Comparison of Toxic Chemicals in Wood and Cigarette Smoke

Australian Air Toxics NEPM - PAH

The Australian Air Toxics National Environment Protection Measure (NEPM) covers 5 toxic pollutants – benzene, formaldehyde, polycyclic aromatic hydrocarbons (**PAH**), toluene and xylene. PAH will be discussed first, because of their complexity and known carcinogenic potential. Wikipedia reports that the U.S. EPA has designated 16 PAH compounds as priority pollutants - naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, benzo[g,h,i]perylene, and indeno[1,2,3-cd]pyrene. This list of 16 EPA priority PAHs is often targeted for measurement in environmental samples - http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon#PAH_compounds

According to the USA Surgeon General's report (USSGR)[1], five of these chemicals are in cigarette smoke. However, all 16 PAH are in eucalypt smoke[2]; you would have to smoke 16,000 - 222,000 cigarettes to produce the equivalent amount of PAH as burning 1 kg firewood in a correctly-operated heater. Most wood heaters burn about 30 kg wood per day, so to produce the PAH from the average correctly-operated wood heater would require the smoke from 0.5 - 7 million cigarettes.

Table 1: comparison of PAHs and other chemicals covered by the Australian Air Toxics or Air Quality National Environment Protection Measure (NEPM) in wood and cigarette smoke

	Carcinogenic Potency/ IQ study	ug/kg wood[2]	ng per cigarette[1]	Cigarettes needed to emit same as burning 1kg wood
PAH				
Naphthalene		5500	2-4 ug	1,833
Ace/other naphthylenes		16000	3-6 ug	3,556
Acenaphthene		6400		
fluorene		8300	0.6-1 ug	10,375
phenanthrene	.0005	8400	200-400	28,000
anthracene	.0005	1800	50-100	24,000
fluoranthene	.05	5800	300-450	15,467
pyrene	.001	4100	300-500	10,250
benz[a]anthracene	.0005 *	750	20-79	16,667
chrysene	.03*	800	40-69	16,000
benzo[b]fluoranthene	.1 *	680	4-22	52,308
benzo[k]fluoranthene	.05 *	290	6-12	32,222
benzo[a]pyrene	1.0 *	820	20-49	27,333
dibenz[a,h]anthracene	1.1 *	900	4	225,000
benzo[g,h,i]perylene	.02 *	520		
indeno[1,2,3-cd]pyrene	.1 *	590		
NEPM-listed chemicals		mg/kg wood[2]	ug/cigarette	
Benzene		200	12-50	6,452
Formaldehyde		360	20-100	6,000
Toluene		69	20-60	1,725
Xylenes		18		
PM2.5		4500	20000	225
CO		120000	14-23	6,486,486
NO$_2$		140		
SO$_2$		15		
Lead		1	8-10	61
Other chemicals				
Acrolein		88	60-140	880
Dioxin		4.2 ng/kg		

Carcinogenic potencies are used by the Australian National Pollutant Inventory to convert to B[a]P equivalents;* = PAH measured in the study relating pre-natal exposure to children's IQ at age 5. Woodsmoke results are for burning eucalypt firewood in mainly correctly-operated Australian wood heaters, (Tables 8 & 9, J. Gras' study[2]), except lead (from Larson & Koenig[3]). 20 mg PM2.5 per cigarette from Hildeman[4]

Wikipedia lists three additional PAHs that are considered dangerous – coronene, benzo[j]fluoranthene, and ovalene. Although not tested for in the Australian analysis, Larson & Koenig[3] list coronene as a constituent of woodsmoke (800-3,000 ug/kg), but the USSGR does not list it in cigarette smoke. Larson & Koenig[3] lump the benzofluoranthenes together (600 – 5,000 ug/kg) so it is not possible to report specifically about benzo[j]fluoranthene, though the USSGR shows 6 – 21 ng of benzo[j]fluoranthene per cigarette. Ovalane is not reported as a constituent of either wood or cigarette smoke.

Other pollutants covered by Australian National Environment Protection Measures (NEPM)

The other 4 pollutants covered in the Australian Air Toxics NEPM are benzene, formaldehyde, toluene and xylene. The Australian Ambient Air Quality NEPM covers particles, carbon monoxide (CO), nitrogen dioxide, ozone, sulphur dioxide and lead. With the exception of PM2.5, where a burning 1 kg of wood produces as much PM2.5 as 225 cigarettes, and lead (61 cigarettes), 1 kg wood burned in a correctly-operated heater produces as much pollution as 1,725 to 6.5 million cigarettes (see Table 1).

Dioxins and related compounds

The Australian woodheater study[2] lists average dioxin emissions as 4.2 ng/kg – double the value used until then in Australian emissions inventories, but there is no mention of dioxin in the USSGR.

PCDDs, PCDFs and (PCBs): polychlorinated dibenzo dioxins (PCDDs) and furans (PCDFs) and dioxin-like polychlorinated biphenyls (PCBs), are amongst the most toxic pollutants known. A 12-month study of 6 locations in Australia covering industrial and residential sites, showed that levels of these harmful pollutants were close to zero, except when wood heaters were in use, when concentrations were up to 10 times higher than the non-heating season (see graph, right from Gras et al. http://www.cmar.csiro.au/e-print/open/gras_2005a.pdf).

Histogram of seasonal variation in PCDD/F loading by location.
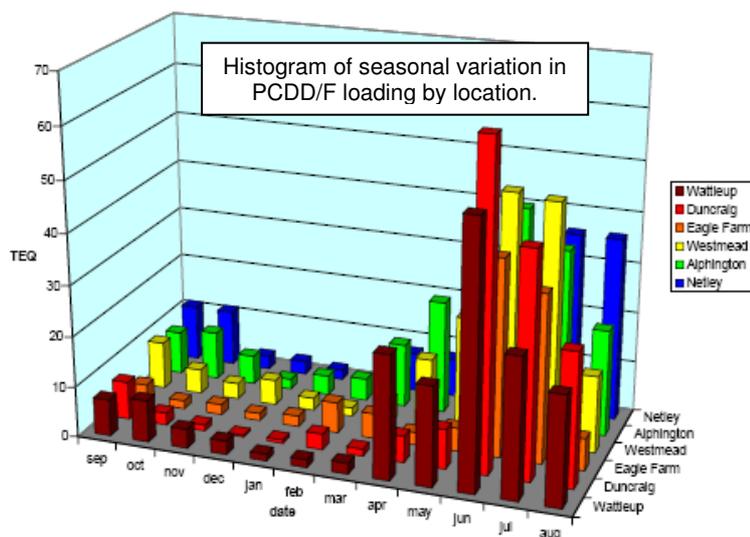
Other important chemicals

One other important chemical is acrolein, shown in 2005 to be the chemical in cigarette smoke responsible for inhibiting the immune system.[5] Breathing woodsmoke is also known to suppress the immune system. For example, when mice were subjected either to woodsmoke, oil furnace fumes, or clean air for 6 hours, then challenged by a respiratory bug. 21% of those exposed to wood smoke were dead two weeks later, compared with only 5% mice exposed to fumes from the oil furnace or to clean air.[6]. Using a woodheater for 1 day is likely to produce as much acrolein as in the smoke of 26,000 cigarettes.

This could be why infants in exposed to high levels of woodsmoke have even greater increased risk of bronchiolitis (8%) than living within 50 metres of a major highway (6%).[7] When interviewed, the author of the research study explained that "*Bronchiolitis is the number one reason why a child ends up in a hospital in the first year of life*" and that this study "*lets families know about concerns about infant exposure to traffic and wood-burning appliances. If they can avoid those things, they should.*" http://www.medicinenet.com/script/main/art.asp?articlekey=107393.

Pregnant women - PAH exposure causes genetic damage and reduces children's IQ

In developing countries, children whose mothers cook with wood (as opposed to kerosene) stoves have reduced IQ, memory and poorer social skills in Belize, Kenya, Nepal and American Samoa, and also in Guatemala

Polycyclic aromatic hydrocarbons (PAH) are the main toxins in woodsmoke. A US study published in 2009 and study of Polish women published in April 2010 found that exposure to PAH during pregnancy is associated with reduced IQ when the children start school at age 5.

The US study measured exposure to PAHs in women's home environment during the third trimester of pregnancy. Measured exposure was used to split the mothers into two groups – those with PAH over 2.26 ng/m^3 (high exposure) and those with PAH less than this (low exposure group). After adjusting for the mother's intelligence, quality of the home environment, exposures to other PAH and other relevant factors, children whose mothers were in the high exposure group scored about 5 points lower on average on several measures of

IQ than those whose mothers were in the low PAH group. The relatively low PAH exposure (over 2.26 ng/m^3) is of great concern, because measured wintertime PAH in Armidale, where about half of houses have wood heaters, averaged 8.62 ng/m^3, maximum 24.0, see http://woodsmoke.3sc.net/pah)

The second study of pregnant Caucasian women in Poland confirmed the results. "*The effect on intelligence was comparable to that seen in NYC children exposed prenatally to the same air pollutants,*" explained Frederica Perera, professor of Environmental Health Sciences. The Polish study measured exposure to benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, ibenz[a,h]anthracene, benzo[g,h,i]perylene, indeno[1,2,3-cd]pyrene (see Table 1). Four of these PAH have the highest-listed carcinogenic potential. Two are in cigarette smoke, but all four are in woodsmoke. For the two in both wood and cigarette smoke, burning 1 kg firewood produces as much toxic PAH as in 16,000 cigarettes (Table 1).

Research published in March 2012 measured DNA adducts (genetic damage) specific to benzo[a]pyrene in umbilical cord blood, and also measured the mothers' exposure to PAH during the 3rd term of pregnancy. The study provided clear evidence that B[a]P exposure is linked to behavioural problems. The 41% of children with detectable B[a]P adducts in umbilical cord blood had a 4-fold increase in attention problems, and 2.6-fold increases in attention/hyperactivity problems and anxiety problems.[8]

Suporting information

The review by Naeher[9] notes: "*Organic extracts of ambient particulate matter (PM) containing substantial quantities of woodsmoke are 30- fold more potent than extracts of cigarette smoke condensate in a mouse skin tumor induction assay (Cupitt et al., 1994)*" This supports the view that, gram for gram, woodsmoke is actually worse than cigarette smoke. Although woodsmoke doesn't contain nicotine, and studies of the chemical composition of woodsmoke are generally limited to recognised carcinogens and toxins such as PAHs and dioxins (unlike cigarette smoke which has been comprehensively studied), Table 1 shows that woodsmoke contains much higher concentrations of these chemicals than cigarette smoke. Indeed 2 chemicals with carcino-gentic potential of 1 - benzo[g,h,i]perylene and indeno[1,2,3-cd]pyrene are in wood, but not cigarette smoke.

Cigarette smoke also contains other chemicals – some beneficial if eaten e.g. linolenic acid (omega-3) and oleic acid (a key ingredient of "Lorenzo's Oil") and others that are clearly harmful in large doses. Some chemicals have thresholds, below which harmful effects are not detected. Others, including PM2.5 and carcinogens, have no threshold – the risk of a cancer-causing mutation is directly proportional to exposure, but there is no threshold, below which there is no risk. This comparison concentrates on the latter type of chemicals that are considered sufficiently hazardous to be included in the Australian Air Toxics NEPM, or the Ambient Air Quality NEPM.

PM2.5 exposure inside houses – similar to living with a smoker

Results from Launceston in 2003 show that fine particle measurements inside people's homes in winter were 31.4 ug/m3 greater than in summer.[10] A US study found that living with a 1-pack per day smoker increased exposure by 30 ug/m^3.[11] Winter in a woodsmoke-affected city such as Launceston would therefore appear to be worse than living with a 1-pack per day smoker.

PM2.5: one woodheater = 2,670 – 4,000 passenger cars

According to one researcher: "*In the limited amount of studies that have been done so far that have directly compared smoke from fires with the same level of particulates and smoke from car exhaust, industry have all tended to show that the effects from the wood smoke are actually worse for lung conditions than a similar amount from, say, car exhaust*" http://www.abc.net.au/news/stories/2008/04/24/2226672.htm?site=news

Most heaters in the Australian study were operated correctly – emissions averaged 4.5 g/kg for eucalypts, with a much higher value 15.8 g/kg for pine.[2] In contrast, a study of real-life emissions in Launceston (where households who volunteered to have their emissions measured appeared to take a lot more time and trouble to operate their heaters correctly – even adding wood in the middle of the night rather than stoking them up for an overnight burn) averaged 9.4 g/kg. A typical heater burns about 30 kg per day and, with real-life emissions of normally-operated heaters, according to Prof John Todd, of 10 to 15 g/kg of wood, will emit 300 – 450 g PM2.5 per day, the same as produced by 15,000 – 22,500 cigarettes.

With annual firewood consumption of about 4 tonnes/year, the average wood heater in Armidale emits 40 to 60 kg of PM2.5 per year, as much health-hazardous PM2.5 pollution as 2,670-4,000 passenger cars (typical emissions 0.001 g/km, see Figure 7 below from the NISE report[12]) each driving 15,000 km/year.

Figure 7: Average and maximum PM$_{2.5}$ results by vehicle and age category (fleet subset)

NISE2 fleet: average PM$_{2.5}$
Error bar shows maximum recorded result in that vehicle category

Key: PV-S, PV-M, PV-L, SUV-C, SUV-L, LCV
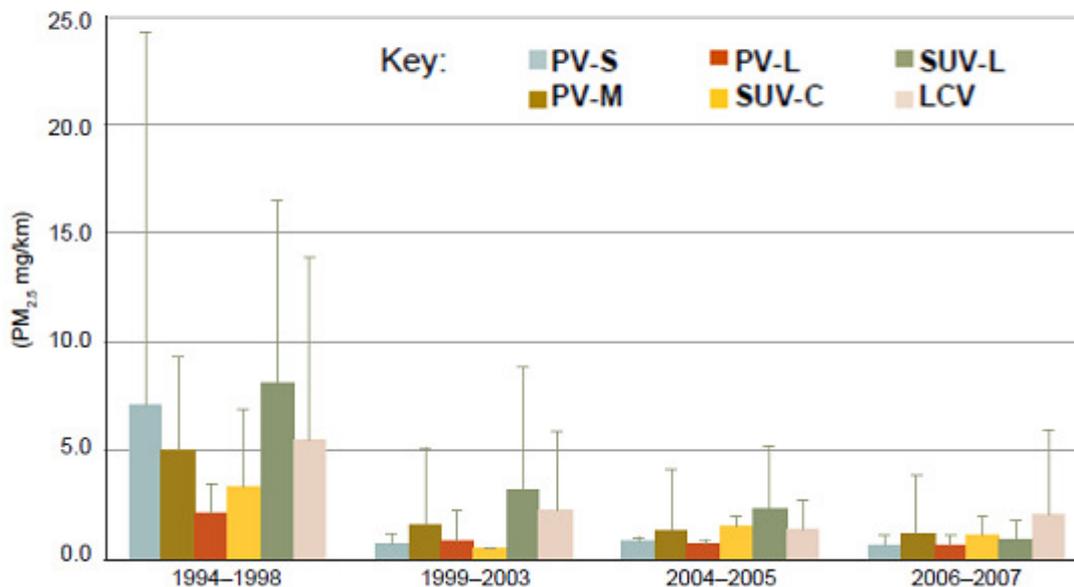
Note: There are no fine particulate matter limits for petrol vehicles in the ADRs.

SUV's exhaust stream cleaner than air polluted by a wood-burning fireplace 100 feet away

A Radiance Research M903 Nephelometer (coupled with a pressure and temperature compensation sensor and heater) was used to measure woodsmoke at the front door of a house (100 feet from the chimney of a neighbour using a wood-burning fireplace) and the exhaust stream of a SUV. "*In August 2015 we decided to test the PM 2.5 levels from a 2013 Ford Explorer with a V8 engine. The nephelometer was positioned 15cm away from the exhaust pipe on a calm day. After several minutes of readings on a warmed up engine, the PM 2.5 levels ranged between 8 and 11 with a modal response of approximately 8.5 ... This shows us how clean vehicles emissions are when compared to woodsmoke fires. Paradoxically you would be safer (at least from a PM 2.5 perspective) breathing off this tailpipe like a snorkel than living near a wood fire like this where readings have sometimes hit 200 (ten times the provincial limit).*" More info: http://gabriolacleanair.blogspot.com.au/2015/11/how-clean-are-emissions-from-suv.html

More complete list of chemicals

The Burning Issues website provides an abbreviated list of chemicals, noting toxicity and which are in cigarette smoke: http://burningissues.org/car-www/pdfs/WoodSmokeBroTG2.pdf

*+carbon monoxide, methane, VOCs (C2-C7),*aldehydes, +formaldehyde, *+acrolein, +propionaldehyde,butyl aldehyde, +acetaldehyde, furfural, substituted furans, +benzene, +alkyl benzenes, +toluene, acetic acid, formic acid, *nitrogen oxides (NO, NO2), *sulfur dioxide, +methyl chloride, +naphthalene, +substituted

naphthalenes, oxygenated monoaromatics, guaiacol (and derivatives), *+phenol (and derivatives), syringol (and derivatives), +catechol (and derivatives), *+particulate organic carbon, oxygenated polycyclic aromatic hydrocarbons, +PAHs: fluorene, phenanthrene, +anthracene, methylanthracenes, +fluoranthene, *+pyrene, +benzo(a)anthracene, +chrysene, +benzofl uoranthenes, *+benzo(e)pyrene, *+benzo(a)pyrene, *perylene, +ideno(1,2,3- cd)pyrene, *benz(ghi)perylene, *coronene, +dibenzo(a,h)pyrene, retene, dibenz(a,h)anthracene, trace elements: Na, Mg, Al, Si, S, Cl, K, Ca, Ti, V, +Cr, +Mn, Fe, +Ni, Cu, Zn, Br, +Pb; particulate elemental carbon, normal alkanes (C24-C30), cyclic di-and triterpenoids, dehydroabietic acid, isopimaric acid, lupenone, friedelin, +chlorinated dioxins

*Indicates a chemical also found in cigarette smoke +Indicates a chemical that is classifi ed as **toxic** by U.S. Law

The American Lung Association, simply states: "*When possible, the American Lung Association strongly recommends using cleaner, less toxic sources of heat. Converting a wood-burning fireplace or stove to use either natural gas or propane will eliminate exposure to the dangerous toxins wood burning generates including dioxin, arsenic and formaldehyde.*"

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Other Information, Ideas

Health Experts recommend using clean heating in preference to wood heaters

The **Australian Lung Foundation** (**ALF**) recommends: "*use alternative methods (instead of wood heaters) for climate control, including insulating and improving the energy efficiency of homes, flued gas and and electric heaters and energy efficient house design*" more info

The **American Lung Association** (**ALA**) recommends: "*avoid burning wood in homes where less polluting heating alternatives are available*" more info and also

The **American Lung Association** "*strongly recommends using cleaner, less toxic sources of heat. Converting a wood-burning fireplace or stove to use either natural gas or propane will eliminate exposure to the dangerous toxins wood burning generates including dioxin, arsenic and formaldehyde*" see http://www.lungusa.org/press-room/press-releases/cleaner-alternatives-for-winter-heat.html

The **UK Government** recommends: "*Avoid burning solid fuels if possible. If you live in a smoke control area, burn only authorised smokeless fuels (your local authority can advise you)*" more info

NSW "Action for Air" (2009) **acknowledges PM2.5 are particularly dangerous**: "*Health research identifies particles of less than 2.5 micrograms (PM2.5) as a particular concern because their smaller size means they can be inhaled deeper into the lungs, and because there is no safe threshold level to use for setting standards.*"

We can't keep smoke pollution out of our homes; the particles (PM2.5) are so tiny they enter our homes along with the air we need to breathe. The only way to keep them out would be to make the house airtight, but then we'd die from lack of air!

Annual Fine Particle Pollution (PM2.5) from heating a Northwest home
(pounds per year)

Source: US EPA &
Puget Sound Clean Air Agency

Puget Sound
Clean Air Agency
pscleanair.org

| Uncertified Woodstove (244 lbs) | EPA-Certified Woodstove (97lbs) | Pellet Stove (27 lbs) | Oil Furnace (<1/4 lb) | Gas Furnace (<1/6 lb) |
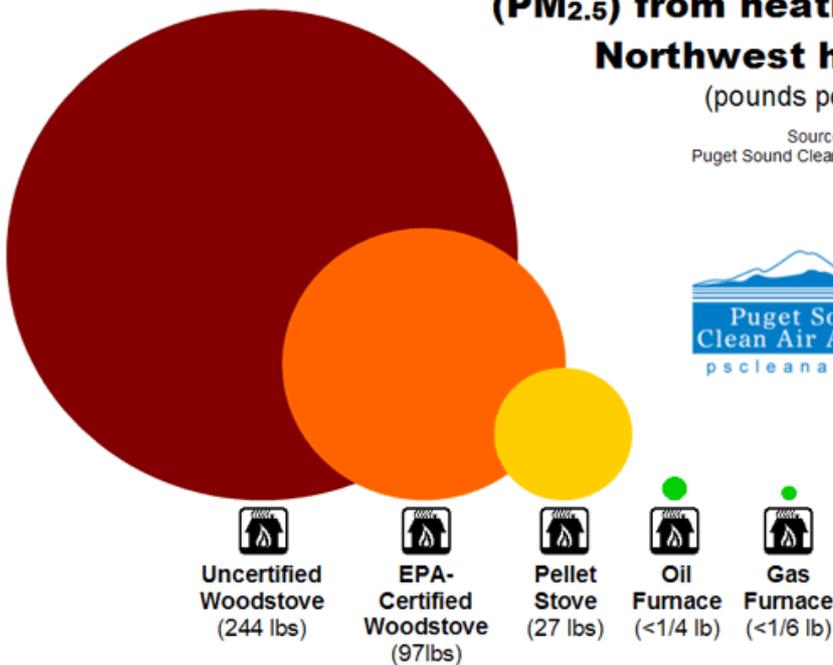
Seattle Government Agency: Comparison of PM2.5 emissions from wood, oil & gas heating: http://www.pscleanair.org/images/chart_circles.gif

Note: in Australia, Prof John Todd said at the NSW DECC's Woodsmoke Reduction Workshop that older style models have similar (sometimes better) emissions than newer models, both emitting about 10 to 15 grams of smoke per kg of firewood, or about 40 to 60 kg of PM2.5 per year.

Note: Although open-hearth fireplaces are a significant source of fine particle pollution (even more than wood stove fires), they are not included in the above diagram because this diagram compares emissions based on equivalent heat output, and fireplaces are not actually a heat source for a residence. Homeowners will often find their house growing colder while a fire is burning in an open fireplace because warm air from the home is being drawn up the chimney.

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Canberra's PAH – 3.9% of households cause 67% of the problem

The ABS reports that in 2007-08 only 3.9% of ACT households used wood as the main form of space heating – 57.3% use gas, 35.3% electricity, 0.7% oil and 1.6% no heating.[13] Yet the shows domestic solid fuel burning (wood – the ABS reports no other solid fuel use for space heating) is responsible for 67% of Canberra's PAH emissions – 16,000 kg/year out of a total of 24,000 kg/year.

Indicative Top Sources

- Solid fuel burning (domestic)
- Motor Vehicles
- Lawn Mowing
- Cutback Bitumen
- Water Supply, Sewerage and Drainage Services [281]
- All Others

Emissions of Polycyclic aromatic hydrocarbons by Source

Source: National Pollutant Inventory (2007-08)

Health Effects of Air Pollution in Armidale

Additional visits to GPs for respiratory complaints

A UNE study published in 2007 reported that winter woodsmoke causes 8.8 additional visits per day to GPs in Armidale for respiratory complaints, or about 750 additional visits per year. The estimated economic cost was $189.35 per visit, i.e. about $142,000 per year.[14] The community will also have to bear the cost of more serious ailments, including hospital admissions, which were not included in this total.

Premature deaths

The most serious problem is the loss of life expectancy. The most relevant study of woodsmoke and health was in Christchurch, NZ. Analyses published in 2007 show that (after adjusting for other factors such as age, sex, ethnicity, socio-economic status and tobacco smoking habits) death rates were related to smoke levels[15]. Estimates for each increase of $10\mu g/m^3$ of PM10 exposure were:
• 34% increase in respiratory deaths
• 11% increase in circulatory deaths
• 8% increase in all deaths
Assuming woodsmoke has a similar effect on health in NZ and Australia, the best estimate is that woodsmoke increases Armidale's death rate by about 9.2%, or that the 177 residents of Armidale expected to die next year would have lived a total of 150 more years of healthy life if we had clean air. In NZ, a year of healthy life was valued at NZ$75,000. Assuming a year of life in Armidale is worth $50,000, the estimated cost of woodheaters in Armidale is 150 x $50,000 = $7.5 million.

Reduction in Children's IQ

Polycyclic aromatic hydrocarbons (PAH) are the main toxins in woodsmoke. A US study measured exposure to PAHs in women's home environment during the third trimester of pregnancy. Measured exposure was used to split the mothers into two groups – those with PAH over 2.26 ng/m^3 (high exposure) and those with PAH less than this (low exposure group).

After adjusting for the mother's intelligence, quality of the home environment, other exposures to PAHs and other relevant factors, children whose mothers were in the high exposure group scored about 5 points lower on average on several measures of IQ than those whose mothers were in the low PAH group[16] - http://autismjabberwocky.blogspot.com/2009/07/study-watch-prenatal-airborne.html.

Wintertime PAH measurements in Armidale averaged 8.62 ng/m^3 (max 24.0 ng/m^3) - http://www.environment.nsw.gov.au/air/dopahhm/pahresults.htm - about 4 times higher than what was considered high PAH exposure in the IQ study.

There are about 270 births per year in the Armidale Dumaresq LGA. Given that Armidale's winter average PAH was four times greater than what was considered high in the US study, as well city residents, people in country areas with wood heaters and some of their neighbours are likely to be affected. The wood heating season lasts for over 4 months, so a third of the 270 births (i.e. 90) are likely to be exposed to more than 2.26 ng/m^3 of PAH pollution during the third trimester. If a 5 point loss of IQ leads to a $1,250 per year reduction in income, or $50,000 over a child's lifetime, the estimated cost is $4.5 million per year.

Other costs

Woodsmoke associated with many other health problems, e.g. mouth and throat cancers[17], middle ear infections[18] and bronchiolitis in children. Exposure to woodsmoke was noted to produce a higher increase in the risk of bronchiolitis (8%) than living within 50 metres of a major highway.[7] PM2.5 pollution in general is associated with cot deaths[19]; exposure to PM2.5 in childhood is associated with increased risk of chronic obstructive pulmonary disease in adulthood – see http://www.upi.com/Health_News/2009/07/23/Particulates-in-babys-lungs-may-COPD/UPI-87811248375081/. These costs have not been quantified.

Total costs

The above estimates – GP visits $142,000; lost of healthy life years $7.5 million; reduced IQ of babies: $4.5 million – amount to over $12 million per year, i.e. about $3,500 per year for every woodheater in the area.

This estimate is similar to estimated costs elsewhere, e.g. a team of 25 experts in NZ estimated that the cost of woodsmoke pollution in Christchurch was more than NZ$2,700 per heater per year. This was based on an internationally-accepted estimate (used for traffic pollution) of 4.5% increased mortality per 10 ug/m^3 of PM10 exposure. Estimated costs based on the 8% increase observed in Christchurch for woodsmoke would be more than NZ$4,000 per heater per year.

Does information on health costs change people's perception of woodheating?

Information is needed on whether people who understand the health effects of woodsmoke would support more effective woodsmoke reduction policies. We already have the views of participants to the UNE study on possible woodsmoke-reduction policies. In order to improve our education message and formulate better policies, we need a survey asking questions such as:

1) Imagine you were a healthy 75 year old. How much would you pay for another year of healthy life: (Responses could be left open, or include some suggested values, e.g. norms from other studies)

2) Imagine you (or a close friend or relative) were about to start a family and you learned that exposure to a certain chemical was likely to reduce the baby's IQ by 5 points, with some suggestions that exposure might increase the risk of autism. How much do you think should be spent on avoiding this chemical?

Etc etc

More information - ideas

Montreal banned new wood heaters from 28 April 2009

Montreal has freezing cold winters. Daily minimum temperatures average -13C in January; daily maxima average -5C. Despite the cold climate, installation of all new wood stoves was banned from 28 April 2009, to protect people's health – http://www.montrealgazette.com/Technology/Wood+stove+passes/1543628/story.html Woodheating accounts for 47% of Montreal's PM2.5 pollution, including 45 winter days from November 2008 to March 2009 with PM2.5 levels exceeding the standard. PM2.5 cause an estimated 6,028 cases of infantile bronchitis, 40,449 days of asthma symptoms and 1,540 premature deaths in Montreal. http://www.pq.lung.ca/environment-environnement/wood_smoke-fumee_bois/enjeu-montreal/

California and Launceston

California's Healthy Hearths Program (http://www.aqmd.gov/healthyhearths/Why_HH.htm) bans all wood burning devices in new buildings and also bans use of all wood burning devices whenever PM2.5 pollution is forecast to exceed the air quality standard.

Launceston, Tas, also suffers from woodsmoke pollution. In the 1990s an initial "Breathe the Benefits" campaign encouraging people to operate heaters correctly failed to produce an improvement. Subsequent community education programs explained the health problems caused by woodsmoke. Nearly three quarters of families with woodheating switched to non-polluting alternatives, as recommended by the ALF. Air pollution measurements reduced dramatically. After a community survey, Launceston's Strategic Plan 2008-2013 was formulated. It seeks further funding for the woodheater buyback program, and to "*Evaluate the introduction of a by-law that prevents the installation of wood heaters in homes*" by 2011 (Strategy 1.1 of Priority 1, see: http://www.launceston.tas.gov.au/content/view/164/365/)

NSW Local Councils

The installation of new wood heaters has been banned by several local authorities, including Waverley and Pittwater, as well as for new buildings in Holroyd, Manooka Valley and the Oran Park and Turner Road Growth Precincts.

Dublin banned smoky home heating - 2,000 fewer deaths over 6 years

The health effects of air pollution are real. When one study of air pollution, involving six cities, was followed up, PM2.5 had dropped substantially in one city, moderately in another, remaining stable elsewhere. Death rates fell in the first two cities relative to the other four. Dublin reduced PM2.5 pollution by banning non-smokeless coal in September 1990. There were 15.5% fewer respiratory and 10.3% fewer cardiovascular deaths in the 6 years after the ban, compared with the previous 6 years – a total of 696 fewer respiratory and 1458 cardiovascular deaths during the first 6 years of the ban[20]. Having experienced the health benefits, it is hard to imagine Dubliners would want to back to the smoky old days.

New Zealand: strict limits on emissions (e.g. < 0.7 g/kg in Otago)

NZ also suffers from woodsmoke pollution. Measured pollution was used as input to a cost-benefit analysis (http://www.hapinz.org.nz/) which concluded that woodheaters in Christchurch (pop 333,000) cause 124 premature deaths, with estimated total cost of NZ$127 million per year, about $2,700 per heater per year.

NZ introduced strict policies to control woodsmoke, e.g. in Otago, only appliances rated less than 0.7 g/kg (i.e. emitting no more than a pellet stove) can be installed and appliances with PM10 discharge standards of 1.5g/kg and higher will be prohibited from use from 1 January 2012
http://www.orc.govt.nz/Portal.asp?contentid=1242&nextscreenid=201.102.103.101&categoryid=20&screenid=201.102.101.101&sessionx=384EE7A8-D570-400A-89B4-BA61A920F08B

Policy in NZ emerged after studies of the health effects. New analyses published in 2007 show that (after adjusting for other factors such as age, sex, ethnicity, socio-economic status and tobacco smoking) death rates in Christchurch were linked to woodsmoke levels. An increase of $10\mu g/m^3$ of PM10 exposure was estimated to:
• increase in respiratory deaths by 34%
• increase in circulatory deaths by 11%
• increase in all deaths by 8%

This implies that living in the most polluted areas (>$20\mu g/m^3$ PM10) increases mortality by about 16% (respiratory deaths by about 68%) compared to living in unpolluted areas with <1 $\mu g/m^3$. An earlier 25-expert study, assuming a 4.3% increase in death rates per $10\mu g/m^3$ of PM10 exposure (the standard dose-response relationships for traffic pollution) estimated the annual health costs of woodsmoke in Christchurch exceed NZ$127 million, i.e. more than NZ$2,700 per heater per year. Using the observed 8% increase in deaths per $10\mu g/m^3$ PM10 exposure, the health cost increases to about NZ$5,000 per heater per year.