Woodsmoke is a major health problem because …

- Profit-driven industry
- Uninformed unsuspecting population
- Ineffective, overly-bureaucratic regulatory system
Example: Profit-driven industry:
Industry reps (AHHA) distort evidence: “On completion of the change out program, Libby Montana has improved its air quality by more than 80%”
Actual reduction after spending over $2.5 million replacing 1130 stoves in a town of 2600 residents = 28% (Graph below from: [http://www.bc.lung.ca/documents/Biomass-BCLAWebinar.pdf](http://www.bc.lung.ca/documents/Biomass-BCLAWebinar.pdf))
Profit-driven industry blocked attempts to reduce pollution

- Standards Australia Meeting, 2007. Recommended 15 votes to 4 to halve emissions limit (as a temporary measure while developing a new emissions test) and put health warnings on new heaters to advise owners about the health problems of breathing woodsmoke.
- Even though NZ had introduced an even stricter limit in 2005, the change was vetoed by the Australian wood heating industry.
- Standards Australia did not withdraw the standard, nor did governments.
- Buyers misled into believing that new wood heaters conform to “Strict Australian Standards”!
- Car driving 20,000 km per year – PM2.5 emissions 0.02 kg (petrol) or 0.1 kg (diesel) per year. Brand new Australian wood heater 20 kg (Sydney) or 40 kg (Melb) as much as 200 to 400 diesel SUV or 1,000 to 2,000 petrol cars!
- Annual health costs (NEPM-est = $263/kg) $5,260-$10,520/heater/yr
Woodsmoke may be worse than car exhausts

"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 exhausts." (ABC News, Thu Apr 24, 2008)

Not just PM2.5  "Woodsmoke caused more DNA damage in human cell lines than traffic-generated particulate matter per unit mass, possibly due to the high level of polycyclic aromatic hydrocarbons in wood smoke" (Reference: Mut. Res.-Genetic Toxicology and Environmental Mutagenesis 674: 116-122.)

Tandem health & Climate Benefits

UN Environment Program & World Meteorological Association recommended phasing out log-burning heaters in developed countries to reduce global warming (CH4 & BC Emissions) as well as improve health
Profit-driven industry claims don’t know sources of urban PM2.5!

- Carbon dating – 67% (Sydney CBD) to 100% (Perth residential areas) of particles have modern carbon – i.e. wood, not coal, oil or diesel!
- Hunter valley & Liverpool, Sydney – chemical fingerprinting – large proportion of PM2.5 is woodsmoke
- How pollution varies with season

Daily Average PM2.5 Measurements

No Armidale data from end June - Council unable to maintain equipment!
NSW EPA Emissions Inventory

Most other sources same throughout the year – wintertime woodsmoke (purple line) dwarfs all other sources of PM2.5 emissions. Inventory for 2008, pub. 2012
Monash, ACT: daily PM2.5 levels - 2.3% of ACT households use wood as main heating

AHHA says they can’t see the increase in particle pollution in winter!
Even health professionals may be unsuspecting …

**Armidale health professional:** From two years of age my daughter suffered respiratory illness every year. It started in early May each year approximately two weeks after wood fires were lit, and continued until the end of winter when the fires stopped. This occurred until my daughter was 12 years old, when we moved to a house above the smoke line.

Since then she has not suffered from the same respiratory illness. It just stopped! We did not have to go to the doctor or buy any more medication. During the same time my son suffered from a persistent cough during winters, this also stopped when we moved house.

Our previous house was heated by a wood fire our new house is not. Otherwise nothing changed We have always had a good diet and our children participated in several sports. The only thing that changed was our moving out of a house that had a wood heater in an area that was in a heavy smoke zone into a non wood heated house out of the smoke zone.

Our decision to move house was not driven to get out of the smoke, but we were surprised in the dramatic change in our children’s health when we did.

Many scientific studies (Armidale, Launceston, Christchurch, Seattle, Utah) link woodsmoke to respiratory & heart diseases, cancer, middle ear infections and (children in developing countries) reduced IQ, memory & social skills.
Devastating effects on health become obvious if have clean air until neighbour installs wood-heater

- **Example 1**: Sydney, near coast: “Our next door neighbour installed a new and approved wood burning heater in 2010. The smoke from this flue immediately entered most rooms of our old, renovated house. My wife’s asthma was triggered by the smoke and last winter she developed bronchitis and needed multiple treatments with antibiotics.”

- **Example 2**: Sydney, near coast: “After exhaustive attempts to try to remedy the situation and upon advice from GP’s and specialist medical practitioners I was finally forced to sell my home and move.”

- **Health messages drowned out by WH Industry propaganda**
  e.g. NSW Chief Medical Officer Kerry Chant that the heaters are *so detrimental to the health she supported banning and phasing them out in built-up urban areas*

- **‘Catch-22’** – public believe that governments would regulate if woodsmoke was really harmful – governments don’t regulate because of lack of apparent public support
NSW Asthma Foundation

• Recommend an independent body to set health-based standard for wood heaters
• Removal of existing heaters that don’t meet the health-based standard when houses are offered for sale.
• Temporary restrictions on the installation of new heaters until they meet the health-based standard
• Licensing fees to cover the cost of wood smoke-reduction programs with assistance for people whose health or lifestyle has been affected by wood smoke.
• NSW EPA Consultancy report – Estimated Woodsmoke Health Costs $8 billion in NSW (over 20 years, Aus $20 to $24 billion)
• Above measures predicted to save $6-7 billion for cost of $0.1 billion

• Problem (and pollution) getting worse - Sydney:
  2008: 71,000 wood-heaters; 2011: 83,000 wood-heaters
Low Hanging Fruit

PM2.5 cause about 10 times as many other premature deaths as ozone, the next worst pollutant (European data)

NPI data on PM2.5 emissions

Power generation – 10,000 tonnes/year
Coal mining – 7,500 tonnes/year

Woodheater Consultation Regulation Impact Statement
Domestic woodheaters – 40,000 tonnes/year

NEPM Reporting – more that 1 jurisdiction says they will struggle to meet advisory PM2.5 standard.

Political reasons for COAG delays in implementing PM2.5 standard?

Picking the low-hanging fruit could save $18 bill health costs & remove a significant barrier to a decent PM2.5 std.
8 ug/m³ advisory PM2.5 standard due to community pressure

• NEPC report: “Submissions from community members overall favoured the use of risk assessment, indicating a preference for the use of USEPA dose-response relationships for both long term and short term mortality”

• 24 individual & community group submissions (out of 52) - 12 were personal contacts whom I’d encouraged to take part

• “As a consequence of the strong view in the submissions that a long term standard should be considered ... The Project Team will be giving consideration to the development of an annual average standard in addition to a short term 24 hour standard.”
A new heater rated < 2.5 g/kg (this level of smoke observed for ~ 1 hr)

Only solution for neighbours = move out of town! (NSW POEO doesn’t work)
Another new heater rated < 2.5 g/kg (installed in Armidale with council permission in Aug 2014 - this level of smoke continued for over 10 hrs)

Only solution for neighbours = move out of town! (POEO legislation doesn’t work)
Australian Air Quality Group: woodsmoke.3sc.net
aaqg.3sc.net

Further information, provided in the following additional slides was not shown at the Air Quality Summit for brevity.

(adapted from an earlier talk, available at:

Robinson_OEH_Wood_Smoke_Workshop_Sept_2012.pdf)
Most widely used particle monitor (TEOM) under-estimates woodsmoke!

Top line = PM2.5 from approved monitor, bottom line = TEOM
Rolling 24-hour PM2.5 averages, source: http://seatoskyairquality.ca/transitioning-to-new-air-quality-monitoring-equipment/
Death rates increase with woodsmoke levels
People living in the worst areas (20 ug/m\(^3\)):
- 16% higher total mortality
- 22% higher circulatory mortality
- 68% higher respiratory mortality
- than people living in the cleanest areas

Estimates adjusted for other factors (age, sex, tobacco smoking, socio-economic status & ethnicity)

deadth rates 8% higher (respiratory deaths 34%) for each additional 10 ug/m\(^3\) of PM10

Cohen et al. characterised particles & identified woodsmoke as a major source - around 40% of the fine fraction in winter dropping to nearly zero in the summer. “Clearly wood heaters in the Liverpool area in winter are a major source of fine particle pollution.”

PM2.5 increase in winter (graph, individ data points excl. Sept 09 dust storm)

Sydney: 1,800 thousand vehicles, 106 thousand woodheaters

Cohen used filter-based sampling – many woodsmoke chemicals evaporate off TEOMs at 50ºC

Carbon dating, Rozelle, Sydney CBD Jul/Aug 1993 (4 pm to 8 am) – 67% modern, i.e. wood, not traffic or coal
Health effects of woodsmoke pollution

Christchurch, NZ.
Pollution (76% woodsmoke) varies markedly across the city
PM2.5 & Health (Canada – 61% of Quebec’s PM2.5 from woodsmoke)

- Median PM2.5 7.3: ug/m³ (below Aust PM2.5 advisory standard).
- Increase of 3 ug/m³ PM2.5 (approximately the same amount as the increase in annual PM2.5 pollution in Canberra from woodsmoke) was associated with a 9% increase in deaths from ischemic heart disease and 3-4.5% increases in all deaths.

Reduce woodsmoke, improve health:

San Joaquin Valley, California 2003
Mandatory curtailment of residential wood burning when air quality is forecast to be poor, voluntary curtailment, restrictions on the type of fuel burned, complaint process, prohibition of uncertified devices, limit on the density of residential burning devices.

• Result: 25% reduction in winter PM2.5
• 4.8% reduction in age-standardized mortality due to ischemic heart disease;
• 5.4% reduction for cerebrovascular disease

Reduce woodsmoke, improve health

HEPA Filters

Compare periods with & without filters in the machines to obtain unbiased estimate of removing particles from inside homes

Result: 75% reduction in woodsmoke particles

33% reduction in C-reactive protein levels, endothelial (blood vessel lining) function improved by 9.4%, indicating a reduced risk of cardiovascular disease

Conclusion

Studies where woodsmoke is the dominant source of particles show similar increases in mortality for equivalent increases in PM2.5, suggesting that woodsmoke PM2.5 are no less harmful than other PM2.5. Studies also show significant improvements in health from reducing woodsmoke

High PM2.5 outside -> High PM2.5 inside houses

CSIRO research – Outdoor vs indoor PM2.5 pollution over 7 days
Children of mothers cooking with woodfires (compared to kerosene stoves) have lower IQ

- **Guatemala**: Children of mothers breathing woodsmoke in the third trimester of pregnancy had lower performance on neurodevelopmental tests at ages 6 and 7. Specifically, the researchers found impairments in visuo-spatial perception and integration, visual-motor memory, and fine motor skills.

- **Belize, Kenya, Nepal and American Samoa**: “Exposure to open-fire cooking, as opposed to cooking on kerosene stoves, was associated with both lower cognitive performance and less frequent structured play, regardless of culture, child age and educational level, and socioeconomic status.”

References: [http://ucrtoday.ucr.edu/6664](http://ucrtoday.ucr.edu/6664) and [http://www.enn.com/health/article/43574](http://www.enn.com/health/article/43574)
Developed Countries – assess chemical exposure

- PAH study (pregnant women)
  - > 2.26 ng/m³ (considered ‘high’ exposure), associated with 5 point reduction in child’s IQ on starting school
    - Babies in ‘high’ group also 14 times more likely to have methylation of the ACSL3 5’-CGI, associated with developing asthma before age 5
  - Armidale average PAH measurements:
    - winter 8.62 ng/m³, (max 24.0), summer PAH = 0.28

- BaP study- (pregnant women) average BaP 0.5 ng/m³
  - 41% of babies had detectable BaP adducts in umbilical cord blood, they had 2.6 - 4 times the risk of behavioural & ADHD problems aged 6 to 7

- Average BaP measurements Armidale winter:
  - 1.3 ng/m³, max 3.77 (summer 0.02) – much higher than BaP study

References:  http://woodsmoke.3sc.net/pah
emissions from 16.4 million motor vehicles, & 0.89 million houses with woodheating

2010/2011 data within Australia - Polycyclic aromatic hydrocarbons (B[a]Peq) from All Sources

A list of emissions of the chosen substance by source. Click on a source to add it to the current search criteria. Industrial sources are indicated by their three digit ANZSIC Group code. Diffuse sources are indicated by [*].

<table>
<thead>
<tr>
<th>Source</th>
<th>Air (kg)[1]</th>
<th>Land (kg)[1]</th>
<th>Water (kg)[1]</th>
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<tr>
<td>Solid fuel burning (domestic) [*]</td>
<td>500,000</td>
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</tr>
<tr>
<td>Motor Vehicles [*]</td>
<td>300,000</td>
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<tr>
<td>Domestic/Commercial solvents/ aerosols [*]</td>
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</tr>
<tr>
<td>Lawn Mowing [*]</td>
<td>35,000</td>
<td></td>
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</tr>
</tbody>
</table>
Wood vs Cigarette Smoke

- John Gras’ study (some overloaded burns, but many involved correct operation) – 820 ug of BaP per kg wood
- Burning 10 kg wood in an Australian wood heater emits more BaP as in the smoke from a quarter of a million cigarettes
- Review of Woodsmoke Health effects “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)”
- Woodsmoke = “A witch’s brew of carcinogens” (Stone, 1995)
Ultafine PM is not membrane bound, allowing direct access to mitochondria and DNA, enhancing its toxicity.
Healthy mice were exposed for 6 hours either to woodsmoke, oil furnace fumes or clean air. Then challenged with a respiratory bug. 2 weeks later, 21% of those exposed to woodsmoke were dead, compared with 5% exposed either to clean air or oil furnace fumes. The article described woodsmoke as "a witches’ brew of carcinogens". Acrolein (in wood and cigarette smoke) suppresses the immune system. Burning 1 kg wood produces as much acrolein as in smoke of 880 cigarettes.

UNEP & WMO screened 2,000 measures to improve health & reduce short-term global warming

- Methane – 25 times as much warming as CO₂ over 100 years, 72 times as much over 20 years
- “Near-term warming is pushing natural systems closer to thresholds that may lead to a further acceleration of climate change. For example, the melting of permafrost in the Arctic is releasing additional quantities of methane into the atmosphere, which in turn contribute to additional global warming” (UNEP, 2011).

Two of the top 16 measures were phasing out log-burning heaters in developed countries & banning open burning of agricultural waste.
Effect of proposed measures for methane & black carbon

Copenhagen Accord: Limit global temperature rise to 2 °C

Effect of measures to reduce carbon dioxide

No action

Projections for global temperature °C

Temperature (°C) relative to 1890-1910
Chair: Drew Shindell (National Aeronautics and Space Administration Goddard Institute for Space Studies, USA).

Vice-chairs: Veerabhadran Ramanathan (Scripps Institution of Oceanography, USA), Frank Raes, (Joint Research Centre, European Commission, Italy), Luis Cifuentes (The Catholic University of Chile, Chile) and N. T. Kim Oanh (Asian Institute of Technology, Thailand).

High-level Consultative Group: Ivar Baste (UNEP, Switzerland), Harald Dovland (formerly at the Ministry of Environment, Norway), Dale Evarts (US Environmental Protection Agency), Adrián Fernández Bremauntz (National Institute of Ecology, Mexico), Rob Maas (The National Institute for Public Health and the Environment, Netherlands), Pam Pearson (International Cryosphere Climate Initiative, Sweden/USA), Sophie Punte (Clean Air Initiative for Asian Cities, Philippines), Andreas Schild (International Centre for Integrated Mountain Development, Nepal), Surya Sethi (Former Principal Adviser Energy and Core Climate Negotiator, Government of India), George Varughese (Development Alternatives Group, India), Robert Watson (Department for Environment, Food and Rural Affairs, UK).

Scientific Coordinator: Johan C. I. Kuylenstierna (Stockholm Environment Institute, University of York, UK).

Coordinating Lead Authors: Frank Raes (Joint Research Centre, European Commission, Italy), David Streets (Argonne National Laboratory, USA), David Fowler (The Centre for Ecology and Hydrology, UK), Lisa Embserson (Stockholm Environment Institute, University of York, UK), Martin Williams (King’s College London, UK).

Lead Authors: Hajime Akimoto (Asia Center for Air Pollution Research, Japan), Markus Amann (International Institute for Applied Systems Analysis, Austria), Susan Anenberg (US Environmental Protection Agency), Paolo Artaxo (University of Sao Paulo, Brazil), Greg Carmichael (University of Iowa, USA), William Collins (UK Meteorological Office, UK), Mark Flanner (University of Michigan, USA), Greet Janssens-Maenhout (Joint Research Centre, European Commission, Italy), Kevin Hicks (Stockholm Environment Institute, University of York, UK), Zbigniew Klimont (International Institute for Applied Systems Analysis, Austria), Kaarlo Kujanpää (International Institute for Applied Systems Analysis, Austria), Johan C. I.
Why the confusion?

- About half of current warming now attributed to non-CO₂ chemicals, e.g. CH₄, O₃, CO, black carbon etc
- International agreements still require Kyoto protocol (1997) for emissions inventories – although now out of date & doesn’t cover all these chemicals
- 100-year Kyoto time horizon too long? Technological improvements such as concentrated solar power + molten salt storage, wind, wave, biomass-power stations, growing algae to produce oil, will all be on-stream in much less than 100 yrs
- Burning a tree now, instead of leaving it to decompose over the next 40 years -> CO₂, CH₄ & black carbon emissions now -> increased current warming -> increased CH₄ from permafrost -> increased future warming

80-90% of firewood sold in the ACT from non-sustainable supplies
3.7 tonnes firewood per year -> 7.4 tonnes CO₂ + CH₄ + BC

“renewable” not the same as “being renewed”
Timelines

- Dockery et al. (1993): Six Cities study showing big effect of long-term PM2.5 exposure
- Schwartz et al. (1996): increased daily mortality mainly associated with PM2.5
- 1996: Australian NEPM (ignored long-term PM2.5 exposure)
- 2003: advisory PM2.5 standard, to be confirmed during NEPM revision in 2005
- 2005-2014: continued delays and extensions to NEPM revision process
- 2008: CSIRO study, Launceston – “not a large distinction in emissions between compliant and non-compliant woodheaters”
- NEPM delays have not prevented implementation of new vehicle standards, but nowhere near same improvements in real-life emissions of woodheaters
NSW BASIX does not promote woodheaters

Matthew Wright – Beyond Zero Emissions
Climate Spectator Article

As well as having a warmer, more comfortable home, he argues this this is perhaps probably one of the best heating options to reduce global warming.

“I have gone from 3000kWh in gas down to 328kWh in electricity”
People in Armidale:

Woodsmoke causes about 750 additional visits to Armidale GPs for respiratory complaints every year.
Many people do not realise that woodsmoke is affecting their health

From two years of age my daughter suffered respiratory illness every year. It started in early May about two weeks after wood fires were lit, and continued until the end of winter when the fires stopped.

This occurred until my daughter was twelve years old, when we moved to a house above the smoke line. Since then she has not suffered from the same respiratory illness. It just stopped! We did not have to go to the Doctor or buy any more medication.

During the same time my son suffered from a persistent cough during winters, this also stopped when we moved house. Our previous house was heated by a wood fire our new house is not. Otherwise nothing changed. We have always had a good diet and our children participated in several sports.

The only thing that changed was our moving out of a house in Armidale that had a wood heater in an area that was in a heavy smoke zone into a non wood heated house out of the smoke zone. Note our decision to move house was not driven to get out of the smoke, but we were surprised in the dramatic change in our children’s health when we did.
Situation is getting worse: current woodsmoke measurements are about 15% higher than 1999!
No reduction in woodsmoke pollution, 2008-12

Aarmidale: PM2.5 pollution by month & year

Data not available for May 2012
New stoves don’t solve the problem!

PM2.5 measurements before and after virtually all old woodstoves replaced with new, certified models (and some replaced with non-polluting heating)

Libby, Montana stove exchange

New stoves still relatively high emitters

95% of stoves exchanged

Source: Woodsmoke and health, Michael Brauer, BC Lung Association Webinar, February 9, 2012
Wood heater owners less aware of health effects & so experience fewer problems from other people’s smoke

Same survey showed a majority of Armidale’s wood heaters are post 1999 so comply with AS4013
Explained Health Problem:
- in Quebec, 61% of PM2.5 from wood heating, compared to 22% from industries and 14% from transportation
- Older wood heating system releases as many PM2.5 nine hours as a car does over one year (18,000 km)
- New ones as many PM2.5 in about 18 hours

Health Canada: 1,540 premature deaths from air pollution in Montreal.

Other health impacts specifically from PM2.5:
- 6,028 cases of infantile bronchitis in Montreal per year (9,505 cases in Quebec)
- 40,449 days of asthma symptoms in Montreal (62,707 days in Quebec)

No new wood heaters to be installed - $6 million fund to replace existing ones with alternatives
Montreal, Canada
Pellet heaters are allowed

- 90-95% reduction in PM2.5 by switching to a pellet heater – cleaner air, better health!
Solutions: Christchurch, NZ

- **Total cost of woodheating** – NZ$127 million
  NZ$2,700 per heater per year

- **No new wood heaters to be installed**
  except models rated < 1.0 g/kg wood, installed as replacements for more polluting models

- **Phase out all heaters rated > 1.0 g/kg**
  From 2008 onwards, all heaters rated more than 1.0 g/kg to be replaced after 15 years use

- **Clean Heat Program**
  Subsidies to replace wood heaters with insulation and non-polluting heating. Total of 1973 wood heaters replaced with reverse cycle systems - 1% increase in electricity usage (families much better off than buying firewood).
What about Australia?

- **Explain the health problems** – heart & respiratory diseases, effects on young, elderly & unborn children – CASANZ?

- **Initiate development of a health-based standard**
  Diesel utes/4WD = 0.1 kg per year
  Could a woodheater with temperature sensor & gas booster/afterburner achieve something similar?

- **Allow pellet heaters** & only as replacements for more polluting models, woodheaters rated < 1.0 g/kg firewood

- **Phase out all heaters rated > 1.0 g/kg**
  Say, over a 7-year period

- **Copy Christchurch’s Clean Heat Program**
  Subsidies to replace wood heaters with insulation and non-polluting heating. In Christchurch, 1% increase in electricity usage for replacing wood with efficient reverse cycle – less GHG, families much better off than buying firewood.
This is the alternative if, as now, new heaters rated up to 2.5 g/kg continue to be installed