

Wood Combustion for Industrial, Commercial and Institutional Heat & Power: Implications for Public Health and Public Policy

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 - Northeast States for Coordinated Air Use Management
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- Advisory Committee

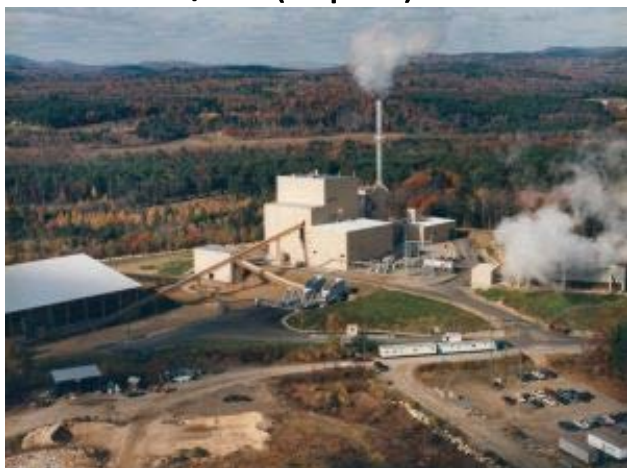
Lowell Center for Sustainable Production, University of Massachusetts, Lowell

- Interdisciplinary center of faculty, staff, fellows at University of Massachusetts, Lowell
 - Environmental health sciences; epidemiology; industrial hygiene
 - Policy
 - Sister organization with chemists and engineers
- Premise
 - Our systems of production and consumption are not only root causes of environmental and health problems, but also significant contributors to the solution.
- Approach
 - research and analysis
 - strategic engagement of leaders and decision-makers around topics at the intersection of health, environment and economy

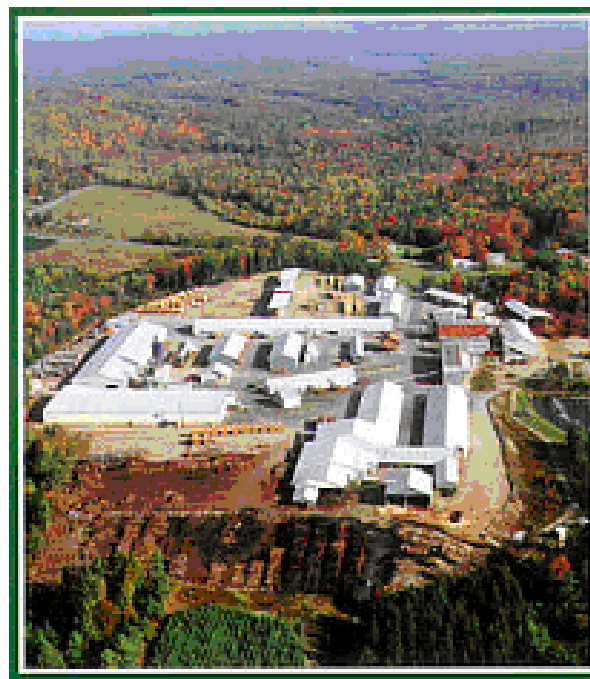
Institutional, Commercial and Industrial (ICI) Biomass Combustion



Randolph Union High, VT 3.5
MMBtu/hr (input)



Livermore Falls, ME
589.5 MMBtu/hr (input)



Robbins Lumber Co, ME
70 MMBtu/hr (input) [2 units]

Convergence of Need and Opportunity

- ICI wood biomass combustion is:
 - proliferating in the Northeast
 - potentially hazardous to human health
 - currently under the radar of decision-makers charged with protecting public health
- Debate so far has focused on carbon neutrality
- There are solutions—technical, program, policy

Goals and Activities of ICI Biomass Initiative

- Goals
 - Elevate health in decision-making about the use of wood as fuel for Industrial, Commercial and Institutional (ICI) boilers, and in renewable energy decision-making more broadly;
 - Advance healthy, renewable energy
- Activities
 - Synthesize scientific information relevant to health effects of ICI wood-burning; conduct policy research
 - Engage health leaders in reviewing relevant science and proposing policy recommendations (e.g., June 14th health professionals meeting)
 - Convene cross-agency/interdisciplinary dialogue about health effects and about policy steps to enhance public health protection

ICI wood combustion is proliferating

- Projections: Biomass could replace reduce petroleum-based fuels: 30% by 2030 (DOE)
- Vision: 25% of all thermal energy in region to be met by renewable fuels, 74% biomass, by 2025 (Biomass industry)
- Wood is good culture
 - Independence from “foreign oil”; less expensive fuel
 - Local economic revitalization
 - Forest health
- Federal and state promotion
 - subsidies (tax incentives and grants) and state targets/programs for renewable energy, including biomass
 - E.g., Fuels for Schools
- Perceived abundant forest resources in the Northeast

Inventory of Northeast Facilities with ICI Wood Biomass Units

Table 1: Inventory* of Facilities with Industrial and Institutional/Commercial Wood Combustion Units in the Northeast U.S.

State	Electric Generating Units		Other Industrial		Institutional and Commercial	
	Operating^	Proposed	Operating^	Proposed	Operating^	Proposed
CT	2	1	1	0	0	~2
MA	1	~y6	8	NA	3	~1
ME	15	NA	50	NA	18	~10
NH	8	~4	25	~1	12	~2
NJ	0	0	0	0	0	~1
NY	4	~2	18	NA	13	NA
PA	3	NA	67	NA	12	NA
RI	0	0	0	0	2	0
VT	2	~4	18	1	60	NA

*This inventory is incomplete and thus an approximation given that states do not maintain inventories of proposed facilities and small ICI combustion units are not regulated the same by all states.

^Operating or having approved air permit to operate; smaller units in some states do not require an air permit to operate.

Primary data sources: (1) data collected from the 9 state environmental agencies based on regulated units; (2) Biomass Energy Resource Center's community-scale database (www.biomasscenter.org/database) for small commercial/institutional units not always regulated by states; (3) The Wilderness Society's map of wood biomass energy facilities <http://wilderness.org/files/Wood-Biomass-Energy-Facilities-in-Northeast-map.pdf> used for proposed units only.

Wood fuel composition

- Raw Materials
 - byproducts of forest management/restoration activities
 - manufacturing/mill waste (e.g. sawmills, pulp mills)
 - urban forestry residue
 - construction and demolition waste
 - State regulations allowing C&D wood debris vary
 - EPA's new Commercial & Industrial Solid Waste Incinerator Rule: future of C&D burning?
- Wood fuel typically chipped or made into compressed wood pellets

Wood Smoke Emissions



- Complex mixture of 100+ gases/particles
 - “criteria pollutants”: PM, CO, NO_x
 - VOCs: formaldehyde, acrolein
 - PAHs
 - Metals: As, Mn, Cd, Pb
 - Dioxins/furans (C&D wood debris)
- Use for heat coincides with winter stagnation
- Exposure proximity—high intake fraction
- Dispersion less with lower stacks
- Toxicity affected by completeness of combustion

Hazardous to health

- Health effects associated with exposure to many of the pollutants in wood smoke emissions
- Robust evidence on risks from exposure to particulate matter
 - mortality
 - cardiovascular disease
 - respiratory effects
- Evidence of risks from exposure to wood smoke
 - at high exposures: mortality, cardiac arrest, systemic inflammation
 - from residential wood smoke
 - bronchiolitis (8% increase)
 - middle ear infections (32% increase)
 - asthma exacerbations
- Removing woodsmoke: improvements in measures of blood vessel health; decreases in inflammatory indicators (Allen et al 2011)
- Peak exposures occur that exceed levels at which harm from PM exposure is known to occur

Health Effects: PM & CVD (Brook et al, 2010)

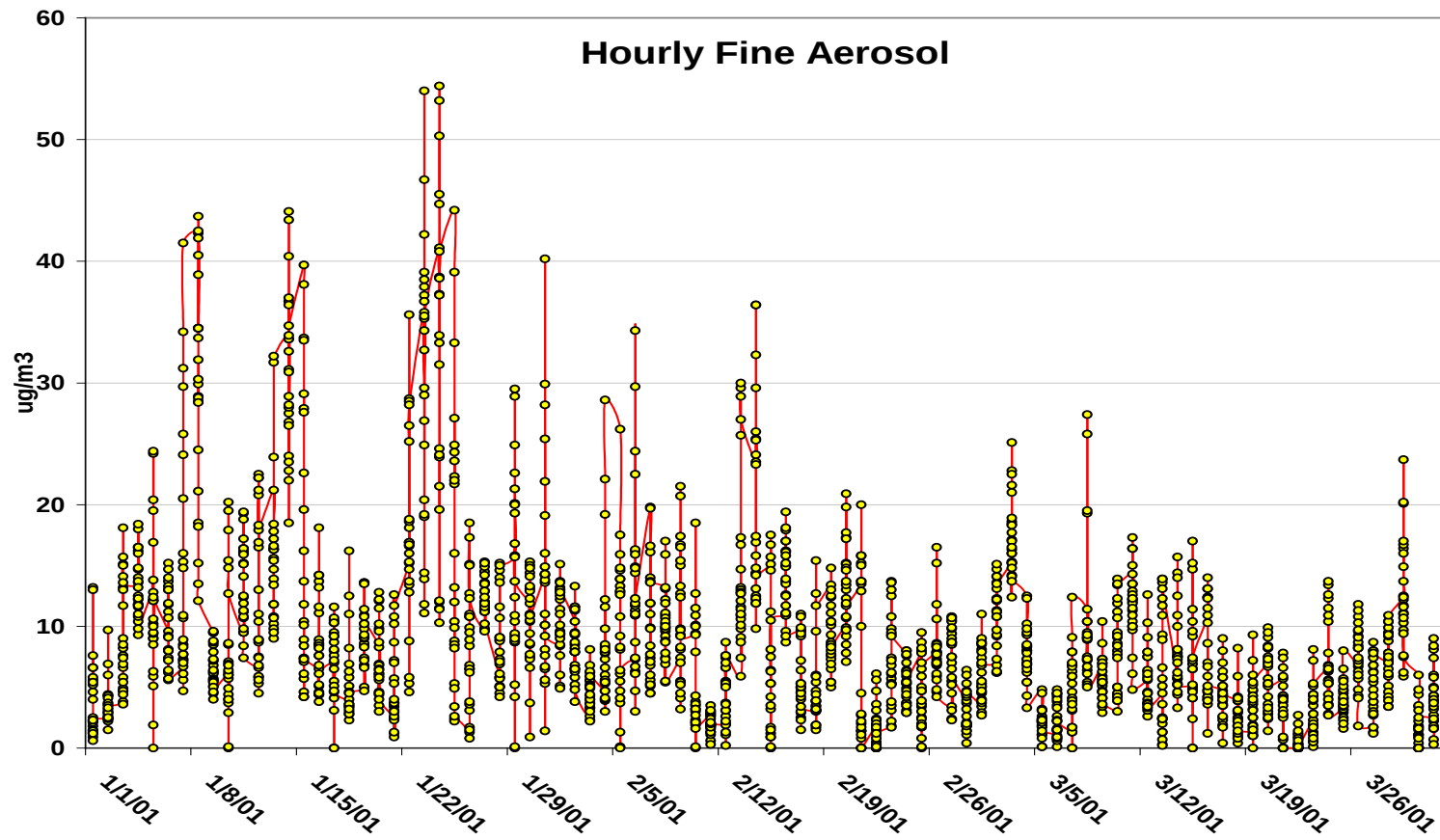
	Short-term exposure (days)	Longer-term exposure (months to years)
Cardiovascular mortality	+++	+++
Cardiovascular hospitalizations	+++	+
Ischemic heart disease	+++	+++
Heart failure	++	+
Ischemic stroke	++	+
Vascular diseases	+	++
Cardiac arrhythmia/cardiac arrest	+	+
Systemic inflammation	++	+
Systemic oxidative stress	+	
Endothelial cell activation/blood coagulation	++	
Vascular/endothelial dysfunction	++	
Blood pressure	++	
Altered heart rate variability	+++	+

Health Effects: Respiratory Outcomes & PM

- Increased risk of cardiopulmonary outcomes
 - COPD, daily cardiopulmonary mortality
- Infants & children:
 - impaired lung function & lung function growth
 - increased respiratory symptoms
 - increased health care utilization visits for respiratory disease
 - exacerbation of asthma
- Risks after very short-term exposures

Study	Age	Health Outcomes	Significant + Association with:
Delfino et al. 2002	Children	Asthma symptoms	1 hour; PM10 (51 $\mu\text{g}/\text{m}^3$)
Mar et al. 2005	Children	Airway inflammation & injury	1 hour; PM2.5 (8.3 $\mu\text{g}/\text{m}^3$)
NYSERDA 2006	Children	Asthma ED visits	1 hour; PM2.5 (27 $\mu\text{g}/\text{m}^3$)

Averaging Obscures Peak Exposures



Health Effects: Asthma and Wood Smoke, Evidence from Landscape Fires (sample of studies)

Study	Age	Health Outcomes	Significant + Associations w/:
Brauer et al. 1998	All	Outpatient asthma visits	PM10
Emmanuel et al. 2000	All	Outpatient asthma visits	PM10
Chew et al. 1995	Children	Asthma emergency room visits	PM10
Johnston et al. 2002	All	Asthma emergency room visits	PM10
Morgan et al. 2010	Adults	Asthma hospital admissions	PM10
Johnston et al. 2007	All	Asthma hospital Admissions	PM10

Health Effects: Asthma and Wood Smoke, Evidence from Residential Wood Burning (sample of studies)

Study	Age	Health Outcomes	Significant + Association with:
Yu et al. 2000	Children	Asthma symptoms	PM10, PM1, CO
Sheppard et al. 1999	< 65	Asthma hospitalizations	PM10, PM2.5, CO, O3
Norris et al. 1999	Children	Asthma hospitalizations	PM10, PM2.5, CO
Lipsett et al. 1997	All ages	Asthma emergency room visits	PM10
Schwartz et al. 1993	All ages	Asthma emergency room visits	PM10
Vedal et al. 1999	Children	Peak expiratory flow & respiratory symptoms	PM10 (among asthmatics)
Koenig et al. 1993	Children grades 3-6	FEV1 & FVC	PM2.5 (among asthmatics)
Allen et al. 2008	Children with asthma (not using corticosteriod therapy)	FEV1	levoglucosan

Potential Health Effects: Cancer

- Carcinogens include PAHs, arsenic and cadmium, all associated with lung cancer
- Benzene and formaldehyde associated with hematologic and other malignancies
- Biomass combustion, primarily indoor, called Group IIA by IARC (2010)

Susceptible & Vulnerable Populations

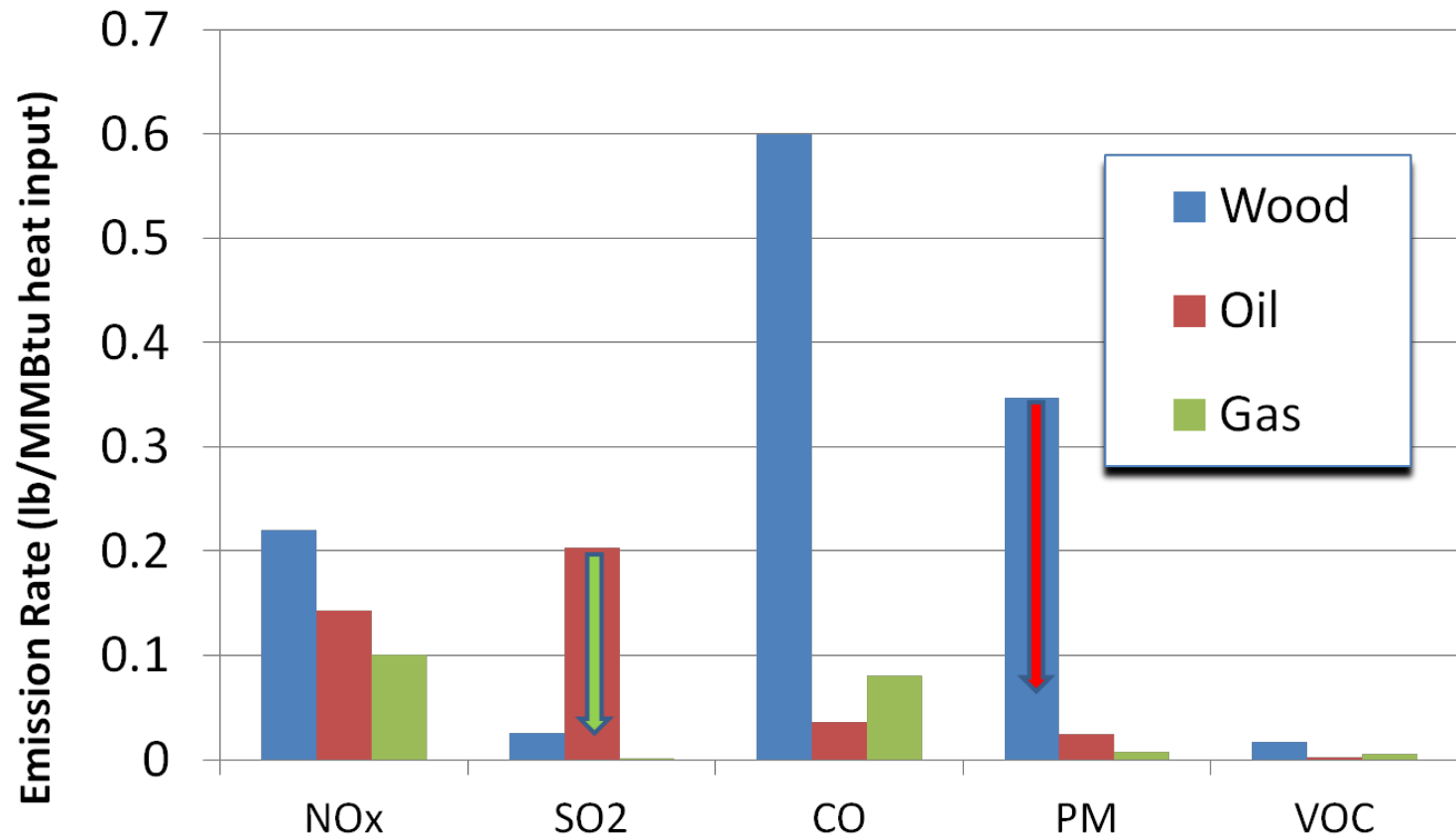
- Susceptible populations: risk at lower levels of exposure to woodsmoke
 - pre-existing respiratory disease
 - infants and children
 - schools: kids exercising out of door
- Vulnerable populations
 - geographic areas with high existing pollution loads
 - inversions and topographic conditions that prevent dispersion

Health Effects across the Wood Biomass System

- Local populations exposed to air emissions, indoors and outdoors
- Wood chip and pellet workers exposed to wood dust, molds and endotoxins
 - Combustible dust explosions
- Biomass power plant workers at increased risk for asthma and other respiratory symptoms
- Potential diesel exhaust-related effects on truck drivers and nearby communities
- Teachers, janitors

Emission rates from ICI wood combustion relative to other fuels

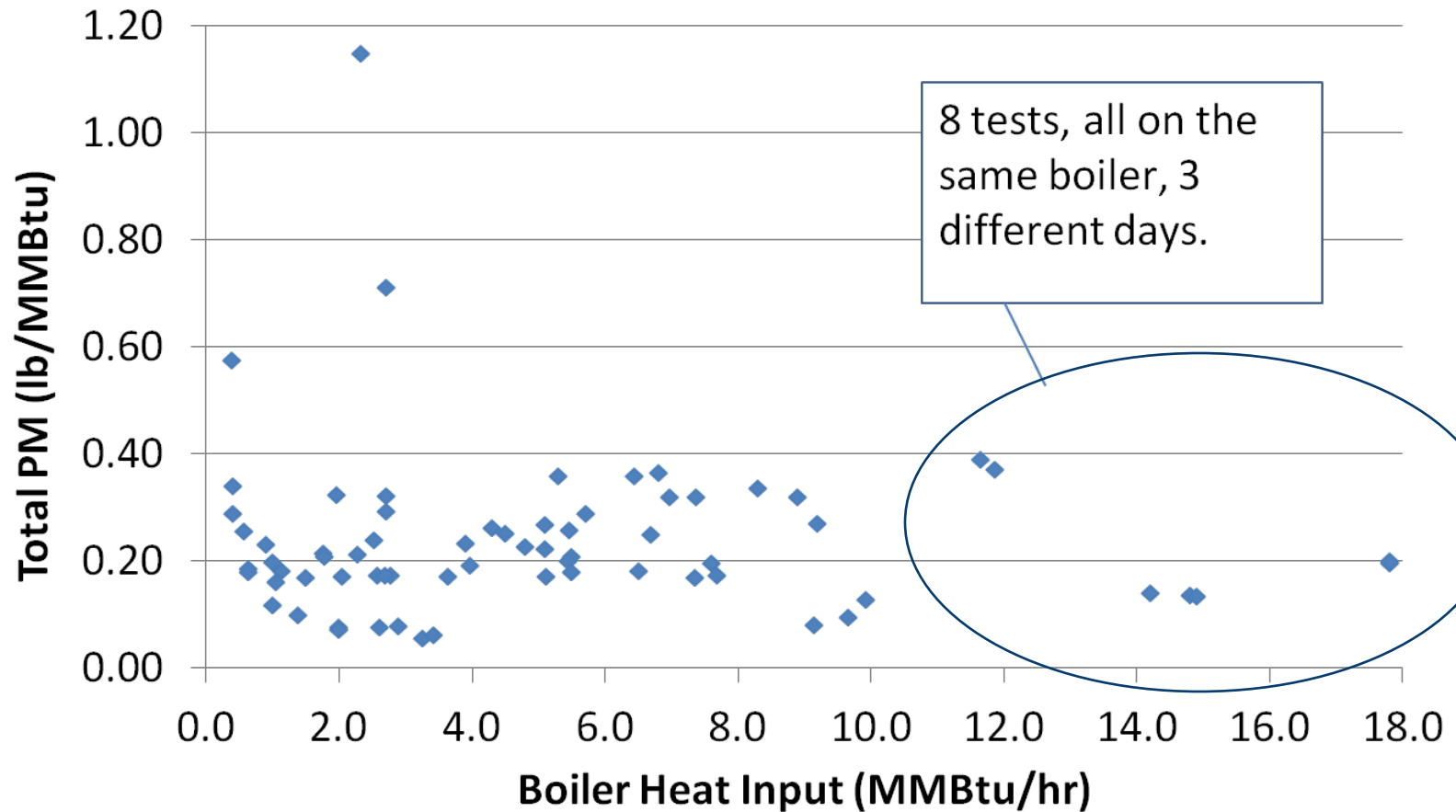
(Steve Snook, VT. DEC, based on EPA AP-42)



Wide variability in emissions of ICI units currently in operation

- Current wide variability
 - boiler design, controls
 - fuel type
 - fuel quality (moisture, impurities)
 - operating conditions (run load, heat demand)
 - topographical conditions
 - weather, season

PM Variability: small boilers with various controls



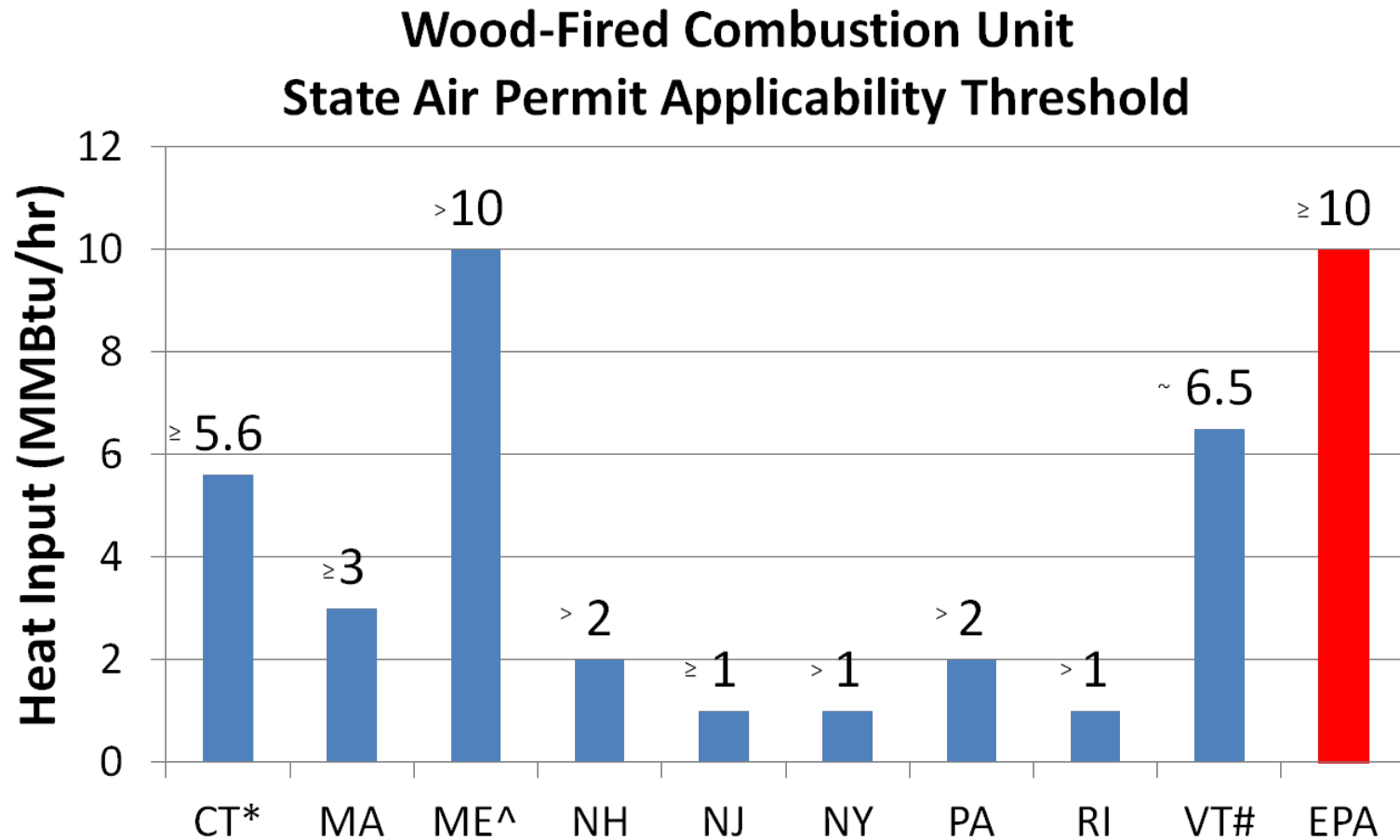
Summary of health concerns and challenges

- Emissions of key pollutants higher than other fuels
- Literature raises concern about health impacts of
 - Key pollutants
 - Wood smoke exposure
- High intake fraction...high exposure close to source
- Boiler operation practices can produce particles of higher toxicity
- Wood smoke collects and stays in valleys, and during stagnation
- Wood smoke is substantial percentage of PM in some places/seasons
- For small scale ICI, few impact analyses exist. Those that do have relied on manufacturers' specifications, not actual emissions data
- Problems of modeling short stacks
- Conditions affecting exposure vary widely; therefore difficult to characterize for policy purposes.
- Indoor air quality overlooked

Policy Research

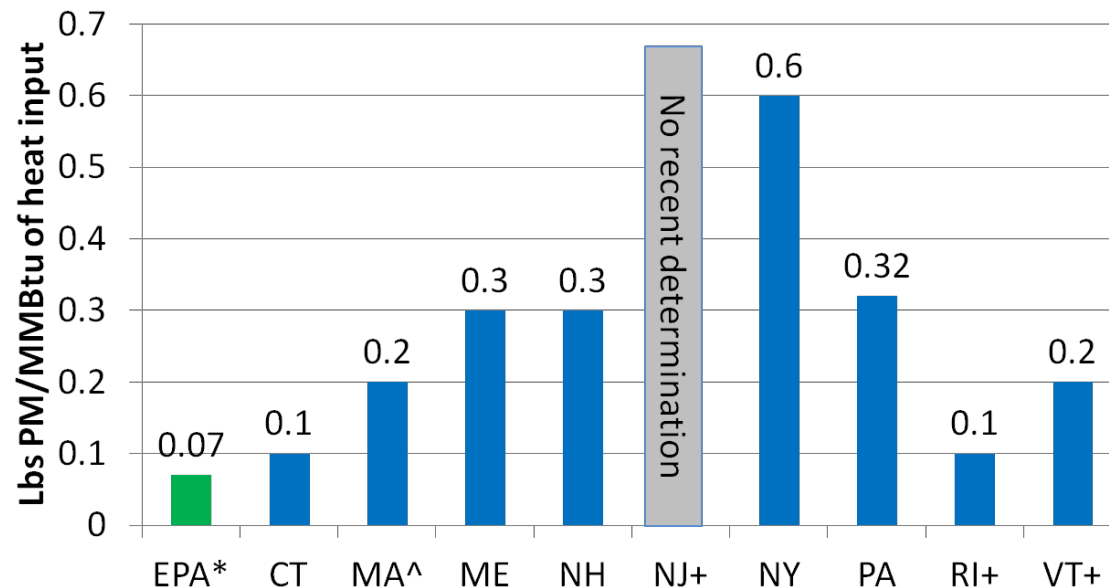
- What are roles and responsibilities of each agency with regard to ICI wood combustion?
- How do policies and practices vary across states?
- What size units are regulated under federal/state clean air laws?
- Are units limited in the amount of emissions they can release?
- How is health addressed in decision-making?
- Does policy promote cleanest technologies?

Institutional scale not regulated in some states



Where regulated, inconsistent approaches

**PM Emission Standards for Small ICI
Wood-Fired Combustion Units**



*For new units 10-30 MMBtu/hr; Limit = 0.03 for new units $\geq$ 30 MMBtu/hr

^Critical PM Concern Communities: Limit = 0.2 lb/MMBtu

+Decided on a case-by-case basis. Recent determinations noted.

State	Northeast States' Ambient Air Dispersion Modeling/Impact Analysis Permit Threshold
CT	Required if the source's emissions exceeds any of the following: ■ PM2.5: ≥ 10 tons/year ■ PM10 or SO2: ≥ 15 tons/year ■ NOx: ≥ 40 tons/year ■ CO: ≥ 100 tons/year
MA	Required if the source's emissions exceeds any of the following: ■ PM2.5: ≥ 10 tons/year ■ PM10: ≥ 15 tons/year ■ SO2: ≥ 40 tons/year ■ NOx: ≥ 40 tons/year ■ CO: ≥ 100 tons/year MassDEP may require dispersion modeling for any plan application, including emission increases less than the cited thresholds
ME	Required if the source's emissions exceeds any of the following: ■ PM10 or PM2.5: >25 tons/year ■ SO2: > 50 tons/year ■ CO: > 250 tons/year ■ NOx: > 100 tons/year ■ Lead: > 0.6 tons/year ■ Chromium: > 0.2 tons/year
NH	Required of: ■ units ≥ 2MMBtu/hr (heat input)—criteria pollutants only. ■ Combustion of virgin fuels, including biomass are not subject to 's state toxics rule
NJ	Required of: ■ major sources (e.g. facilities emitting more than 100 tons/year of PM). ■ sources sited in an existing non-attainment area. ■ for any unit requiring a permit (over 1 million btu per hour) if there is a substantial public concern
NY	Required of: ■ major sources (e.g. facilities emitting more than 100 tons/year of PM). ■ sources sited in an existing non-attainment area.
PA	Required of: ■ major sources (e.g. facilities emitting more than 100 tons/year of PM). ■ sources sited in an existing non-attainment area.
RI	■ Required when emissions exceed acceptable ambient levels (AALs). ■ Required if an applicant requests an expedited permit review.
VT	■ Required of: sources with annual emissions of any criteria pollutant exceeds 10 tons per year ■ when Action Levels for air toxics are exceeded (not always required).

Health hazards not taken into account in public policy decision-making

- Environment agency decision-making
 - some flying under regulatory radar
 - ambient air quality assessment
 - too small to independently cause violations
 - this may change if NAAQS is lowered
 - local populations' vulnerability/susceptibility not part of ambient air quality standards
 - environmental impact assessments don't include health
- Facilities decisions by Education agencies
- Energy/renewable energy planning
- Forest Service or other grant programs

Cleaner technologies exist, but are not in wide use

- Substantial reductions in emissions of pollutants is possible with advanced technologies
 - NYSERDA conclusions on advanced wood boilers
 - advanced wood boilers can achieve the same efficiency as oil-fired boilers
 - lower PM emissions; more inorganic composition compared to conventional wood chip boilers
- Post combustion controls can reduce PM emissions to levels seen in oil burners
- Cleanest-burning units (European) face barriers
- Most states: no carrots, minimal sticks
 - “Energy policy geared towards incentivizing least efficient uses of biomass”

Biomass/Health Effects Science Policy Symposium: November 7, 2011

- Strategic convening
 - Representatives from health, environment, education, energy, forestry agencies, state and federal
 - Nine Northeast states
 - Health scientists and health professionals
 - Biomass industry and health advocacy stakeholders
- Meeting goals:
 - Exchange information about the state of the science on health effects associated with ICI wood combustion
 - Generate recommendations about policy and program changes that to enhance public health protection in the context of the proliferation of ICI wood-burning

Biomass/Health Effects Science Policy Symposium Agenda

- **Morning Sessions: Health Effects of the Use of Wood for Heat and Power in the Northeast**
 - State of the Science: Woodsmoke Emissions and Health
 - ***Particulate Matter, Air Toxics & Health: The Big Picture.*** Doug Dockery, Harvard School of Public Health
 - ***Biomass Combustion, Exposure and Health Effects.*** Mike Brauer, School of Environmental Health, University of British Columbia
 - ***Toxicity of Wood Smoke Particles Generated Under Different Combustion Conditions.*** Anette Kocbach Bølling, Norwegian Institute of Public Health
- **ICI Wood Burning in the Northeast**
 - ***Air Emissions and Permitting: ICI Biomass Boilers*** Steve Snook, VT Department of Environmental Conservation
 - ***Energy & Emissions Performance of Commercial Wood Boilers.*** Ellen Burkhard, New York State Energy Research Development Authority
 - ***Estimating Public Health Impacts: Air Receptor Modeling & Measurement.*** Phil Hopke, Clarkson University

Symposium Agenda (cont.)

- **Afternoon Sessions: Policy and Program Opportunities and Recommendations for Reducing Exposure to ICI Wood Combustion Emissions**
 - **Moderated Panel; Current Practice and Perspectives from Northeast States**
 - Suzanne Condon, Massachusetts Department of Public Health
 - Bill Irwin, Vermont Department of Health
 - Suzanne Condon, Massachusetts Department of Public Health
 - Barbara Morin, Rhode Island Department of Environmental Management
 - Mark Torpey, New York State Energy Research Development Administration
 - Ed Murdough, New Hampshire Department of Education
 - Lani Graham, Maine Medical Society
 - Charlie Neibling, Chair, Biomass Thermal Energy Council
 - **Roundtable Discussions and Plenary: Promising Policy and Program Tools for Coordinated Regional Action**
 - Encouraging Cleanest-Burning Technologies
 - Regulatory Programs, Policies and Tools for ICI Wood Combustion
 - Guidance and Educational Materials
 - Filling Important Scientific Gaps
 - Public Health Engagement in Energy Decision-Making
 - Public Health Protection and Large-Scale Wood Biomass Combustion Units

Symposium Outcomes

- Encourage cleaner combustion technologies
 - 4 priorities
 - Develop a best practices guide for the optimizing biomass heating combustion efficiency and performance.
 - Establish regional specifications for wood biomass fuel and appliance standards.
 - Provide financial incentives to off-set the up-front costs of new wood biomass heating projects.
 - Research and development for low-cost advanced emission control technologies.

Symposium Outcomes (Cont.)

- Utilize regulatory programs, policies & tools
 - 5 priorities
 - *All priority regulatory solutions identified require additional regional engagement across states in the Northeast to further refine and develop*
 - Establish a certification process and a recertification/review process for wood biomass combustion systems.
 - Establish a boiler performance rating system to support setting emission limits that drive continuous improvement.
 - Establish and enforce a fuel specification standard.
 - Streamline regulatory requirements.
 - Charge facilities a fee based on *all* pollutants emitted to promote the use of advanced technologies that can lower emissions.

Symposium Outcomes (cont.)

- Develop guidance and educational materials
 - 3 Priorities
 - Require that ICI boiler operators receive formal operations training.
 - Establish and coordinate a regional informational clearinghouse regarding public health risks associated with wood biomass combustion.
 - Require that facility proponents address the public's concerns regarding health impacts (e.g. via a HIA) during air permit processes.

Symposium Outcomes (cont.)

- Fill policy-relevant research gaps
- 3 priorities
 - Design and conduct an efficient study of the health effects (or biological markers) in children to address the extent to which children are being adversely affected ICI emissions in their schools.
 - Design and conduct an exposure study that fully describes the PM and non-PM emissions from a state-of-the art advanced combustion ICI wood biomass unit.
 - Design and conduct a qualitative research study to evaluate the level and sources of public knowledge regarding ICI wood biomass emissions.

Symposium Outcomes (cont.)

- Ensure Public Health Engagement in Energy Decision-making
 - 4 Priorities
 - Formally integrate health into energy planning processes.
 - Establish a regional working group to integrate public health into the energy decision-making process.
 - Develop HIA standards.
 - Establish an informational clearinghouse.

Symposium Outcomes (cont.)

- Public Health and Large-Scale Wood Combustion
 - 4 Priorities
 - Require an HIA when evaluating air permit applications.
 - Improve the regulatory process used by states in the region.
 - Improve understanding of the composition and level of air toxics emitted from large scale biomass combustion.
 - Require that wood biomass combustion units burning construction and demolition debris be regulated as waste incinerators.

Observations

- Principles/values in common: healthy renewable energy
- Early engagement of public and medical community needed
- Cross agency/cross sector conversation results: out-of-the-box thinking; new collaborations
- Relevant beyond biomass: incorporating health into renewable energy decision-making more broadly
- Regional coordination critical
- Science gaps are real, but action can proceed while gaps are filled

Next Steps

- Some states/organizations pursuing ideas/recommendations discussed at Symposium
- Survey to further prioritize recommendations
- Generate symposium report
- Pennsylvania meeting
- Seek partners and funds for top priorities

THANKS!