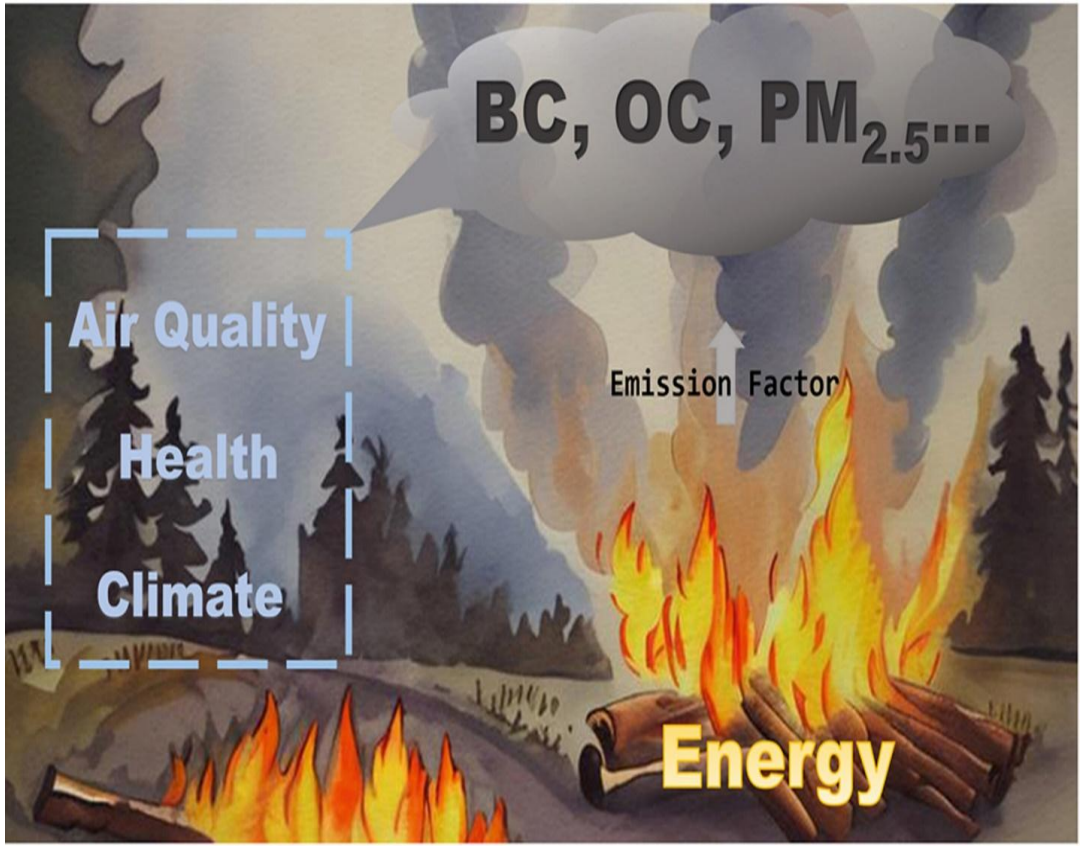
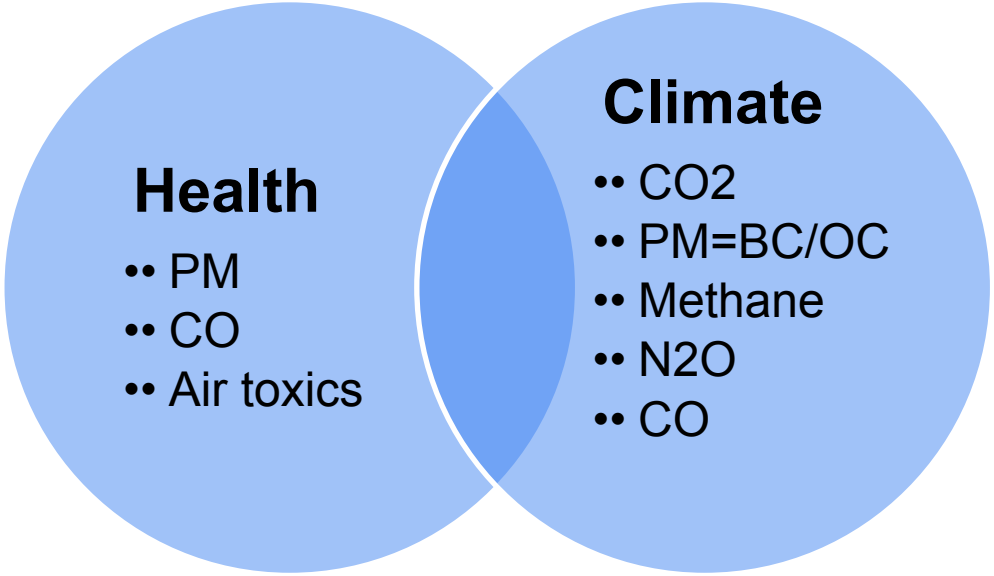
Biomass pellet heating stoves: Addressing health and climate



Aprovecho Research Center

Can biomass be burned cleanly enough to qualify as a renewable energy in the post fossil fuel era?



What is “clean enough” to protect urban health?
What is “clean enough” to protect climate?

Biomass and health

- Aprovecho used an EPA Air Quality model to predict the needed emission factors, especially PM2.5, to protect health including variables such as population density, wind patterns, current levels of pollution, etc.

- An outside air emissions model was built by The Lane Regional Air Pollution Authority (LRAPA) to estimate the air pollution that the small town of Oakridge, Oregon would experience if residential biomass heating stoves were less polluting.

- The model estimated that air quality would meet WHO Standards if the 1,006 wood burning heating stoves in the low density mountain town emitted a PM2.5 emissions rate of 2.0g/hr.

- When population density rises, etc. the emission factors estimated by the model to protect air quality and health are decreased.

Protecting health

- Accurate air quality models are site specific
- Using the Oak Ridge air pollution model a PM2.5 emission rate of 0.79 g/hr has been estimated to protect health when 15% of the population density of New York City switches from natural gas to pellet biomass heating stoves.
- Existing pellet stoves are currently achieving similar PM2.5 emission factors
- The ARC modified US Stove pellet stove emitted 0.08 g/hr PM2.5

Event	Population Density	Individual Heating Stove 24hr Average Emissions Rate	Concentration of PM2.5 in the Inventory Area
Oakridge, OR	people/km2	g/hr	ug/m3
Measured worse case day of all sources in the valley	512	9.18	40
Hypothetical all 2020 heating stoves with background sources	512	2.00	12
Hypothetical all EPA 2020 heating stoves, NYC population density	11313	2.00	81
Hypothetical heating stoves to meet WHO Standard, NYC population density	11313	0.79	35

Biomass and Climate

There is **a lot** of uncertainty around the Global Warming Potential of Black Carbon (BC) and Organic Carbon (white), which varies geographically.

On the other hand, estimates can be valuable when comparing stoves.

In the IPCC table, CO2 has a Global Warming Potential of 1. For example, by weight, BC has an estimated 2421 times more Global Warming Potential compared to CO2.

Species	Global Warming Potential (GWP)-20 (IPCC, 2013)
BC	2421
OC	-244
CO	5.9
VOCs	14
CH4	81
SO_4^{-2}	-141
NOx	289

Organic Carbon (white) -244 Black Carbon 2421

Species Global Warming Potential @20 years (IPCC, 2013)

PM: Black Carbon 2421
PM: Organic Carbon (white) -244

CO 5.9
VOCs 14
CH4 34
SO_4^{-2}-141
NOx 289

Lowering the Black Carbon fraction in smoke has the potential to effectively reduce the Global Warming Potential

Negative GWP is not impossible?

CO2e emissions from natural gas vs ARC pellet stove

34.4 million BTU heat per year per USA household (7,12)
117 lb CO2/million BTU natural gas (8)
2% leakage rate of CH4 well to user (9, 10,11)

		Natural Gas
CO2e 20 yr	ton/year	**5.27**
CO2	ton/year	2.01
CO2e from CH4	ton/year	3.26

ARC Improved Pellet Breckwell Stove

Test cycle		High Power	Medium Power	Low Power	Weighted Average (ASTM E2515)		Weighted Average (ASTM E2515)	
Heating Stove Metrics								
CO2 emissions rate	g/hr	3303	2013	722	1582	CO2e, CO2	0	
PM emissions rate	g/hr	0.23	0.08	0.04	0.084			
BC emissions rate	g/hr	0.009	0.005	0.005	0.006	CO2e, BC	13.5	
OC emissions rate	g/hr	0.22	0.08	0.03	0.079	CO2e, OC	-19.2	
CO emissions rate	g/hr	0.90	0.82	2.54	1.692	CO2e, CO	10.0	hrs/year
VOC emissions rate	g/hr	1.20	1.20	1.20	1.20	CO2e, VOC	16.8	2190
CH4 emissions rate	g/hr	0.11	0.09	0.07	0.084	CO2e, CH4	6.8	total
Nox emissions rate	g/hr	2.3	1.3	0.4	1.022	CO2e, Nox	295.4	ton/year
PIC CO2e	**g/hr**	668	411	150	323	**CO2e, PIC**	**323.3**	**0.161**

CO2, PM, BC, OC, CO, VOC from ARC testing
CH4 NOx from Brookhaven testing

2190 hr/year assumes 6 months, 12 hr/day

Biomass and Health/Climate

Pellet stoves are known to have low Black Carbon ratios.

Decreasing the Black Carbon fraction seemed to reduce the Global Warming Potential.

Combining EPA Outdoor Air Modelling and the IPCC Global Warming Potential estimates provide ARC with a framework to create biomass stoves that better address urban health and climate when including the GWP pollutants in the emission testing.

Can biomass be burned cleanly enough to protect health and climate and join solar, wind, hydro, thermal as a renewable energy resource in the post fossil fuel era?

Yes, it seems to be quite possible.

References

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