

Wood Heat and Air Quality Workshop

Tuesday, July 26, 2016

Professor Rick Peltier

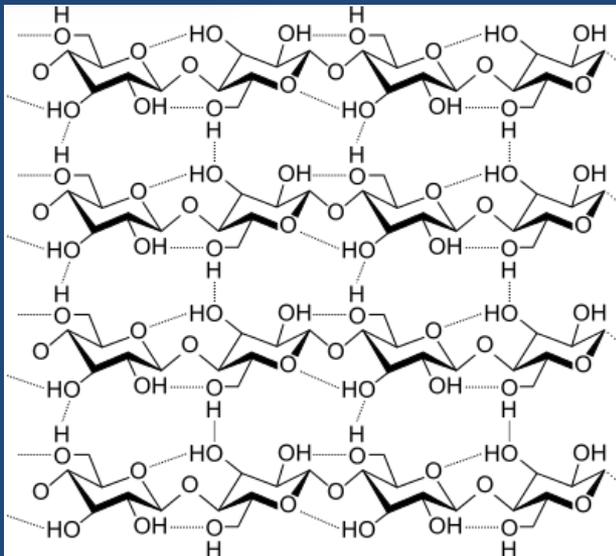
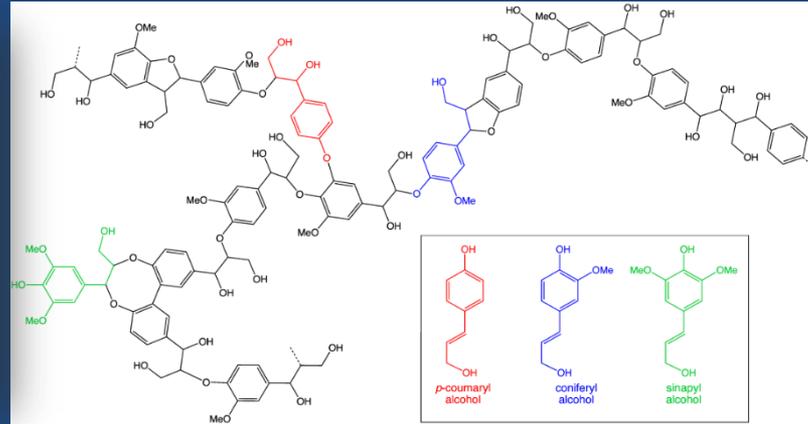
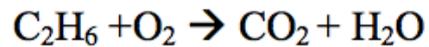
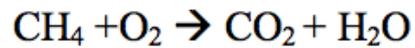
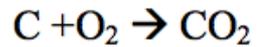
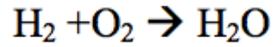
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Questions for Today

- What are the air emissions & air quality impacts of commercial scale wood heat facilities and how do they compare to other fuels?*
- How are wood heating systems regulated?*
- What are best practices for installation and best available control technologies to minimize emissions?*
- Are there standards for the composition of wood pellets or wood chips used in wood heat boilers?*
- How is the ash from these facilities typically disposed of?*

Combustion 101



+ [all sorts of other compounds] → ???

The Promise of Commercial Pellet Boilers

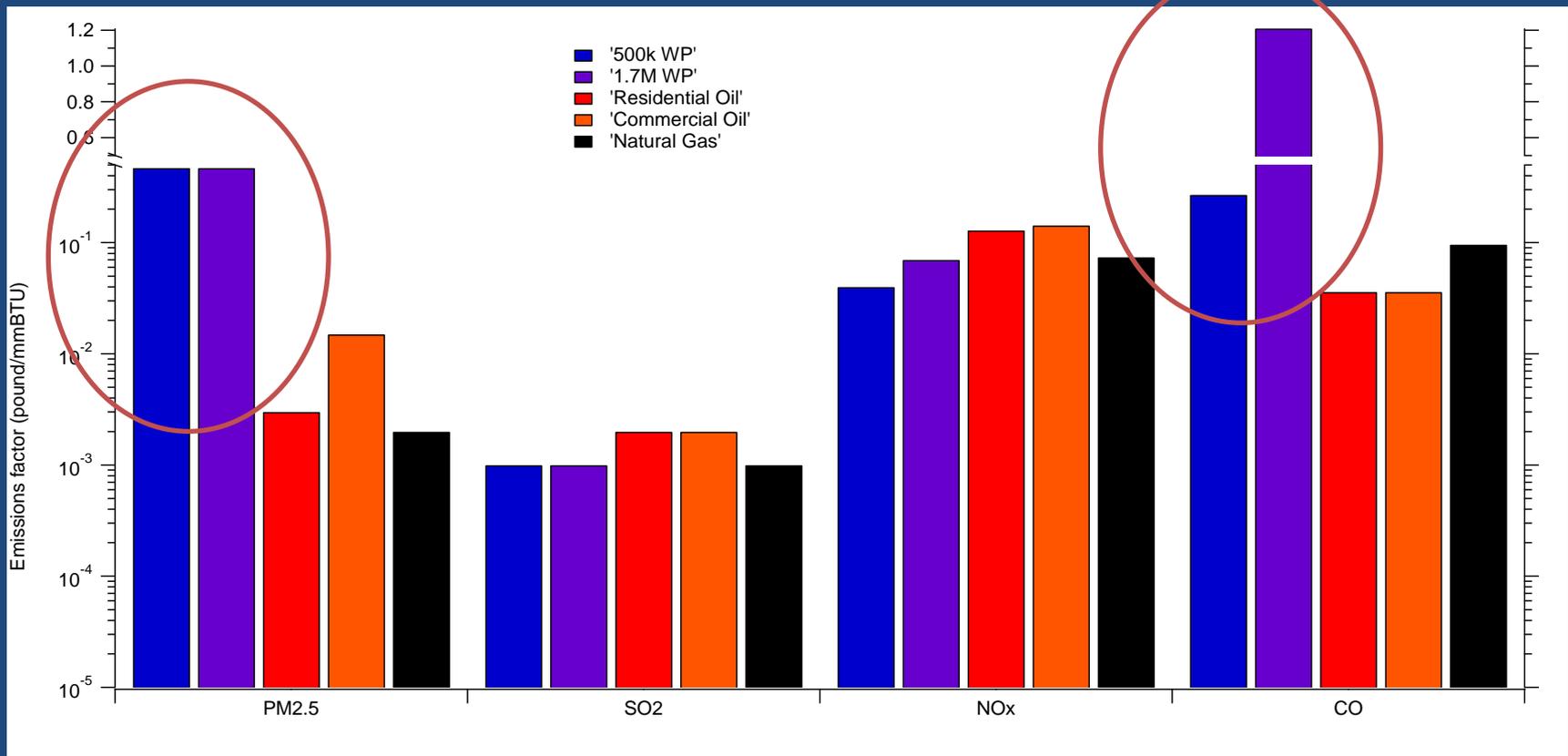
- Designed with 2-3 combustion stages, resulting in efficient burn
- Usually installed with lambda controls – that is, continuous monitoring of burn efficiency and feedback control to adjust burn conditions (dampering or combustion air, increasing fuel flow, etc).
- 60-85% thermal combustion efficiency is typical, but varies depending on load.

Comparing different wood boiler types

Emission Species	Residential:		Commercial:		This study:		This study:		This study:	
	Emission factors (Deangelis <i>et al.</i> , 1980)		Emission factors (EPA, 2008)		517k BTU/hr		517k BTU/hr		1.7M BTU/hr	
	Fireplace (g/kg)	Wood Stove (g/kg)	Wet Wood (lb/mmBTU)	Dry Wood (lb/mmBTU)	Wood Chips (g/kg)	Wood Chips (lb/mmBTU)	Wood Pellets (g/kg)	Wood Pellets (lb/mmBTU)	Wood Pellets (g/kg)	Wood Pellets (lb/mmBTU)
PM	13*	9.1*	0.350*	0.300*	0.54*	0.112*	0.47	0.060*	0.47	0.06*
SO ₂	0.2	0.2	0.025	0.025	0.02	0.004	0.0065	0.001	0.005	0.001
NO _x	2.0	0.49	0.220	0.490	1.84	0.302	.35	0.040	0.42	0.07
CO	67	180	0.600	0.600	2.13	0.348	2.16	0.270	7.62	1.21

- measurements include only particles with diameters less than 2.5µm, cyclone used for PM control
- *- multiclones used in series for PM control
- no controls for PM

How does this compare?



Wood pellet data from NYSERDA report (2012); all other data from AP42

What does this tell us?

- From an emissions standpoint, not really an impressive difference between different technologies.
- In general, pellet emission technology needs more study.
- Two pollutants are higher: particulates and carbon monoxide
 - Relatively simple control technology available for PM; not so much for CO.

Still much uncertainty

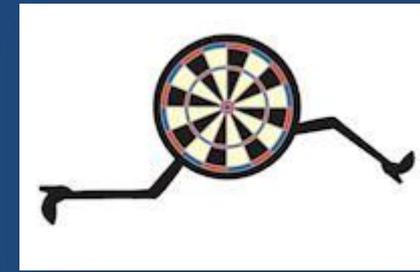


- MA DEP

Air Quality in Western Massachusetts

- Generally attaining standards everywhere.
- Important exception: Ozone still a problem.
 - Ozone usually a ‘summer’ problem.
 - Not enough to be listed as non-attainment (except Dukes County)
- Wintertime inversion issues in W Mass, however.

Clean Air Act and NAAQS



Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	Not to be exceeded
Nitrogen Dioxide (NO₂)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb ⁽²⁾	Annual Mean
Ozone (O₃)		primary and secondary	8 hours	0.070 ppm ⁽³⁾	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM _{2.5}	primary	1 year	12.0 µg/m ³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO₂)		primary	1 hour	75 ppb ⁽⁴⁾	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

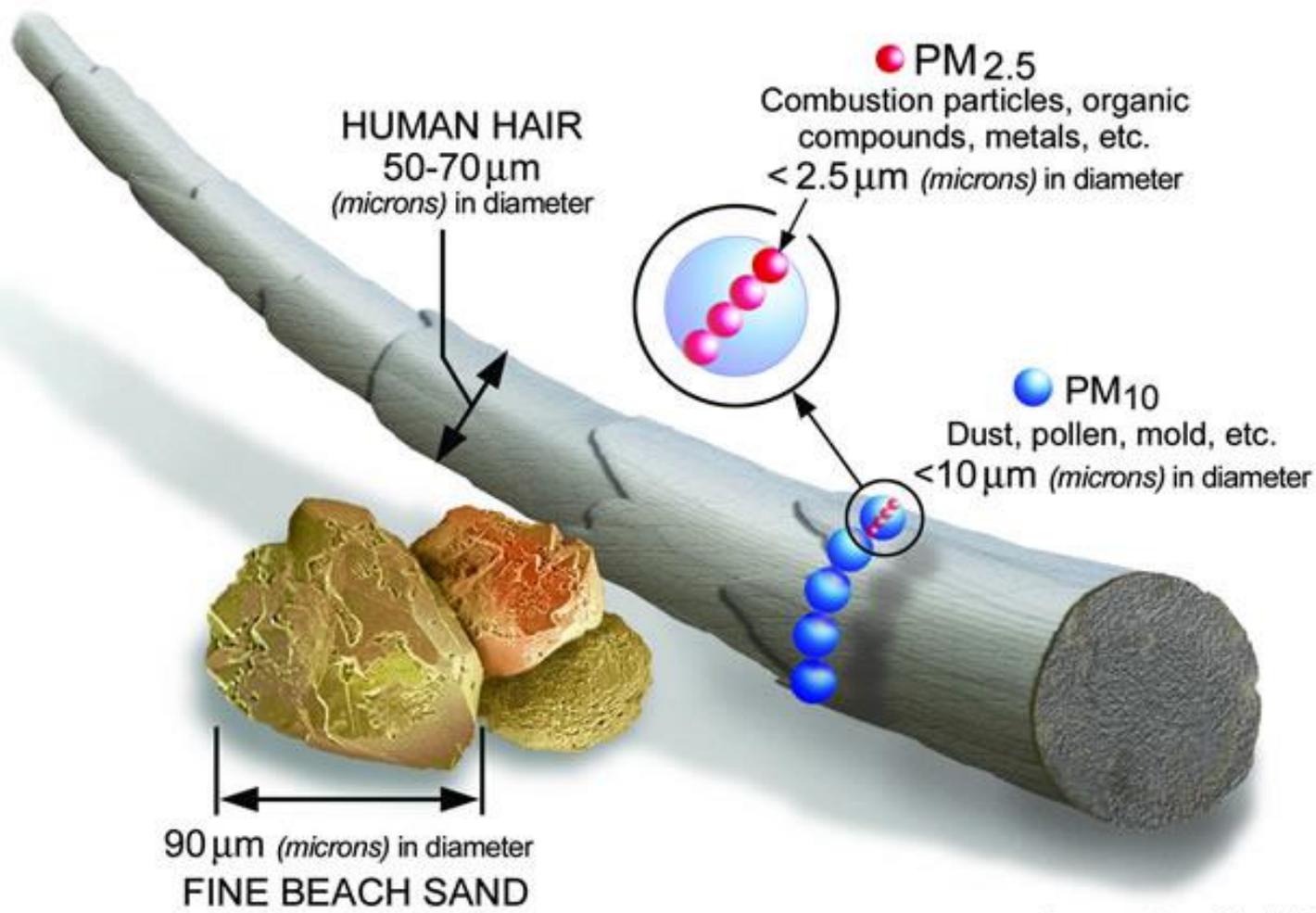
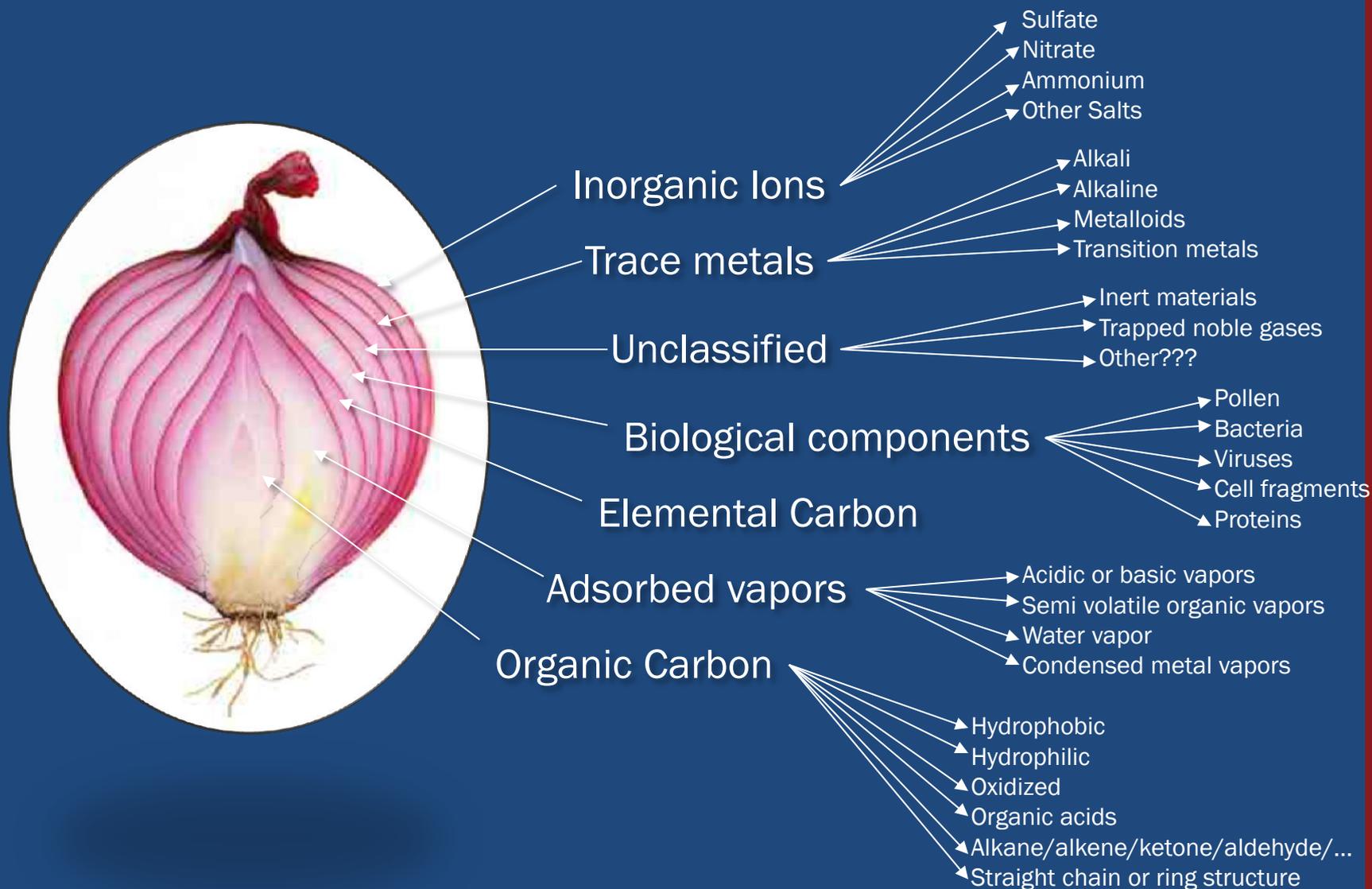


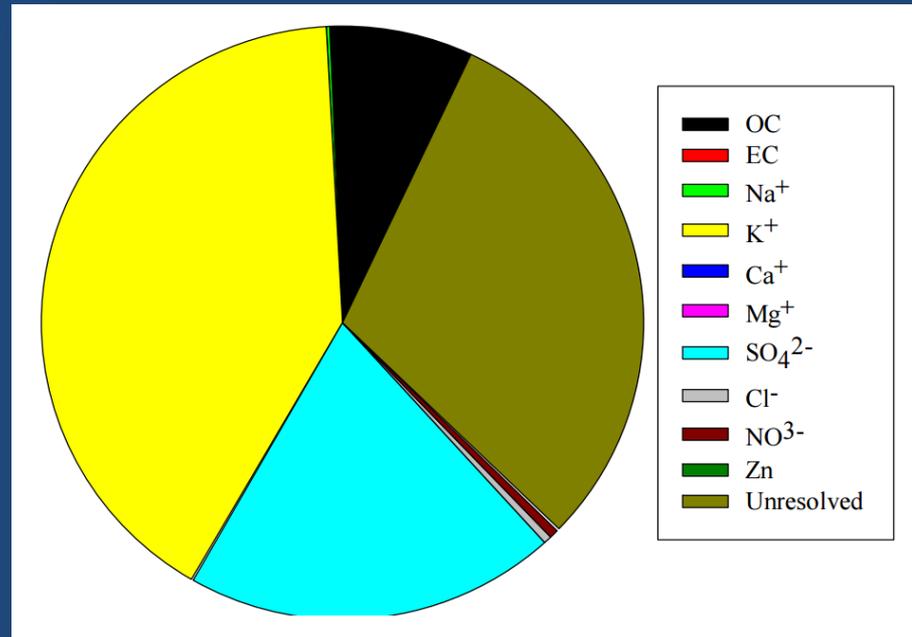
Image courtesy of the U.S. EPA

A closer look:



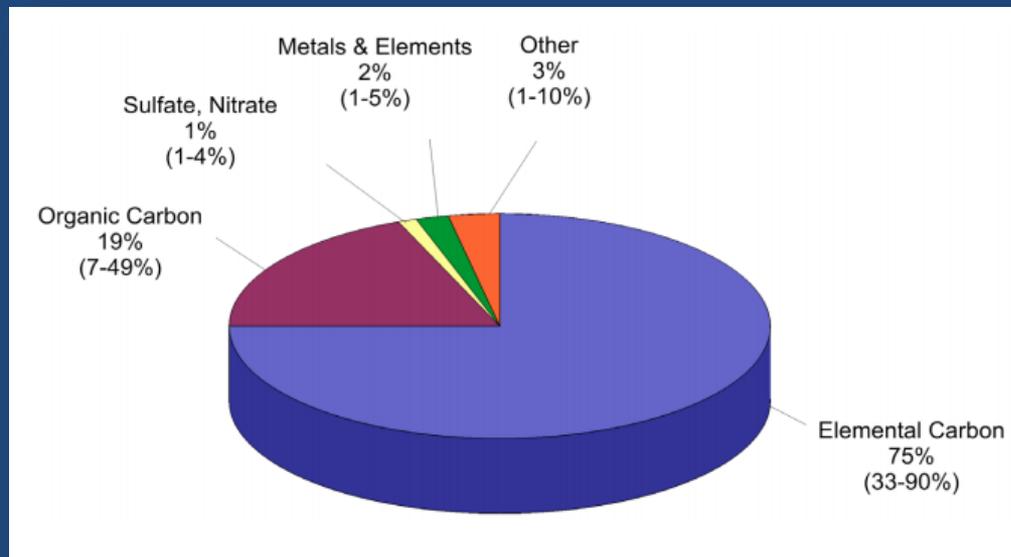
Still much unknown in pellets

- Emphasizes importance of known fuel source.
- Hard vs softwood probably irrelevant (similar thermal content).
- Burner design and pellet source is essential for protecting health.



More known about fuel oil

- Known carcinogen (G1, IARC, 2012).
- Hundreds-to-thousands of volatile gases.
- Short-lived climate pollutants (BC)



U.S. EPA (2002b) Health assessment document for diesel engine exhaust. Report by the National Center for Environmental Assessment Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C., EPA/600/8-90/057F. Available on the Internet at http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=36319

Outside of the lamppost

PAH	Commercial Wood Pellets (ng/BTU) ¹	AP42 Wood residue (ng/BTU)	AP42 Fuel oil Burner (ng/BTU)
benzo(a)anthracene	0.38	n/a	0.004
benzo(b)fluoranthene	0.57	n/a	0.013
benzo(a)pyrene	0.86	0.12	n/a
dibenz(a,h)anthracene	mdl	0.001	n/a
indeno(1,2,3-c,d)pyrene	3.42	0.004	n/a
benzo(k)fluoranthene	0.75	0.002	0.005

¹517kBTU/hr pellet boiler, NYSERDA (2012)

Carcinogens

Simplifying the story (a little)

- Recent work in Finland compares PAH emissions from large scale wood chip and oil boilers, as well as small scale pellet and oil boilers.
- Of all measured PAHs, fuel oil (large and small) >>> wood >> pellet
- For most worrisome PAHs, the same results are observed

So where do we stand?

- Natural gas: lowest combustion emissions; important distribution concerns
- Fuel oil: relatively efficient (heat yield and pollutants), non-renewable fuel source.
- Pellets: not completely tested (but looking promising), somewhat higher emissions for certain pollutants, variable combustion efficiency.

From a Public Health Perspective

- Natural gas emissions are the lowest.
- Not an impressive difference between oil and pellet emissions (at least the ones we have measured).
 - But we are particularly concerned with fuel oil combustion emissions.
- Federal emissions guidance (e.g. AP42) somewhat helpful, but not the complete story.

Consider Exposure

- Many strategies in exposure reduction
 - thoughtful siting
 - point of emissions controls (ESP, wet deposition)
 - effective stack heights (particularly important where atmospheric trapping occurs)
 - operation conditions (if pellet, consider heat reservoir technologies)
- Be cognizant of your population; children demand careful attention to your choice.

Solutions to assessing impact

- Consider measurements
 - EPA-quality not likely viable (\$10k + each)
 - Modest price sensors available (<\$1000)
 - DIY approaches – even student/citizen-led initiatives can work at almost no cost.
- Measurements do not have to measure everything.
- Important to obtain baseline data – facility perimeter, downwind, upwind, inside.