A carrot and a nudge: large scale approaches to residential wood smoke in the Tacoma (former) PM nonattainment area

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Clear the Air, Paths to Attainment
Sept 26-28, 2016
Fairbanks, AK
Ewe! Where is this coming from?
2006 revision of Daily PM2.5 standard brings area into nonattainment

Fine Particle Concentrations at Tacoma South L and Other Puget Sound Sites
Daily Fine Particle Concentration, 3-Year Average of the Daily 98th Percentile

- Former Federal Standard
- Current Federal Standard
Designation occurs in 2009

Fine Particle Levels in Tacoma and Federal Daily Standard

(Daily PM2.5 [1-year 98th percentile] and Design Value [3-year mean of Daily])

- Former Standard
- New Standard
- Standard
- Daily PM2.5 (1-year 98th percentile)
- Design Value (3yr mean)

Year:
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013

Fine Particle Concentration (µg/m³):
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
Where is the nonattainment (aka Smoke Reduction Zone)?
The Tacoma-Pierce County Non-Attainment Area

Fine Particulate Nonattainment Area in Tacoma and Pierce County
The solution: a collaboration

- Clean Air Task Force (stakeholder group) with independent facilitator
- Puget Sound Clean Air Agency sponsored, with major help from WA State Department of Ecology
- open to public, accepted comments at every meeting
- met 12 times over 8 months
The solution: a collaboration

Clean Air Task Force membership included representatives from:

- citizen wood burners
- business
- realtors
- Hearth/Stove retailers
- Respiratory health professional (UW)
- the Port of Tacoma
- Joint Base Lewis-McChord
- Electric and gas utilities
- regulators
The solution: a collaboration

Clean Air Task Force discussion progressed through:

1. Background science on air pollution, health, and Tacoma data
2. Relevant Regulations
3. Brainstorming solutions
4. Narrowing and revising solutions
5. Making final recommendations
About the Nonattainment area (now, Smoke Reduction Zone)

- About 200 square miles
- About 220,000 urban, suburban and rural households
  - Median income = $51,000
  - Poverty rate = 12%
  - ~25,000 households (17%) are at 150% of federal poverty level
- 10 cities and towns plus many unincorporated communities (most of the county’s urban growth area)
- About 24,000 uncertified wood stoves (2007 inventory)
  - ~21,000 of those are being used
  - ~3,500 wood is “Primary” source of heat (Census, 2005-2009 ACS)
  - ~600 wood is sole source of heat (Assessor records)
Where, when, how, why ??????
Exceedances only occur in the winter...

Number of days per month over the Federal Standard since 2002

<table>
<thead>
<tr>
<th>Month</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
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<tr>
<td>February</td>
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<td>March</td>
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<td>May</td>
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<td>September</td>
<td>0</td>
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<tr>
<td>October</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>24</td>
</tr>
<tr>
<td>December</td>
<td>30</td>
</tr>
</tbody>
</table>

Tacoma South L Street
Daily Federal Standard = 35 Micrograms per Cubic Meter
Temperature drops, PM2.5 goes up...

Tacoma South L, fall-winter hourly PM2.5
On worst winter nights, diurnal pattern matches burning habits...

- diurnal pattern
- stagnation at night
- rapid increase in evening when burning occurs
- dissipates after midnight
- venting during the day
- typically clear with high pressure ridge
Emissions Inventory highlights residential wood burning as largest PM2.5 source...
PMF (fingerprint) results of chemical composition analysis...

Sources of wintertime fine particle pollution in South End Tacoma/Pierce County

- Wood Smoke: 53%
- Gasoline Vehicles: 20%
- Industrial: 10%
- Ships: 4%
- Diesel Vehicles: 5%
- Sea Salt: 5%
- Fireworks: 1%
- Dust: 2%

Ogulei (2010)
When highest? Normal ventilation – most days

3,000 ft

300 ft
When highest? Ventilation during an inversion

3,000 ft

300 ft inversion “lid”
The solution: a collaboration

Clean Air Task Force discussion progressed through:

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Recommended Strategies:

1. Improve Efficacy of Burn Bans (but have exemptions)

2. Remove uncertified wood stoves (by 2015)

3. Continue and enhance changeout program with incentives
Recommended Strategy #1

- Improve Effectiveness of Burn Bans
  - Beef up enforcement: people and coverage
  - Lower the threshold for calling burn bans (triggers dropped from 35 to 30 ug/m3)
  - Expand communication and outreach
Outreach Campaign

- New Burn Ban website
- Paid advertising
  - Print – Ads 2x weekly, major pubs
  - Digital – The News Tribune online
  - Outdoor – 5 at a time, 8-week/set
- Earned media
  - Print, TV, radio news, editorial
  - Government access
- Direct mail postcard
  - Targeted 80,000 pieces
- Community outreach
  - 60+ local presentations
  - 40 local publications
  - 28,000 flyers distributed locally
- Engaged partners
- Social media, text and email alerts
Enforcement Improvements

- Use staff of local gov. partners in on-call basis
- More patrols, was 2 or 3 teams, maxed at ~ 40 teams
- Lower thresholds for calling burn bans
- Patrol more hours at common burning times (nights and weekends)
- Developed nighttime capability (most burning is at night, day has inequality issue)
- Create “no other adequate source of heat” program (NOASH)
“No Other Adequate Source of Heat” exemption program

- Houses were designed with wood as primary heat
- Houses with heating systems too small for “adequate” warmth
- About 1-2% of all houses
- Had to submit information about heating system and insulation
- Compared to county records
How did we get 40 teams???

- “Rented” other local agency staff during burn bans
- Four cities and the county
- Developed agreements/contracts
- Required significant training on observations and documentation
- Paid them for their time
Results from 2012/13 and 2013/14 Winters

- Burn bans for ~30 days total
- ~2,700 potential violations documented with photographs (even after dark)
- ~1700 NOVs (Notice of Violations) issued
- ~1000 civil penalties issued
You might ask “How did you document smoke at night?”

Good question!

A: standard low-light photography:

- high ISO
- “fast” lens (open aperture)
- long exposure → tripod
Camera specs

- "off the shelf" Nikon D5100 DSLR with f/1.8 85mm lens
- is only visible light
- GPS tagger adds location to .jpg file
- ISO 3200 at f/6.3, typically 1-10 seconds exposure
- tripod or window-pod
- requires training and practice for those not familiar with DSLR
- biggest problem is correct focus (auto focus doesn’t work)
2013/14 Enforcement Coverage

- Used GPS to track vehicles
- 130,000 single family parcels in SRZ
- 65,000 covered (~50%) at least once
- Better coverage in fewer patrol days
- Fewer re-citation in same burn ban
Strategy #2: Removing uncertified stoves

- New rule banning uncertified woodstoves as of September 2015 (along with incentives)

- Only in the nonattainment area

- Can be rendered inoperable...We prefer old stoves taken to recycler and crushed
Strategy #3: Incentives for removal or replacement of uncertified stoves

- Wood Stove Replacement Program (WSRP)
- **Replace** (with cleaner heating device)
  - Income-Qualified households = FREE
  - $1500 discount for others
  - fireplace pilot program
WSRP: Full cost to income qualified, $1500 to others

I want cleaner heat!
In 2012 added a Bounty Program...

- uncertified stoves recycled for a reward
- Just scrap it!
- Don’t have to replace it
- $200 reward if our contractor picks up
- $350 reward if you do heavy lifting and take to designated recycle yard
Removal (Recycling): $350 drop off, or $200 we pick up

I’ve got this!

$350

pickup my stove!

$200
What kinds of OLD devices are we talking about?

- Wood stoves
- Wood-burning fireplace inserts
- Coal stoves/inserts
- Free-standing, manufactured fireplaces
- Wood-burning furnaces
- Fireplace retrofit (case-by-case)
Results to date...

- Over 3,000 old stoves/inserts removed!
DID WE REALLY SOLVE THE PROBLEM?
Fine Particle Levels in Tacoma and Federal Daily Standard

(Daily PM2.5 [1-year 98th percentile] and Design Value [3-year mean of Daily])

- Standard
- Daily PM2.5 (1-year 98th percentile)
- Design Value (3yr mean)

Former Standard
New Standard

Year

Fine Particle Concentration (ug/m^3)
0 10 20 30 40 50 60 70
Weather corrected PM2.5 trend:

- More Emissions
- Less

Observed Tacoma South L Seasonal PM2.5 Compared to Historic Norm

Equation: $y = -1.49x + 2.4601$

$R^2 = 0.7709$
The end of the story (almost):

- Feb 2015, was re-designated as “maintenance area”!
2016 update to Tacoma PM2.5

Graph showing the comparison between the former and new standards for Tacoma PM2.5. The graph includes data points for annual and 3-year (DV) measurements from 2001 to 2015. Notable changes include a revision in standards, area designation, enhanced outreach, and enhanced enforcement efforts leading to redesignation as "maintenance".
Other strategies and long-term: What about retrofits?

• replacement of wood stoves is ~$2,000-5,000 (w options & installation)
• retrofits start as low as $600
• could retrofits give similar result for lower cost?
• would also provide another option for NOASH or others who really like existing stove
• Well after Tacoma, we received a grant to seek and test emerging retrofit technologies
All retrofits we were previously aware of have one or more of the following limitations:

- too expensive and complicated
- require significant care and maintenance
- have significant technical limitations that render them ineffective, unreliable, or hazardous
The Retrofit Challenge

- With help from WA Dept. of Ecology (R. Tinnemore) obtained NEP grant to:
  - Fund an open search for retrofits to reduce PAHs and fine PM
  - Funded testing for finalists
  - InnoCentives was contracted to promote the challenge and the open search
  - It is difficult to provide financial motivation and protect intellectual property
  - It is difficult to create a meaningful test protocol
• Contracted with OMNI-Test in Portland, OR
• Two uncertified stoves, good representatives of existing stock
• Three test conditions:
  – high burn rate, high wood moisture
  – low burn rate, low wood moisture
  – low burn rate, high wood moisture
• Testing was done in two rounds, only three devices advanced to the second round
• Operated similar to official certification test method
• Also measured PAHs, CO, and temperature
Everyone has the right to breathe clean air.

Uncertified Test Stoves

Schrader (#1)  Princess (#2)
Everyone has the right to breathe clean air.

Grahn Afterburner

GraceFire

StoveCAT

ClearStak

MF Fire
Everyone has the right to breathe clean air.

**Emission Rates with & without retrofits**

**Fine PM emission rate for uncertified stove #1 without, and with, four retrofits**

<table>
<thead>
<tr>
<th>Retrofit</th>
<th>Emission Rate (g/hour)</th>
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</thead>
<tbody>
<tr>
<td>Baseline Schrader</td>
<td>30</td>
</tr>
<tr>
<td>MF-Fire/Schrader</td>
<td>15</td>
</tr>
<tr>
<td>Grahn/Schrader</td>
<td>5</td>
</tr>
<tr>
<td>ClearStak/Schrader</td>
<td>2</td>
</tr>
<tr>
<td>Grace Fire/Schrader</td>
<td>1</td>
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</tbody>
</table>

WA state standard and NSPS step 1
Everyone has the right to breathe clean air.

Emission Rates with & without retrofits

Fine PM emission rate for uncertified stove #2 without, and with, three retrofits

- Baseline Princess
- Grazn/ Princess
- ClearStak/ Princess
- Grace Fire/ Princess

WA state standard and NSPS step 1
Everyone has the right to breathe clean air.

PM Reductions

Retrofit mean reduction in PM emission factor with respect to baseline, on two uncertified stoves

<table>
<thead>
<tr>
<th>Stove</th>
<th>Reduction in PM emission factor</th>
</tr>
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<tbody>
<tr>
<td>Grahn</td>
<td>80%</td>
</tr>
<tr>
<td>ClearStak</td>
<td>90%</td>
</tr>
<tr>
<td>GraceFire</td>
<td>70%</td>
</tr>
<tr>
<td>MF Fire</td>
<td>50%</td>
</tr>
</tbody>
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Stove 1

Stove 2
Retrofit Challenge Summary

- In the end the three devices all met the Challenge criteria and were declared a 3-way tie.
- Each had unique characteristics and may work better in some situations than others and have various advantages.
- We are encouraged and urge continued development and testing, hopefully some field testing...
extra slides
Metrics (2014 Burn Ban Ad Season)

- 10,710 Unique Visits to Webpage, 72 percent new visits
- 1100 Email Alert Sign Ups
- 1407 Text Alert Sign ups (Just over 3000 total for Pierce Co)
- 520 new Facebook followers added during burn ban season
- 665 woodstove applications completed, 363 redeemed
Burn Ban Forecasting: **Cold and Calm** need winds < ~ 1 mph, temps < 35 F
Burn Ban Forecasting: **Calm and Clear** need 50m inversion $> 0.5$ C
Ceilometer (shown) and temp profiles helps diagnose shallow nocturnal PBL
8:45 PM Dec 7 (13 sec f/6.3 ISO 3200)
9:20 Dec 8 (0.6 sec f/1.8 ISO 3200)