# The Northeast Experience: Addressing the Public Health Impacts from Wood Biomass Combustion

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  - New York Energy Research and Development Authority
  - New England College of Occupational and Env. Medicine
  - Northeast States for Coordinated Air Use Management
  - University of British Columbia

# 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

# 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 & environmental sustainability issues (e.g. fuel supply)
- 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

# 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 | ~6 | 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.

# Are there health impacts from ICI wood combustion?

- No epidemiological studies
- Insights gained from understanding:

  I. state of the science of wood smoke toxicology & epidemiology

  II. vulnerable and susceptible populations

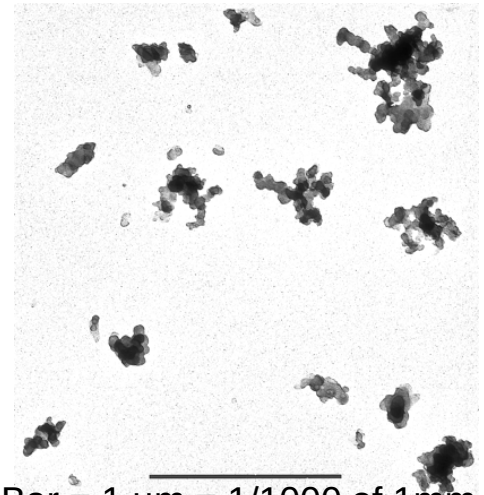
  III. emission data reviewed from a public health lens: data based on real-world operations & conditions that have the potential to affect human health

# State of the science: Woodsmoke PM demonstrates evidence for concern

**Do wood smoke particles pose different levels of risk from other particles?**

- Respiratory disease: No
- Cardiovascular disease: ?

Woodsmoke Particles



Bar = 1 µm = 1/1000 of 1mm

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## Woodsmoke Health Effects: A Review

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**The sentiment that woodsmoke, being a natural substance, must be benign to humans is still sometimes heard. It is now well established, however, that wood-burning stoves and fireplaces as well as wildland and agricultural fires emit significant quantities of known health-damaging pollutants, including several carcinogenic compounds. Two of the principal gaseous pollutants in woodsmoke, CO and $NO_x$, add to the atmospheric levels of these regulated gases emitted by other combustion sources. Health impacts of exposures to these gases and some of the other woodsmoke constituents (e.g., benzene) are well characterized in thousands of publications. As these gases are indistinguishable no matter where they come from, there is no urgent need to examine their particular health implications in woodsmoke. With this as the backdrop, this review approaches the issue of why woodsmoke may be a special case requiring separate health evaluation through two questions. The first question we address is *whether woodsmoke should be regulated and/or managed separately*, even though some of its separate constituents are already regulated in many jurisdictions. The second question we address is *whether woodsmoke particles pose different levels of risk than other ambient particles of similar size*. To address these two key questions, we examine several topics: the chemical and physical nature of woodsmoke; the exposures and epidemiology of smoke from wildland fires and agricultural burning, and related**

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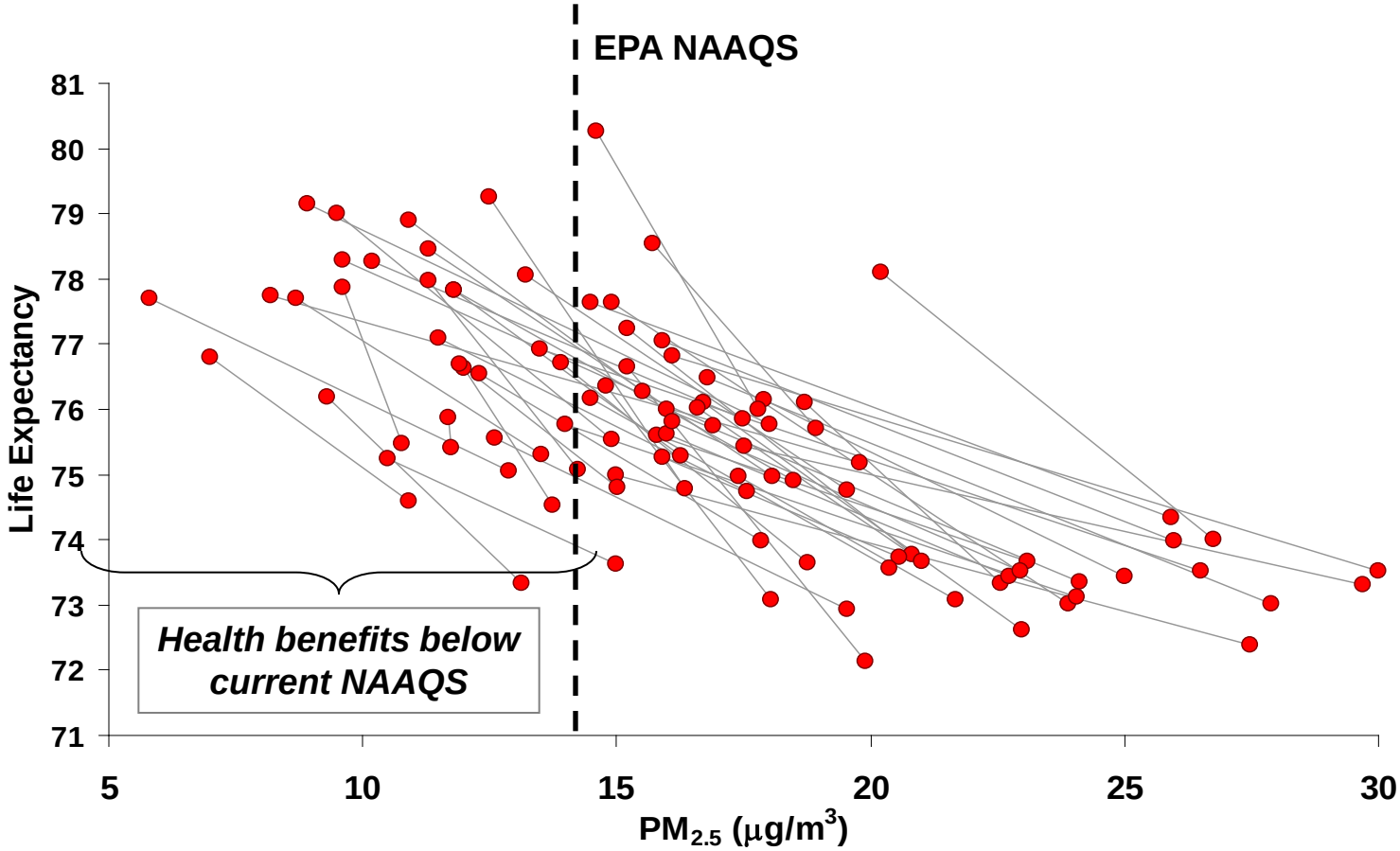
Slide adapted from Mike Brauer presentation, 11/7/2012

Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, Smith KR. Woodsmoke health effects: A review. Inhal Toxicol. 2007 Jan;19(1):67-106.

# Exposure to PM2.5: No bright "safe" line

## Life Expectancy vs $PM_{2.5}$ 1980-2000




*Pope, Ezzati, Dockery (NEJM 2009)*

Slide adapted from Doug Dockery presentation, 11/7/2012

| Classes and Examples of Major Health Damaging Chemicals in Emissions from Wood-fired Combustion units | | |
|---|---|---|
| **Chemical class** | **Primary Examples** | **Known Health Hazard** |
| **CRITERIA POLLUTANTS** | Carbon monoxide | Cardiac |
| | lead (and compounds) | carcinogen, cardiac, reproductive/developmental toxicant |
| | nitrogen oxides | asthmagen, immune toxicant, other respiratory toxicant, |
| | $PM_{2.5}$ | asthmagen, cardiac, other respiratory toxicant |
| | $PM_{10}$ | asthmagen, cardiac, other respiratory toxicant |
| | sulfur dioxide | Asthma, other respiratory toxicant |
| **INORGANIC ACIDS** | hydrochloric acid | corrosive, respiratory irritant |
| | Sulfuric acid | corrosive, respiratory irritant |
| | Arsenic | carcinogen, cardiac, other respiratory toxicant, reproductive/developmental toxicant |
| **METALS [20+ potential compounds]** | Beryllium | carcinogen, other respiratory toxicant |
| | Cadmium | carcinogen, endocrine disruption (osteoporosis), other respiratory toxicant, reproductive/ developmental toxicant, |
| | chromium and compounds | asthmagen, carcinogen, other respiratory toxicant, reproductive/ developmental toxicant |
| | Mercury | reproductive/ developmental toxicant |
| | nickel and compounds | asthmagen, carcinogen, immune toxicant, other respiratory toxicant |
| **POLYAROMATIC HYDROCARBONS (PAHs) [20+ potential compounds]** | benzo(a)pyrene | carcinogen, immune toxicant |
| | indeno(1,2,3,cd)pyrene | carcinogen |
| | Naphthalene | asthmagen, carcinogen |
| **VOLATILE ORGANIC COMPOUNDS (VOCs) [20+ potential compounds]** | Acetaldehyde | asthmagen, carcinogen, respiratory irritant |
| | Acrolein | respiratory irritant |
| | Formaldehyde | asthmagen, carcinogen, respiratory irritant |
| | Benzene | carcinogen, cardiac, reproductive/ developmental toxicant, immune toxicant, neurotoxicant |
| | Toluene | neurotoxicant, respiratory irritant, |
| | 1,3 butadiene | carcinogenic, respiratory irritant |
| | n-hexane | neurotoxicant |
| **Dioxins, furans and other "dioxin-like" compounds** | 2,3,7.8 tetrachlorodibenzo-p-dioxin; 2,3,7.8 tetrachlorodibenzo-p-furan | carcinogen, cardiac, endocrine disruption (type II diabetes, thyroid disorders), immune toxicant, reproductive/ developmental toxicant |

Naeher et al. 2007

# Susceptible & Vulnerable Populations

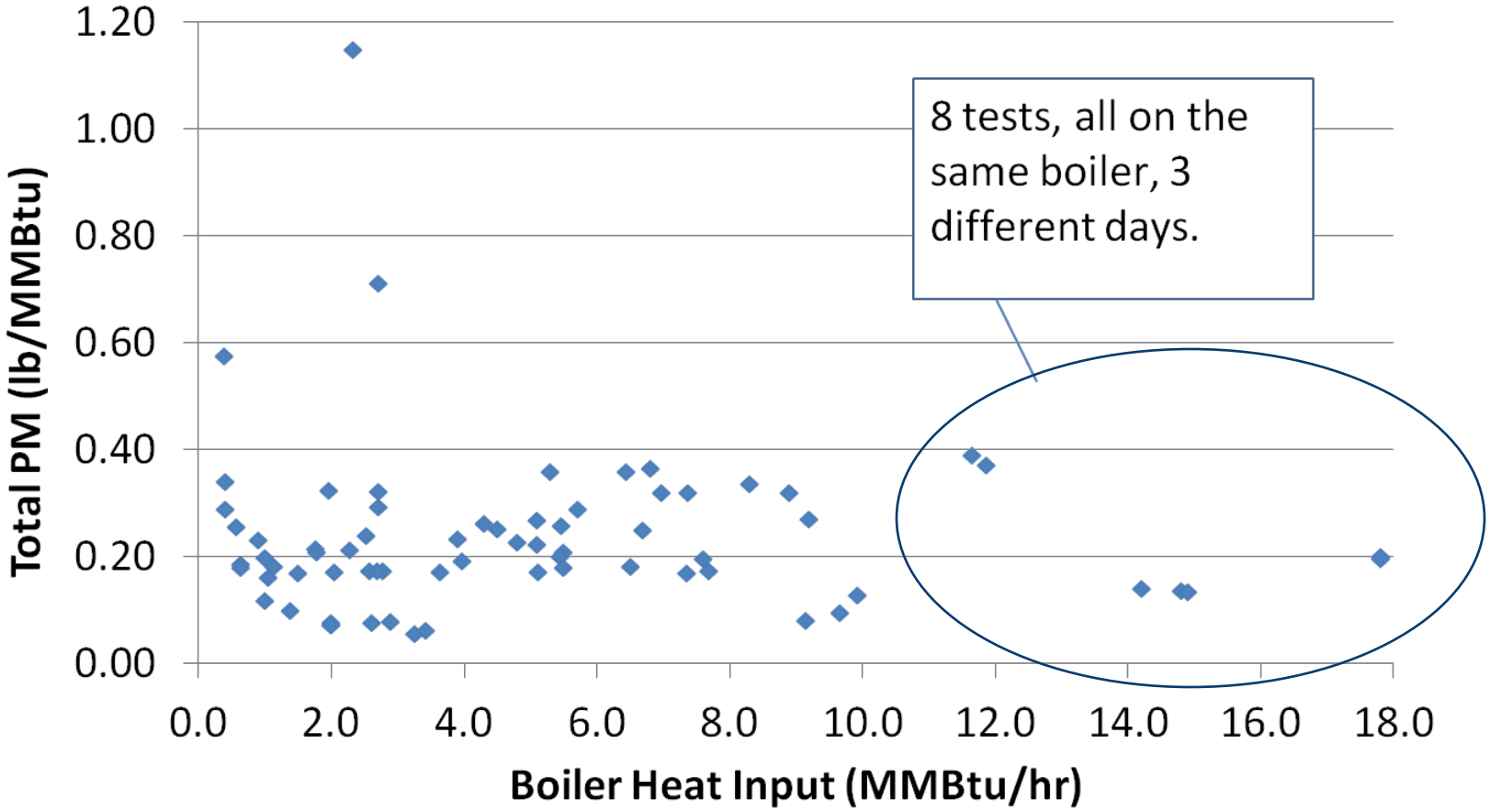
- Susceptible populations: risk at lower levels of exposure to woodsmoke
  - pre-existing respiratory disease
  - infants and children
  - schools: kids exercising out of door
- Vulnerable populations
  - geographic areas with high existing pollution loads

Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, Smith KR. Woodsmoke health effects: A review. Inhal Toxicol. 2007 Jan;19(1):67-106. MacIntyre EA, Karr CJ, Demers P, Koehoorn M, Lencer C, Tamburic L, Brauer M. Exposure to residential air pollution and otitis media during the first two years of life. Epidemiology. 2011 Jan;22(1):81-9.; Karr CJ, Demer PA, Koehoorn MW, Lencar CC, Tamburic L, Brauer M. Influence of ambient air pollutant sources on clinical encounters for infant bronchiolitis. American Journal of Respiratory and Critical Care Medicine, 2009, 180(10):995-1001.; Clark NA, Demers P, Karr C, Koehoorn M, Lencar C, Tamburic L. Brauer M. Effect of early life exposure to air pollution on development of childhood asthma. Environmental Health Perspectives 2010, 188(2): 118:284-290.

# Factors that influence exposure levels: contribute to large variations in emission levels

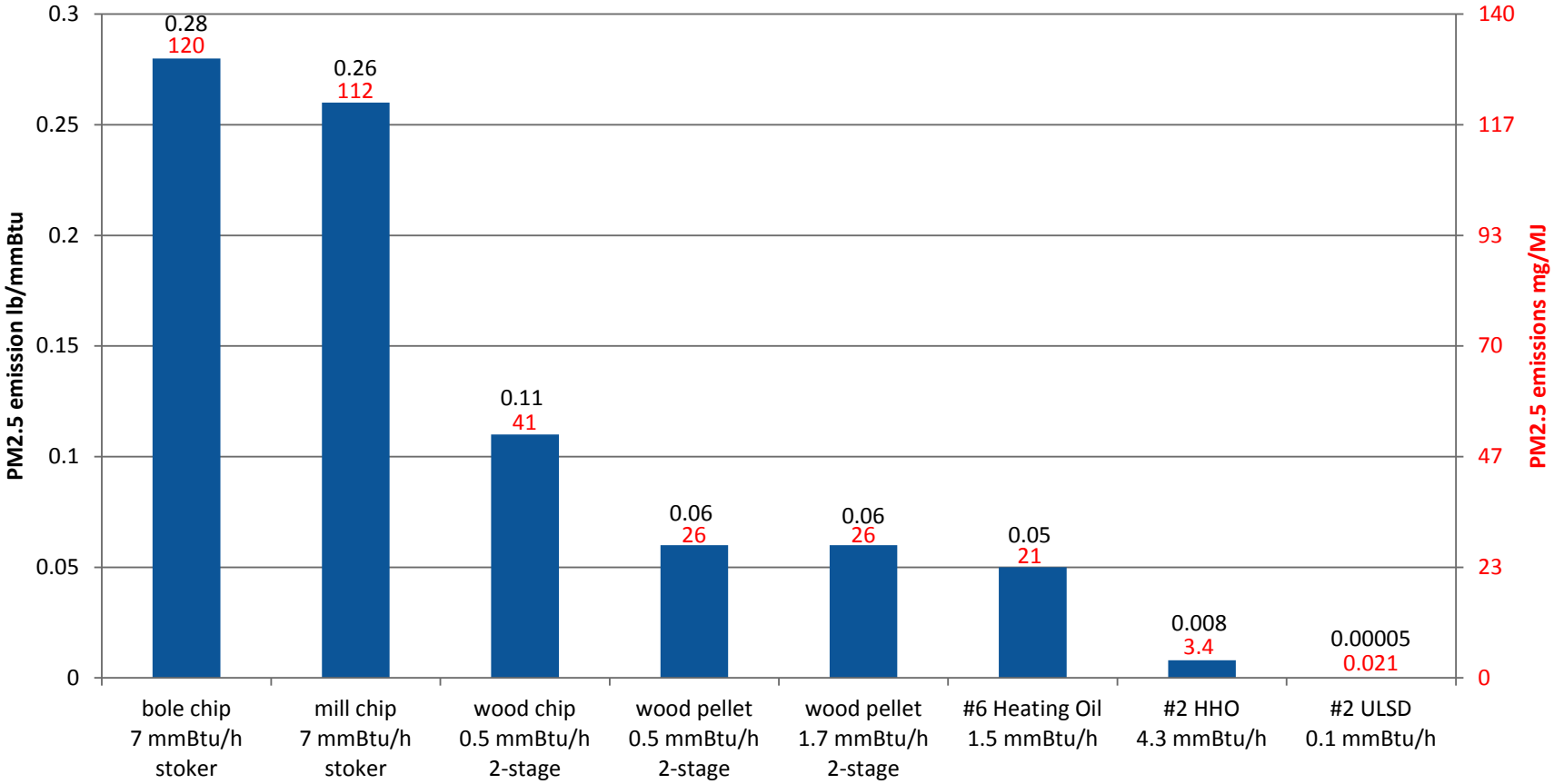
1. fuel type (wood pellets, wood chips, wood logs, bark)
2. boiler design (direct-fired boilers; gasification)
3. fuel quality (moisture, impurities)
4. operating conditions (run load, heat demand)
5. meteorological conditions
6. topographical conditions

# PM Variability: small boilers with various controls




Slide adapted from: Steve Snook, VT DEC 11/7/2011 presentation

# PM Emissions: Boiler design & fuel types

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| Combustion source | Emissions (mg/MJ) | Composition |
|---|---|---|
| Open fireplace | MORE TOXIC | Mostly soot & some organic particles |
| Conventional woodstove | | Soot & organic particles |
| Conventional log boilers | | Mostly organic particles & some soot |
| ‘Modern” woodstoves log/chip boilers | | Alkali salt particles, some organic particles & soot |
| Pellet stoves/boilers | LESS TOXIC | Mostly alkali salt particles |

Adapted from: Kocbach Bølling et al. 2009; M Brauer presentation 1/24/2012

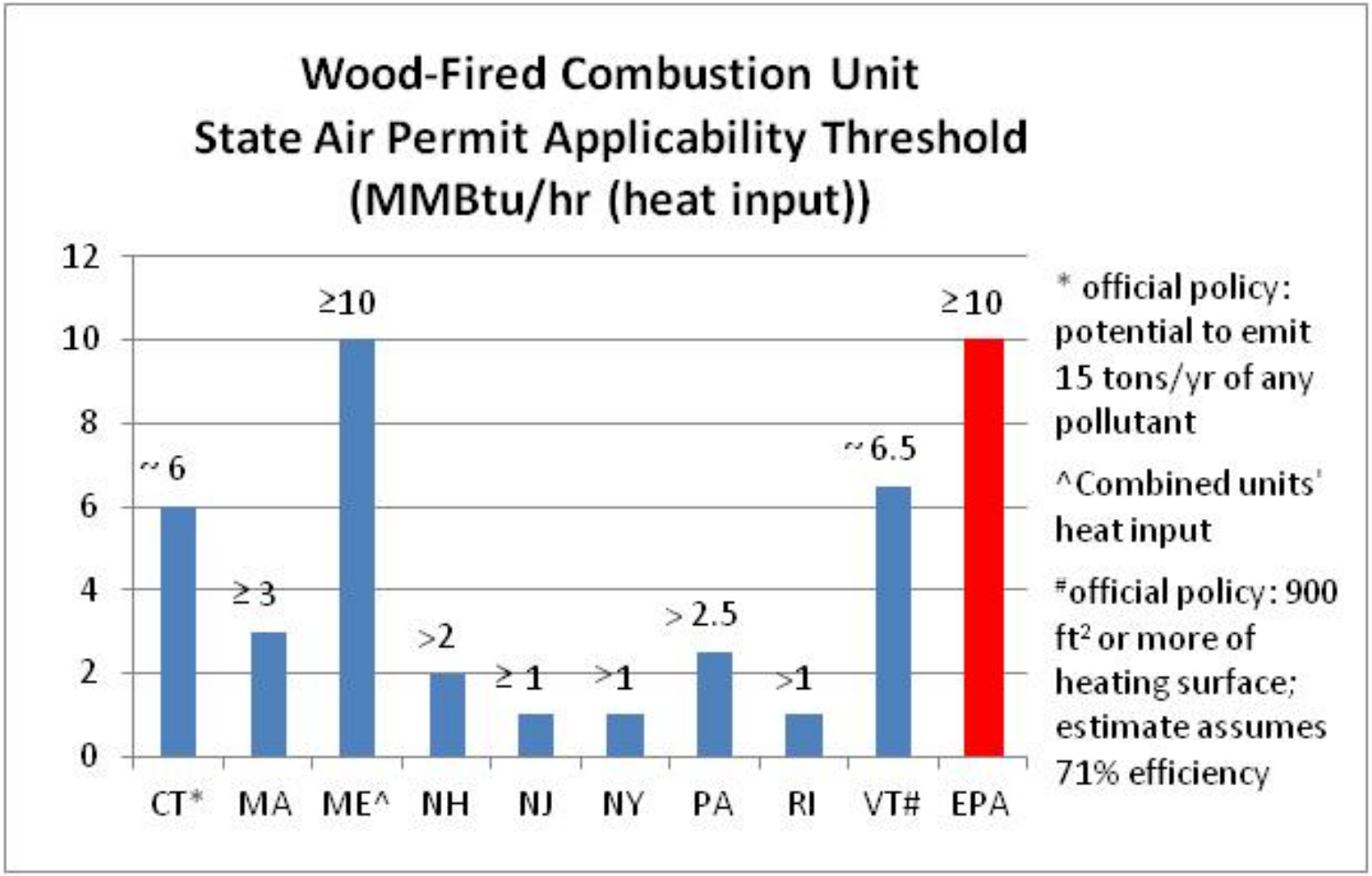
# Summary of health concerns and challenges

- Literature raises concern about health impacts of wood smoke exposure
- Variety of susceptible and vulnerable populations
- Conditions affecting exposure vary widely; therefore difficult to characterize. Lack an understanding of peak exposures.
- Science gaps
  - Lack of studies on ICI exposures
  - Lack of studies on susceptible populations, e.g. exposures from school boilers and impacts on school children
  - Indoor air quality overlooked

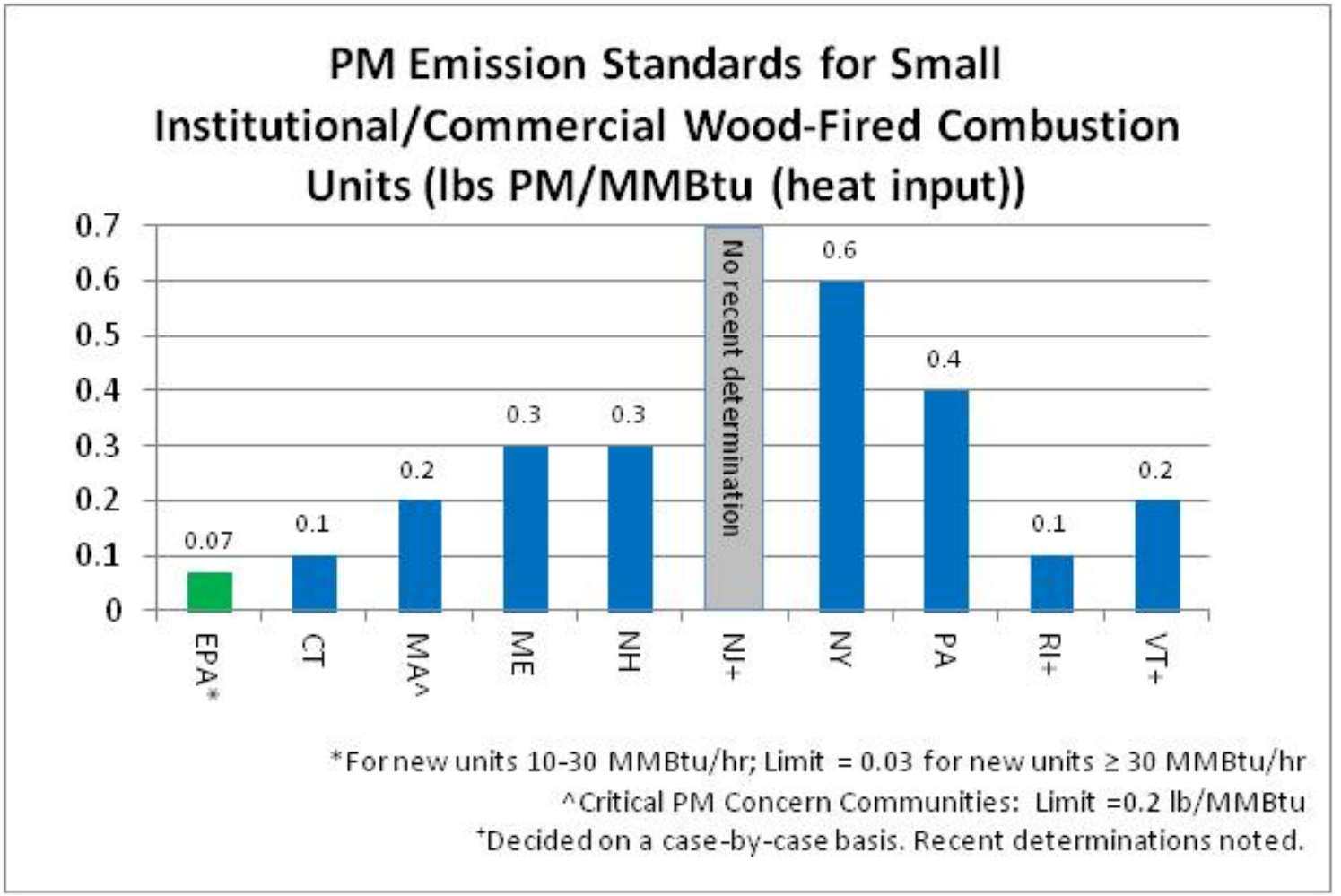
# Policy Research

- How do policies and practices vary across Northeast states?
- How is health addressed in decision-making?
- Does policy promote cleanest technologies?

# Institutional scale not fully regulated in some states



# Where regulated, inconsistent approaches



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

# Cleaner technologies exist, but are not in wide use

- Most states: no carrots, minimal sticks
  - “Energy policy geared towards incentivizing least efficient uses of biomass”
  - Examples of exceptions:
    - MA: requirement of 40% efficiency to receive renewable energy credits
    - NY: requirement of 83% efficiency to receive stimulus funds from NYSERDA for commercial biomass units
- Substantial reductions in emissions of pollutants is possible with advanced technologies

# Gaps in public health protections: environmental decision-making

- Some biomass combustion units flying under regulatory radar
  - not regulated
  - impact analyses not conducted; LOCATION MATTERS
- Local populations' vulnerability/susceptibility not part of ambient air quality standards or permit requirements
- Emissions dramatically vary but permits set based on best combustion conditions
- Peak exposures matter to public health yet reviewed based on environmental compliance (e.g. 24 hr standard)
- Lack of carrots and sticks to promote cleanest burning technologies

# 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

# 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.)

- 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.)

- Fill Policy-Relevant Research Gaps

3 Priorities

- Design and conduct an efficient study of the health effects (or biological markers) to address whether children are being adversely affected by 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.)

- 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.

# Observations

- Principles/values in common: healthy renewable energy
- Early engagement of the public and public health communities needed
- Science gaps are real, but action can proceed while gaps are filled