio of 2.5 to 4.1 g/hr. For non-cat stoves: 7.5 g/hr is the non-cat stove 1988 NSPS Phase II limit and 4.5 is the WA State limit for non-cat stoves (same as the 2015 NSPS step 1). For cat stoves, 4.1 is the 1988 NSPS Phase II limit and 2.5 is the WA state limit.

While not used for the NEI, a step 2 EF was also derived in the “Emissions Memorandum” and is included here as it is used in one of the options below. The step 2 value for non-cat stoves is the step 1 value multiplied by 0.44, which is the ratio of step 2 to step 1 g/hr limits (2.0/4.5). The step 2 value for cat stoves is the step 1 value multiplied by 0.8 which is the ratio of the step 2 limit to WA state g/hr limit (2.0/2.5).

The 1988 Phase II [AP-42 EFs](#) are in Table 1.10-1 and after applying the ratios of the emission limits, the following factors are obtained:

	Phase II Certified (can no longer be sold after May 2015) Lb/ton	**Step 1 Certified (can no longer be sold after May 2020) Lb/ton	Step 2 Certified (Sold May 2020 and beyond) Lb/ton
Non-cat	14.6 (AP-42)	8.76 (=14.6 *0.6)	3.89 (=8.76 * 0.44)
Cat	16.2 (AP-42)	9.72 (=16.2 *0.6)	7.78 (=9.73* 0.8)

** used for the NEI

It should be noted that because the step 1 and step 2 values are derived from AP-42 by applying ratios, they could be considered as the same basis as AP-42, which is EPA Method 5H equivalent units.

Two studies have indicated that certified stoves may have higher emissions factors than those computed in the 2nd and 3rd columns of Table 2.

- 1) The study by James E. Houck, Ph.D., “[A Comparison of Particulate Emission Rates from the In Home Use of Certified Wood Stove Models with USEPA Certification Emission Values and A Comparison Between In Home Uncertified and Certified Wood Stove Particulate Emissions](#)” (Feb. 1, 2012, Docket ID No. EPA-HQ-OAR-2018-0195) showed a lack of correlation between certification values and in situ emission rates, and in most cases the magnitude of the emission rate for given sample is larger than the certification value (see in particular, Figure ES3).
- 2) A post AP-42 test study, “[Long - Term Performance of EPA-Certified Phase 2 Woodstoves, Klamath Falls and Portland, Oregon: 1998/1999](#)” NRML-RTP-195-R37/00), tested Phase II certified stoves in Portland, OR and Klamath Falls, OR, after about 7 years of use, to evaluate the emissions of old

certified stoves. In this study, particulate and POM samples were collected from the stoves during normal in-home use with an automated woodstove emission sampler (AWES). EFs are computed as Method 5H equivalents and compared with AP-42 (see Table 3-10). It should be noted that the individual tests were done in different devices and used wood of different types and moisture contents.

	Phase II Certified Lb/ton	Step 1 Certified Lb/ton	Step 2 Certified Lb/ton	"Worn" Phase II Certified Stoves, Method 5H converted (16 stoves in Klamath Falls and Portland, OR) Lb/ton
Non Cat	14.6 (AP-42)	8.76	3.89	20.6 (11 stoves, 30 runs)
Cat	16.2 (AP-42)	9.72	7.78	25.66 (Table 3-10; 5 stoves, 14 runs)

For the 2020 NEI, for certified stoves, the question is whether the NSPS derived EF is representative, considering

- 1) The lack of correlation between the certification rate and insitu emission factor as shown in Houck 2012
- 2) there are likely a combination of pre-2015 NSPS, 2015 NSPS, 2020 NSPS, and also stoves that have experienced long term use that may have emissions represented by the Klamath Falls/Portland study
- 3) there are exempt single burn rate stoves that emit at the uncertified level (30.6 lb/ton)— these would not have been accounted for in the NEI's uncertified stove distribution because the NEI counted only 20-year old stoves as "uncertified"; there may be exempt single burn rate stoves that are still in use but are less than 20 years old.

With regards to item 1, the emissions memo (page 3) states that "certification data indicate that 26% of non-catalytic and catalytic stoves combined and 70% of pellet stoves already meet the Step 2 standard." The memo also states, "Specifically, this industry data from 2010 indicate that approximately 90% (130 out of 145 catalytic, non-catalytic and pellet stoves combined) already meet the Step 1 limit." These statements, however, characterize the new shipments but not the stoves that are in use.

Based on the calculations used for the NSPS to estimate per-stove emissions rates, which used the EPA's Residential Wood Combustion tool 4.1, about 54% of the stoves were single burn rate exempt (this value was computed using the emissions memo, Table 3, baseline section of the Table). It is not known what year these data are for, possibly 2008 (the base year), nor what percentage are still being used in 2020.

OPTIONS

1. KEEP AS IS (NSPS step 1 EFs)
2. AP-42 certified EFs (phase II)
3. "Worn" Phase II
4. Use a combination (mean) of the Phase II, step 1 and "Worn"
5. Use a weighted average of 74% option 4, and 26% step 2 (NSPS says 26% are step 2)

Below are the EFs for each of the options (lb/ton)

Stove Type	Option 1- NSPS step 1 EF (lb/ton)	Option 2- Phase II EF (lb/ton)	Option 3- Worn Phase II EF (lb/ton)	Option 4- mean EF (lb/ton)	Option 5- weighted mean 26%, step 2 EF (lb/ton)
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Cat	8.76	14.6	20.6	14.7	11.9
Non-cat	9.72	16.2	25.7	17.2	14.7

Are there other options/data sources that can be used? Appendix A discusses one possibility, but it is not Method 5H equivalents and not from in-home tests so may not be useful. Also some of the stoves may not be representative of the mix of stoves used, and may need to be excluded from the average.

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Appendix A

1. [NESCAUM Interim Report](#) -"Interim Report: Development of an Integrated Duty-Cycle Test Method for Cordwood Stoves, Interim Report | Report Number 21-02 | December 2020"

Home Code	construction type Firebox size	Certification	species/moisture	certification value	stove condition	average burn rate (kg/hr)	data from	range of replicates (g/kg)	average EF g/kg	average g/hr	lb/ton
STOVE 1	step 1 high mass noncat tube 3.1 ft3-large (<3)	step 1	maple cordwood 22-27%	<3 g/hr	noncat	2.83	Table 118	2.59 to 5.37	4.18	11.81	8.36
STOVE 2 open door	step 2 1.3 ft3 small <2	step 2	maple cordwood 22-27%	< 2 g/hr	cat	1.16	Table 119	2.43 (w) to 7.01 (c)	4.82	5.57	9.64
STOVE 2 cracked door	step 2 1.3 ft3 small <2	step 2	maple cordwood 22-27%	<2 g/hr	cat	2.66	Table 119	4.57 to 7.01	6.17	16.43	12.34
STOVE 4	step 1 0.8 ft3 small <4	step 1	maple cordwood 22-27%	<4 g/hr	noncat tube	1.39	Table 121	3.66 to 5.69	4.55	6.33	9.1
STOVE 5	step 1 2.1 med (<2)	step 1	maple cordwood 22-27%	<2 g/hr	noncat nontube	2.29	Table 122	1.13 to 4.16	2.29	5.24	4.58
STOVE 6	step 1 2.2 med	step 1	maple cordwood 22-27%	<4 g/hr	noncat tube	1.97	Table 123 - mean of entire run	6.35 to 8.39	8.13	16.05	16.26
STOVE 7	step 2 1.9 med	step 2	maple cordwood 22-27%	<2 g/hr	HYBRID	1.50	Table 124	0.84 to 1.32	1.09	1.63	2.18
STOVE 8	step 1 1.7 ft3 med (<4)	step 1	maple cordwood 22-27%	<4 g/hr	noncat tube	3.65	Table 125- mean of entire run	1.61 to 2.58	2.1	7.66	4.2

Several averages of the above data can be developed.

1. Noncatalytic stoves only (stove 1, 4, 5 and 6): Most stoves are non-catalytic. Stove 8 is a single(high) burnrate and not representative. 9.6 lb/ton
2. Noncatalytic tube stoves only –without stove 8 and without stove 5 , the down draft stove which is not representative of most noncat stoves (stove 1, 4, 6): 11.2 lb/ton
3. Cat stove 2 – average the 2 configurations – 11 lb/ton