

# National Environmental Science Program

Sustainable Communities and Waste Hub  
Hub research plan 2024 – variation to an  
approved project



# Emerging Priority – Developing a real-world testing protocol for evaluating particulate and greenhouse gas emissions from Australian wood heaters.

<b>Project type:</b> <ul style="list-style-type: none"><li>• Hub research project – Emerging Priority Project</li></ul>	
<b>Project status:</b> <ul style="list-style-type: none"><li>• New project seeking approval</li></ul>	
<b>Cross-cutting initiative:</b>	No
<b>Project start date:</b> 30/09/2024	<b>Project end date:</b> 31/08/2025
<b>Project leader details:</b>	Name: Fay Johnston Organisation: University of Tasmania  Name: Amanda Wheeler Organisation: CSIRO

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# Project description

## Project summary

**Wood heater smoke is the single most important source of air pollution in Australia and leads to several hundred avoidable deaths every year.** For example, in Sydney particle pollution from wood heaters causes more deaths and illness each year than either traffic or industrial emissions. (See IP4.02 Report on SCaW IP4 stakeholder workshop held on 9 Dec 2021).

The wood heater testing methods in current Australian protocols, do not reflect typical wood heater operations in a household and as a result, they grossly underestimate actual emissions that occur when the appliances are used after sale. Tightening of existing wood heater standards over the years has not therefore led to a documented reduction in air pollution anywhere in Australia. It is recognised that the current testing protocol is not fit for the purpose of ensuring that wood heaters are designed for minimal emissions to protect community health.

Countries in regions with similar air quality problems from wood heaters, such as New Zealand (NZ), North America and Europe face similar problems with wood heaters and are moving away from outdated testing protocols to real-world testing protocols. However, Australia cannot simply adopt these approaches. We need to develop our own testing methods due to our different dominant fuels (Eucalypt hardwoods) which burn quite differently to softwoods such as pine, which are largely used in NZ, North America and Europe.

**This proposal is in response to a request from Standards Australia who recognise the urgent need for the research to develop a new real-world protocol.** Standards Australia is the nation's peak non-government, not-for-profit standards organisation responsible for standards development. Standards Australia have requested support to renew the current Australian wood heater standards and requested a timeline for this work. The University of Tasmania has a purpose-built facility for undertaking emissions and efficiency testing of wood heaters. It is the only non-commercial facility in Australia which ensures an unbiased method can be developed that will be feasible for implementation across a range of wood heater manufacturers. As Standards Australia do not have funding to support the development of new standards themselves, we request funding from SCaW Hub as an emerging priority.

**Standards based on real world testing have been shown to result in rapid technological advancements for ultra-low emissions appliances** (Pearce and Scott. 2020. 'Ultra-low emission burners-a catalyst for Innovation', Air Quality and Climate Change, 54: 57-63). Modelling undertaken by the NHMRC Centre of Research Excellence – the Centre for Safe Air (led by CI Prof Johnston) conservatively estimated that 700 deaths in Australia each year are attributable to smoke from wood heaters, and that replacement of 50% of these with appliances that meet stringent requirements based on real-world testing protocols, would save approximately 300 lives per annum.

Developing a new protocol is time consuming. Each testing run takes approximately eight hours to run and an additional 2-3 hours to extract, clean and analyse the data. Each test has several stages, and each test needs to be optimised to ensure the protocol is robust, requiring considerable troubleshooting and several replications per stage and per heater. The method must be implementable with a wide range of heating appliances. Based on our pilot studies, in which we demonstrated proof-of concept, we anticipate 9 months of intensive experimental work will be required. (Funding of the pilot work was previously provided through seed funding grants to a total of \$65K from an NHMRC Centre of Research Excellence and Tasmanian Department of Health).

This project is to develop and document a new real-world testing protocol appropriate for wood heater appliances that burn Australian hardwoods.

# Project description

## Background:

### The national problem of woodsmoke

#### *Impacts on community health*

Wood heaters significantly contribute to air pollution in urban, regional, and rural communities across Australia, New Zealand (NZ) and many other parts of the world (Bailey et al. 2019; Chafe et al. 2015). Exposure to smoke from wood heaters increases the risk of developing many serious health problems including lung diseases (Dai et al. 2021), heart diseases (Huynh et al. 2015), pregnancy complications (Assibey-Mensah et al. 2020), and deaths (Johnston et al. 2013). As a result, wood heater emissions are responsible for a substantial amount of community health problems and economic burden (Borchers-Arriagada et al. 2020; Robinson et al. 2021). In Australia, the annual death toll from wood heater smoke is currently estimated to be at 700 per year, making this the most important single source of air pollution-related deaths (Borchers Arriagada et al. 2023). This is the case even in warmer settings such as Sydney, where only 4-8% households heat with wood (Australian Bureau of Statistics 2014, Romanach and Frederiks 2021), wood smoke is the largest single source of fine particulate air pollution (PM<sub>2.5</sub>) and is associated with an estimated 100-240 premature deaths per year, more than the corresponding estimates for emissions from power stations (45) and motor vehicles (72) (Broome et al. 2020).

#### *Impacts on climate*

Wood heater emissions contribute to climate change through emissions of particles and gases, especially carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO) and methane (CH<sub>4</sub>). On average, for each tonne of firewood burnt in existing Australian heaters we produce: 7.9kg of particles, 11.9kg of methane, and 141kg of carbon monoxide. In Tasmania for example, this means that the 390,000 tonnes of firewood burnt each year causes about an additional one million tonnes of carbon dioxide (equivalent) emissions into the atmosphere, almost as much as emissions from vehicles. (Todd 2023). Better heaters, such as ULEBs developed from real-world testing protocols, will reduce methane and carbon monoxide emissions by at least a factor of ten. (Todd 2023)

### The challenges of creating standards for wood heaters

Despite increasingly stringent emission standards for wood heaters in Australia, there has been frustratingly little progress in reducing ambient air pollution from this source. This is partly because the current testing protocol used in Australia is not fit for the purpose for reducing ambient woodsmoke pollution. Testing protocols designed for evaluating the performance of an appliance in a reproducible way in laboratory settings do not provide robust information about the amount of pollution the appliance will add to the atmosphere when used in homes in the community. For example, the existing standards for wood heater testing in Australia and New Zealand, the AS/NZS 4012 standard for efficiency and the AS/NZS 4013 standard for emissions, **exclude the most polluting stage of a burn cycle**, i.e. the start-up, because emissions during this stage are highly operator dependent (Appendix A) (Pearce and Scott 2021). This is one of many possible reasons that appliances that perform well under existing laboratory testing conditions can still produce excessive amounts of air pollution when used in domestic households. Another important reason is the requirement in the existing standards to operate with maximum combustion air until 20% of the mass of the added fuel load is consumed at the start of slow and medium burn rate tests. Householders are advised to leave the air control fully open for 15 to 20 minutes after refuelling because it leads to much less smoke, but the available evidence suggests that this is unlikely to happen consistently in practice. Indeed, a national study found that in almost one in every five times a heater is refuelled the combustion air is *immediately* set to minimum. (Todd 2008).

### Potential solutions – standards based on realistic testing protocols

The NZ province of Canterbury made progress in overcoming these limitations through the development of a simulated real-life testing protocol known as Canterbury Method One (CM1) (Pearce and Scott 2021). Incorporation of CM1 into regulatory requirements in the province led to rapid innovation in the design of wood heaters that can reliably produce relatively low emissions when

operated under realistic household conditions (Pearce and Scott 2021). In NZ, where the CM1 was developed, softwoods like pine are the main fuels used for home heating. However, in Australia hardwood fuels, mostly eucalypts, are more typically used. Hardwoods and softwoods have different combustion properties so consequently, appliances and protocols designed for one type of fuel will not necessarily be optimal for the other. Our previous feasibility study demonstrated that:

- it is possible to adapt the pioneering approach of the CM1 for Australian hardwoods; and
- hardwood fuelled Ultra-low Emission Burners (ULEBs) as defined by the NZ CM1 testing protocol could produce substantially lower pollution emissions (by almost 90%) than existing hardwood burners in Australia (Johnston et al 2023).

### **Why further development is needed in Australia for a hardwood ULEB protocol**

The vast majority of firewood used in Australia is eucalypt hardwood (approximately 95%, Todd 2008), in contrast to softwood species in NZ. However, the differences in density, flammability and charcoal structure between hardwoods and softwoods, and the resulting differences in patterns of homeowner operation mean that some additional changes to the method are required. For example, the following factors all require consideration:

- The slower burn rate of hardwoods mean that testing cycles take longer.
- Hardwood density is higher than softwood
- Australian operating practices (eg lighting procedures, kindling piece sizes, log lengths and weights, log moisture, number of logs added when refuelling, time intervals between refuelling, timing of adjustments to air supply, and timing and number of door openings to stoke the fire (Todd 2008).

The protocol will be applicable to all types of hardwood fuels. Real-world testing protocols already exist for softwoods.

### **Aim:**

To develop a real-world testing protocol for evaluating particulate and greenhouse gas emissions from Australian wood heaters, that is fit for purpose and ready for review and adoption by Standards Australia.

### **Method:**

The project requires use of the purpose-built calorimeter and emissions testing laboratory at the University of Tasmania\*. The methodological steps are as follows -

#### *1. Employment and training of the technical officer- this person has been identified*

Under the direction of A/Prof Todd, an acknowledged expert in Australia who developed softwood real-world test protocols for Environment Canterbury, NZ, we will employ and train a technical officer. Their role will be to systematically implement the testing protocols, operate and maintain the scientific instruments and testing rig, conduct replicated experimental runs, and document the results in detail including observation, photography and measurement. A/Prof Todd is providing his time and expertise in kind for this project in recognition of the public good nature of the project. His previous experience with the NZ standard development has been used to develop this proposal, the timing, and budget.

#### *2. Development of a real world **start up protocol** based on data from wood heater users around Australia and testing of the start-up protocol in 5 contrasting heaters to ensure reproducibility.*

The next stage of the project requires intensive testing and replication of the protocols. It includes ignition and loading of kindling and refuelling protocol following start up, for moving from kindling to logs in a standardised manner. We have budgeted a total of 20 days of laboratory time over 2 months for this work. Non-lab days are devoted to data analysis and interpretation and refinement of the approaches.

3. Development of **phase two - high burn protocol** based on existing user behaviour data. Once refined it will be tested on 5 contrasting heater designs to ensure reproducibility.  
We have budgeted a total of 12 days of laboratory time over 2 months for this work.

4. Development of **phase three - low burn protocol** based on existing user behaviour data. Once refined it will be tested on 5 contrasting heater designs to ensure reproducibility.  
We have budgeted a total of 12 days of laboratory time over 2 months for this work.

5. Development of **partially seasoned burn protocol** based on existing user behaviour data. Once refined it will be tested on 5 contrasting heater designs to ensure reproducibility.  
We have budgeted a total of 6 days of laboratory time over 2 months for this work.

6. **Detailed documentation of the full protocol** including thermal efficiency, combustion efficiency, particle emissions, and greenhouse gas emissions  
Each full test required 3 days of laboratory time. 30 lab days during the final 4 months allocated in total.

### 7. Final reporting and presentations

ScAW Hub, stakeholders, Standards Australia, and publications

### Gantt Chart

	Sept/Oct	Nov/Dec/Jan	Feb/March/Apr	May/June	July/August 2025
Training technical officer					
Convene and regular updates with stakeholder group	X	X	X	X	X
Start up loading and refuelling protocol development					
Phases two and three - high and low burn protocol development					
Partially-seasoned protocol development					
Documentation of full protocol					
Preparation interim and final reports and presentations			X		X

### Documentation and outputs.

1. Interim progress and final reports at 6 and 12 months.
2. A detailed technical document specifying the protocol.
3. Publication of the protocol methods online and in a peer reviewed journal.

*Communication.* Profs Johnston and Todd will present the findings to relevant stakeholders, including:

- Stakeholder reference group
- Standards Australia
- DCCEEW Air Quality Section
- Clean Air Society of Australia and New Zealand in 2024.

## **Outcomes are listed in the section - Pathway to Impact**

### **Stakeholders**

Angela Cartwright - Asthma Australia

Kate Garvey - Public Health Services, Tasmania

Bill Dodd - Centre for Safe Air

John Innis - Clean Air Society ANZ

Nathan Sibley – DEECEW

Lulu Wang – Standards Australia

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## **Is this a cross-hub project?**

No.

## **Does this project contribute to a cross-cutting initiative?**

The project has some alignment with the mission and purpose of the Climate Adaptation Initiative (Climate Systems Hub) and the Threatened and migratory species and threatened ecological communities Initiative (Resilient Landscapes Hub). The Initiative leads for these cross-cutting initiatives will be briefed/consulted during the project delivery. (See Todd 2023 Climate impacts of residential firewood use)

# Pathway to impact

Outcomes
<p><b>Outputs</b></p> <ul style="list-style-type: none"> <li>• Interim and final <b>project reports</b>.</li> <li>• Detailed hardwood <b>testing protocol</b> that simulates real world usage in the community.</li> <li>• <b>Presentation</b> of the work and the protocol to Standards Australia Solid Fuel Burning Appliances Committee CS-062.</li> <li>• <b>Presentation</b> of the work and the protocol to the National Air Quality Technical Advisory committee which is the peak body of air quality scientists from environmental agencies around Australia, and to the Air Quality section of DCCEEW.</li> </ul> <p><b>Pathways</b></p> <p>A key feature of this project is codesign with key industry partners and regulators. The work was initiated directly by a request from Standards Australia who recognise the need for the research but are not able to fund it. Additionally, industry experts will be key advisors to the research team.</p> <p>Standards Australia will follow due process in evaluating and implementing the results. DCCEEW will be fully aware of how the research is accepted and implemented through the following pathways: (1) Their existing membership of the Standards Australia expert group for emissions standards, and (2) Updates from the research group to the hub through our annual reporting.</p> <p><b>Impact</b></p> <p>The public health gains from this work, once implemented, are large. Adoption of standards based on the system combined with a replacement scheme for non-compliant heaters, will lead to meaningful reductions in one of the most important sources of air pollution in Australia, and in turn <b>reduce illness and deaths associated with woodsmoke</b>. This includes an estimated reduction in deaths from 300-600 each year and reduced health care costs due to fewer cases of air pollution related serious cardiovascular events (such as stroke, cardiac arrest, and heart attack).</p>

Research-user	Engagement and communication	Impact on management action	Outputs
DCCEEW: Air Quality Section	Engaged in the development of the project scope and outputs.	The intent of the work is a new protocol for adoption by Standards Australia	Report to DCCEEW summarising progress
Standards Australia	Engaged in an advisory capacity to the project. Presentation of the small pilot study to Standards Australia committee led to the request for further development of the protocol. This work is unable to progress without funding	The protocol will provide an effective reliable and validated method to evaluate wood heater emissions for appliances when used in the community.	A detailed and documented testing protocol
Tim Cannon (Cannon Combustion)	Engaged in a technical advisory capacity	This will ensure the protocol is practical and can be used by a wide range of stakeholders	A detailed and documented testing protocol
<p><b>Additional outputs</b></p> <ul style="list-style-type: none"> <li>• NA</li> </ul>			

# Indigenous consultation and engagement

NA/This is a laboratory-based project with no Indigenous consultation or engagement. Information can be shared via the NESP and HEAL networks.

Which Three-category approach the project meets	<b>Communicate</b>	<b>Collaborate</b>	<b>Co-design</b>
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

# Project milestones

<b>Milestones</b>	<b>Due date</b>	<b>Responsible person(s)</b>
Milestone 1 –Employment and training of technical officer	30 Oct 2024	Prof Johnston and A/Prof Todd (UTAS)
Milestone 2– Interim progress report	31 March 2025	Fay Johnston (UTAS) / Amanda Wheeler (CSIRO)
Milestone 3 – Final report	31 August 2025	Fay Johnston (UTAS) / Amanda Wheeler (CSIRO)
Milestone 4 – Complete technical protocol completed	31 August 2025	Fay Johnston (UTAS) John Todd and technical officer (UTAS)

# Data and information management

The Hub’s Communications and Knowledge Broker will work closely with this EP leadership team to support various levels of stakeholder engagement, including with the Department, the Hub’s Steering Committee, and its Chair. This will include regular and targeted meetings and interactions with the researchers, and bi-monthly meetings of the SCaW hub leadership team, which discusses and shares communications matters relating to all IP4 activities including publicity, events and insights.

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Project output	Data management and accessibility
Reports	<p data-bbox="612 560 1406 624">Subject to approval by DCCEEW, these will be made publicly available on the Hub website, in accordance with the Hub Data Management Strategy.</p> <p data-bbox="612 651 1406 976">Where Indigenous knowledges are included in project outputs, the management and accessibility of those outputs will be subject to the Ethics approvals, FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective benefit, Authority to Control, Responsibility, and Ethics) principles and any specific Indigenous Cultural and Intellectual Property (ICIP) arrangements developed with the communities involved. We will handle the data that emerges from these discussions according to Article 31 of the United Nations Declaration on the Rights of Indigenous Peoples, which Australia has endorsed, and affirms that:</p> <p data-bbox="612 1003 1406 1328"><i>Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions.</i></p>

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# Location of research

At which spatial scale is the project working	National	Regional	Local
<b>Location(s) – gazetted region /place name</b>	Hobart – the only university-based laboratory in Australia. The work is of national significance, but it is in Hobart as that is where the testing facility is located.		
<b>Aboriginal or Torres Strait Islander nation or traditional place name(s)</b>	Nipaluna		

# Project-specific risks

<b>Risk</b>	<b>Potential impact on project</b>	<b>Likelihood (rare, unlikely, possible, likely, highly likely)</b>	<b>Consequence (minor, moderate, high, major, critical)</b>	<b>Risk rating (low, medium high, severe)</b>	<b>Treatment to reduce or manage risk</b>
Delayed contracting	Moderate	Possible	High	Medium	Co-design with DCCEEW the project scope, deliverables and project milestones. Hub HQ and SC fully briefed on project scope, delivery model and DCCEEW expectations.
Delays in recruitment of a suitably skilled technical officer	Moderate	Unlikely	High	Low	We have already identified a suitably qualified and skilled person to do the work.
Delays to project schedule due to equipment malfunction and need for repair	Moderate	Possible	Moderate	Medium	All equipment tested and calibrated prior to commencement

# Project keywords

Air pollution, wood heater emissions testing, Ultralow emissions burner, Australian hardwoods