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Air Quality and Climate Change Impacts of Firewood Use in Tasmania
A Climate Tasmania Discussion Paper
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Firewood used for home heating in Tasmania has many benefits, but it also has some serious shortcomings. The Tasmanian Government has recently released a *Bioenergy Vision for Tasmania* (1) which, unfortunately, does not address our largest bioenergy fuel – firewood. This discussion makes the case for urgent action to address two serious problems caused by residential firewood use: the dangerous health impacts of wood-smoke exposure and the large emissions of climate warming gases. We have several ways of almost eliminating both these problems, but this requires Government commitment and intervention. We urgently require a *Firewood Vision for Tasmania*.

The next few pages discuss Tasmania's current household firewood use. Two serious issues are identified: the adverse health impacts of residential wood-smoke, and the large climate warming emissions. The adverse health impacts of woodsmoke are well known to authorities but the climate change impacts are largely unreported. This discussion makes use of several recent published papers/reports with direct relevance to the quantity of firewood consumed and wood-smoke emissions from residential heating in Tasmania.

The problems are serious and require open and informed debate about the best way forward. Fortunately, there are current technologies available to largely eliminate both problems while still allowing some residential firewood use. These are outlined in this discussion. But the solutions will not be adopted without community understanding and a genuine commitment by regulators.

It is important to acknowledge the benefits of heating homes with firewood before dealing with the problems. Wood heaters are relatively simple and durable appliances. They can deliver large heat outputs, typically 10 to 20kW, when burning vigorously. This means even poorly insulated living areas can be heated to a comfortable temperature with some heat flowing through to other parts of the house. A warm house contributes to healthier residents. In rural areas firewood can be a low-cost fuel, but when the firewood price reaches around $140 per tonne in Tasmania it is cheaper to heat with a reverse cycle air conditioner with a coefficient of performance (CoP) of 3 or more, using the *Heating and Hot Water* tariff. Some households are prepared to pay over $200 per tonne of firewood because they prefer the 'nice' heat from the wood heater (a mix of radiant heat and warm air).

Just as it is important to recognise the benefits of residential firewood use, it is also important to acknowledge adverse impacts, because if they are not acknowledged they will not be addressed. The problem with the wood heaters now in use in Tasmania is that they produce unacceptably high emissions of fine particles (a serious health risk) and high levels of methane (a strong climate warming gas). They also emit large quantities of carbon dioxide. Some of the carbon dioxide is reabsorbed as new trees grow but this takes many decades. Overall, as demonstrated in the following paragraphs, the total carbon dioxide equivalent (CO_2e) emissions from all the firewood burnt in Tasmania is almost 1 million tonnes per year. To

put this in perspective, the State Government estimate for CO_2e emitted by all transport in Tasmania in 2019 was 1.66 million tonnes per year (2).

Background

The adverse health impacts of wood-smoke have been known for decades. Many of the organic chemicals in wood-smoke are the same as those found in cigarette smoke. In the past two decades the link between fine particles in the air (including wood-smoke) and mortality/morbidity has been well established.

Several approaches for reducing smoke because of its health risk have been adopted in Tasmania:

1. Wood heaters sold must comply with the Australian/New Zealand Standard for particle emissions (AS/NZS 4013).
2. Heater buy-back programmes, where the government pays home-owners to remove wood heaters, were used with some success but are not available at the moment.
3. Regulations controlling excessive smoke defined as a continuous smoke plume visible for 10 minutes including a 30 second period where the plume extended 10 metres or more (these regulations are now rescinded).
4. Education about how to minimise smoke when operating a wood heater. The outcomes of these education efforts have been disappointing.

Unfortunately, these four approaches to reducing smoke have not led to the desired reduction in air pollution from wood heaters. Winter wood-smoke remains a significant health problem. New approaches are urgently required.

The contribution of wood heaters to global warming is a more recent concern. It was assumed that because trees grew to absorb the carbon dioxide emitted when wood is burned there was not a problem. Now the urgency in dealing with CO_2 emissions is much greater and waiting 50 to 100 years to reabsorb the CO_2 is not acceptable. We do not know how much firewood comes from land clearing; in which case the CO_2 is not re-absorbed at all. The problem is compounded by the relatively high emissions of methane due to incomplete combustion. Each kg of methane causes 86 times more warming than one kg of CO_2.

Information sources

CSIRO scientists have done in-situ measurements of smoke emitted by wood heaters in people's homes in Tasmania (3). They found that, on average, for every tonne of air-dry firewood burnt about 7.9kg of fine particles is released into the air. Another recent CSIRO study estimated that in 2019 Tasmanian households used 390,000 tonnes of firewood (4). Thirty eight percent of all households used some firewood and, on average, households using wood as their main heating fuel burnt 4½t of firewood per year.

We know that every winter many smaller towns and some suburbs in larger cities in Tasmania have poor air quality because of wood heaters. The levels of pollutants are high enough to cause health problems. Tasmania's excellent air monitoring network provides continuous measurements of fine particles in the air at 35 locations around the State (5). Years of measurements show we are not reducing these pollution levels, except in Launceston where the wood heater buy-back program removed thousands of heaters. Exposure studies indicate about 50 Tasmanians die prematurely each year because of this air pollution (6). The effects of the smoke are greatest in the very young, very old and people with existing heart or respiratory problems. But the smoke also triggers asthma attacks, causes eye irritation and other breathing problems. The annual health costs in Tasmania due to residential wood heating may be over $200 million per year (6). As discussed below, this pollution and its health impacts could be greatly reduced with better wood heaters.

Wood contains a lot of carbon; roughly half the weight of fully dried wood is carbon. When wood burns this carbon combines with oxygen from the air to form carbon dioxide and release heat. In a conventional wood

heater some of the carbon does not get completely converted to CO_2. Some ends up in complex organic compounds which condense into millions of tiny particles/droplets of oils and tars which we see as visible smoke, and which cause the adverse health impacts mentioned above. Some of the carbon combines with hydrogen to form methane and some only partially burns to form carbon monoxide. From a climate change perspective, the two gases we are most concerned about are carbon dioxide and methane. Detailed analysis of the smoke and gases emitted by wood heaters was carried out by the CSIRO in 2002 (7) and this allows us to calculate the average emissions of methane and carbon monoxide. One tonne of air-dry firewood, when burnt in the current generation of wood heaters, produces about 2.33t of CO_2e (CO_2e is the abbreviation used to include the equivalent global warming impacts of certain gases other than CO_2). This number is made up of carbon dioxide (CO_2) (1.27t), methane (CH_4) (0.84t CO_2e) and two other minor pollutants emitted by wood heaters nitrous oxide (N_2O) (0.004t CO_2e) and carbon monoxide (CO) (0.22t CO_2e).

Calculations

The following paragraphs focus discussion on the three largest contributors to climate change: CO_2, CO and CH_4. Better heaters will significantly reduce fine particle emissions. They will not reduce the CO_2 emissions when we burn firewood, but methane and carbon monoxide emissions can be reduced, by at least a factor of 10.

Calculation of the impact of methane and carbon monoxide emissions involves two steps. Firstly, the average emission per tonne of firewood burnt must be estimated. Gras (7) tested a number of Australian wood heaters under various operating conditions and with different firewood species. He monitored 64 different elements and chemical compounds in gases and particles in the wood-smoke. His work demonstrates that as particle emissions increase so do emissions of many other air pollutants, including methane and carbon monoxide. There is an approximate linear relationship between particles and methane (CH_4) expressed as:

CH_4 (g) = 1.5 x particles (g)
and for CO CO (g) = 17.9 x particles (g)

On average, when we burn 1 tonne of firewood we produce:
7.9kg of particles
11.9kg of methane
141kg of carbon monoxide

The second step is to calculate the warming impact of methane and carbon monoxide when compared to carbon dioxide. The science is more complicated here because of both direct and indirect warming effects. Carbon monoxide is not directly a warming gas but it is quite quickly converted into CO_2 in the air (over 2 or 3 months), so 1kg of CO soon becomes 1.6kg of CO_2. Some scientific research suggests considerably larger impact for CO, but the more conservative figure is used here. Methane has a strong warming effect. But methane does not remain in the atmosphere as long as CO_2 so its impact is high for a few decades after it is emitted and then lower if averaged over hundreds of years. Commonly cited figures for the global warming potential for methane are 86 (20-year time-frame) or 34 (100-year time-frame) (8). In view of the urgency of slowing climate change and meeting commitments for the next 20 to 30 years it is appropriate to use the multiplier of 86 (i.e. 1kg of methane is equivalent in its warming potential to 86kg of CO_2).

Applying the estimate of Tasmania's annual firewood consumption to the emissions above we get:
390,000t firewood produces 3,100t fine particles + 495,000t CO_2 + 4,600t CH_4 + 55,000t CO
(The total weight of the gases released during combustion is greater than the initial weight of wood because oxygen from the air is added to the carbon, hydrogen and oxygen making up the organic molecules in the wood.)

Then applying the global warming potentials:
390,000t firewood results in [495,000 + (4,600 x 86= 396,000) +
(55,000 x 1.6 = 88,000)] t CO_2e = 979,000 tonnes equivalent of carbon dioxide CO_2e

How can we reduce fine particles and methane without getting rid of all wood heaters?
The most straightforward and cost-effective way of reducing the unwanted pollutants from wood heating is to encourage more homes to use heat pumps as their main source of heat. Tasmania's electricity supply is almost all renewable energy, so benefits to health and climate warming will result.

We know that the present designs of wood heaters, when operated in people's homes, produce far too much air pollution. We also know that in the Canterbury Region of New Zealand, including Christchurch, the local authorities have set and enforced much more stringent requirements for wood heaters. These are known as Ultra-Low Emission Burners (ULEBs). NZ manufacturers have designed heaters that meet these requirements, they are only marginally more expensive than the older models at retail outlets, and measured air quality has improved as households change to the new heaters. Field measurements have shown these heaters perform well in people's homes. Some testing using eucalypt firewood carried out in New Zealand and paid for with research funding by the University of Tasmania has demonstrated very promising reductions in emissions.

Another type of biomass combustion appliance designed for use in homes, wood-pellet burning heaters, also have low emissions of fine particles and methane. Emissions of fine particles and methane are about one-tenth those of conventional wood heaters (9). This means the health and global warming benefits of wood-pellet burners are similar to the ULEBs. Wood pellet burning heaters are widely used in Europe and North America. They are available in Tasmania and wood-pellets are also manufactured in Tasmania, but the market is very small and so the pellets are more expensive than conventional firewood. A larger market for wood-pellets might drive the price down. The pellets are made from waste wood which could be supplied sustainably.

If the present wood heaters in Tasmania were phased out and replaced with ULEBs we could expect fine particles, methane and carbon monoxide would be reduced to one tenth the present emissions. The improved efficiency of the ULEBs and pellet burners would lead to less firewood consumed for the same quantity of heat (roughly 10% less firewood required for the same amount of heat). In this scenario:

350,000t firewood → 440t fine particles + 530,000t CO_2 + 420t CH_4 + 5,000t CO
(the reason there is more CO_2 is that the carbon in the wood is now being burnt more effectively instead of ending up in the polluting particles, methane and CO)
and in this case
350,000t firewood → 575,000t CO_2e (a reduction of about 415,000t CO_2e or about 42%)

But there is still a significant release of climate warming gas. This is because we have not factored in the absorption of CO_2 as trees grow. With current knowledge this is hard to do because we have very little reliable information about where the firewood comes from. The CSIRO study (4) tells us that the largest supply of firewood is self-collected, some is purchased from commercial businesses, some is purchased from private individuals, some is provided free of charge by friends or relatives. But we do not know how much of this is from sustainably managed forests/plantations and how much is from land clearing. If the firewood comes from land clearing, then all the emitted CO_2 should be accounted for in emission inventories. If it comes from managed forests/plantations, then it is possible to estimate the fraction of CO_2 reabsorbed over various timeframes (20 to 100 years). Ideally, a managed short rotation supply of firewood could greatly reduce the contribution of firewood to Australia's net climate change emissions.

In Tasmania, Sustainable Forestry Tasmania's Annual 2021 Report (10) states that 21,105t of firewood was supplied through their permit system; but this is just 5% of the CSIRO's 390,000t estimate of total firewood use. This suggests almost all the firewood comes from a mix of private forests, land clearing, sawmill wastes and illegal collection from reserves and parks.

Conclusions

The conclusion, based on the findings of three CSIRO reports (3, 4, 7) is that the adverse impacts on health and climate change from the use of firewood in Tasmania are unacceptable. In Tasmania, measured winter fine particle concentrations suggest wood heaters are causing premature mortality of around 50 people each year (6), this is a number that is similar to Tasmania's annual road toll. Also, the 390,000 tonnes of firewood burnt cause about an additional one million tonnes of carbon dioxide (equivalent) emissions that do not appear to be taken into account when reporting the State's net greenhouse gas emissions of minus 3,730,000t CO_2e (2).

There are solutions. The adverse impacts of firewood use can be reduced through greater use of electric heating, improved firewood supply and improved technology (ultra-low emission wood burners). Getting rid of wood heaters all together would be an extreme way of solving both problems, but we would then lose the benefits of this home heating option. We need an informed discussion in the community and a commitment from Government to do something about the problems. A *Firewood Vision*, or more broadly a *Residential Heating Vision*, seems a useful way forward to deal with this urgent problem.

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References

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