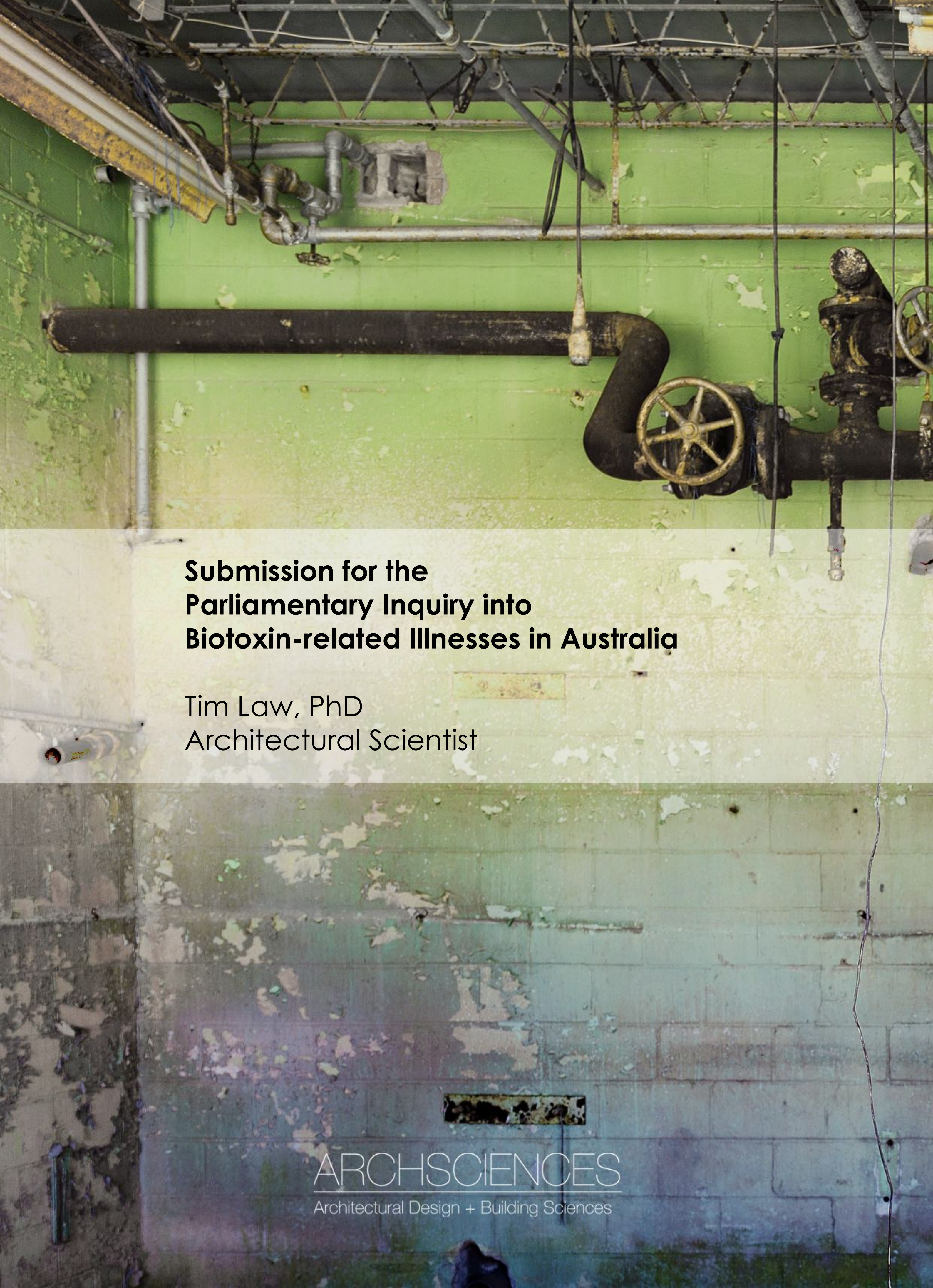

Submission for the Parliamentary Inquiry into Biotoxin-related Illnesses in Australia

Tim Law, PhD
Architectural Scientist

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Architectural Design + Building Sciences

Standing Committee on Health, Aged Care and Sport
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Dear Committee,

You are inquiring into an important matter, perhaps of more significance and gravity than you might be aware. My submission is lengthy in the hope that it will provide you with a sufficiently broad perspective on the magnitude of this problem. I am an architectural scientist, by that I mean I am trained in architecture and with a focus on the performance and failure of buildings. My particular areas of specialisation are in the physics of heat and moisture movement in buildings, and the biological implications of mould on the health of occupants.

A mould problem in buildings is always a moisture problem. Architects, developers, builders and occupants are all familiar with water ingress issues. The ABC Radio National's aptly named episode *Nightmare Builds* (Roxburgh, 2017) highlights the prevalence of rain ingress into apartments accompanying the rush to capitalise on Sydney's apartment boom. Another major source of flooding comes from plumbing failures, most notably bursts occurring from braided hoses (Helen Wellings, 2017; SMH, 2017). These problems are widespread and widely recognised. Water intrusion events are serious in scope, but at least the problem is clearly manifested and incontrovertible. To use medical terminology, a water intrusion event is like an *acute* illness, well defined in its onset and occurrence.

A mould problem in buildings is always a moisture problem.

There is still much that can be done to avoid these problems, but I will not dwell on them, as the larger part of problem that confronts us with the biotoxin parliamentary inquiry is less detectable, less blatant. I need to bring to your attention that what we have is a vapour accumulation problem leading to high humidities and condensation. These conditions make the mould problem every bit as serious as a water intrusion event, but it is far more insidious because it is far less visible. This is where systemically water damaged buildings (WDBs) result in chronically ill patients with CIRS.

CIRS and architecture

Figure 1: My PhD thesis published as a book with Springer.

My story begins with my PhD candidature looking at thermal comfort in an energy-constrained world, for which I was intent on finding a method of achieving comfort utilising the most energy-efficient methods (Figure 1). Upon completion of my candidature, I remained in Tasmania and was accosted by builders who found mould in their buildings soon after occupation (Figure 2), who were hoping to have an explanation why, when they tried to do things correctly by the codes and standards, they were still presented with an outcome that was plainly unacceptable.

Figure 2: New house in Launceston 5 months after occupation. Photographs supplied from builder who would like to remain unnamed. Copious condensation forms on door and windows. However it is only upon prying open the roof is the extend of mould growth appreciable.

It became clear that my story was the same story of the construction code: for some reason we had assumed that comfort was a universal right and energy efficiency was a necessary objective. However, it turns out that this thinking led to the unintended consequence of creating WDBs (Law & Dewsbury, 2018).

We had assumed that comfort was a universal right and energy efficiency was a necessary objective. It turns out that this thinking led to the unintended consequence of creating water-damaged buildings

Although it would be ideal for us all to be both comfortable and healthy, if we were forced to make a choice, which would it be? It was obvious to me that the lack of comfort was an inconvenience, and nothing too serious. For as long as the body's core temperatures were not perturbed, being too hot or too cold was really only an annoyance requiring us to make some biological or environmental adaptations. Mould on the other hand could have far reaching implications on health and wellbeing. To be sure I was not unique in my thinking, in one of my lectures I asked a class in the School of Architecture to chose between renting a room that was cold but dry, or one that was warm but damp enough to have mould. The students unanimously opted for the uncomfortable room without mould (Figure 3). The logic they offered was that they knew of ways to stay warm with clothing, drinks and personal heaters. However, when it came to mould they knew of no alternative from sharing the same air with these toxin-producing organisms. Viscerally, these students knew that mould was a problem, or was at least a potential problem.

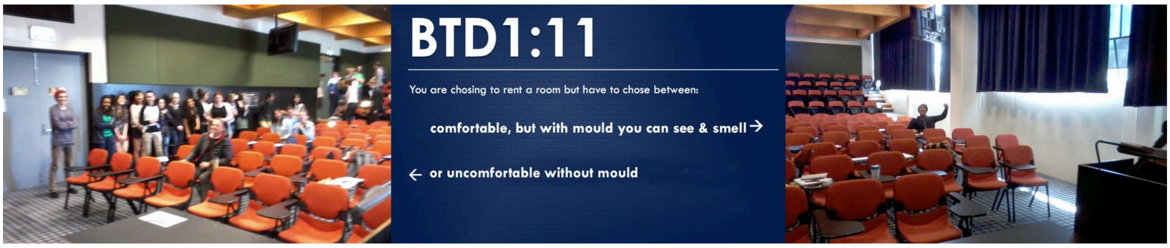

Figure 3: The slide presented to the class where they were to choose between discomfort or the absence of mould. Students would indicate their choice by standing at either side of the lecture theatre. The one student who chose the mouldy option later changed his mind.

The role of mould in WDBs

The World Health Organistion (WHO, 2009) in its extensive review of literature concludes that, “Sufficient epidemiological evidence is available from studies conducted in different countries and under different climatic conditions to show that the occupants of damp or mouldy buildings, both houses and public buildings, are at increased risk of respiratory symptoms, respiratory infections and exacerbation of asthma." (p.93) This is one of the most cited health impact of mould in damp buildings and used in a number of position statements, like that of the American Industrial Hygiene Association (AIHA, 2013).

The effects of moulds on building occupants are varied. It could be 1. allergenic to some (like asthmatics); 2. pathogenic to others, by which I mean invasively so, like in the case of *Aspergillosis*, *Histoplasmosis*, *Coccidioidomycosis* (Kendrick, 2000).; 3. Alternatively, mould can cause toxicosis through skin contact, inhalation or ingestion. Mycotoxins (mould toxins) are a secondary metabolite, so they are not used in the primary function of growth and reproduction. These mycotoxins accumulate and are then released sporadically (Kendrick, 2000, p145), possibly for competitive exclusion depending on the antagonist (Zain, 2011). This is of particular concern in cool climates, as toxin production usually increases at low temperatures (Wannemacher & Wiener, 1997). Most health practitioners will be familiar with the allergenic, pathogenic and toxicological effects of mould.

In contrast, it is the aspect of Chronic Inflammatory Response Syndrome (CIRS) that is not as well known, and not broadly medically recognised in Australia (McGowan, 2018). Shoemaker (2011) explains, "We now know that this idea from toxicology has little bearing on mold illness, as indeed mold illness isn't toxicological at all, but is immunological instead." As a physician, he found mould patients presenting similar symptoms to those who suffered from dinoflagellate toxin exposure (like during a toxic algal bloom) he treated elsewhere. These negatively charged toxins (mostly called ionophores), do not get excreted but are reabsorbed further down the gut. The accumulated toxics causes individuals with susceptible genetic makeup to have an over sensitised immune response that places them under chronic inflammation.

... indeed mold illness isn't toxicological at all, but is immunological instead. (Shoemaker)

Because CIRS is systemic, it has a complex multi-organ multi-symptom presentation. Figure 4 shows symptoms clusters that aid in the diagnosis of CIRS. A CIRS patient manifests symptoms in at least six clusters.

CIRS Symptom Clusters		
Fatigue		Red Eyes Blurred Vision Sweats (night) Mood Swings Ice-pick Pain
Weakness Decreased assimilation of knowledge Aches Headache Light Sensitivity	Unusual skin senstiivity Tingling	
Memory Impairment Decreased Word Finding	Shortness of breath Sinus congestion	Abdominal Pain Diarrhea Numbness
Difficulty Concentrating	Cough Excessive thirst Confusion	Tearing Disorientation Metallic Taste
Joint Pain AM Stiffness Cramps	Appetiate Swings Difficulty regulating body temperature Increased urination	Static Shocks Vertigo

Cluster table © R.Shoemaker

Figure 4: CIRS symptom cluster table.

Over time Shoemaker has developed a very clear diagnostic procedure and systematic treatment protocol. I supervised a group of Masters of Architecture students who prepared the following infographic to simplify and graphically explain CIRS (Figures 5 & 6).

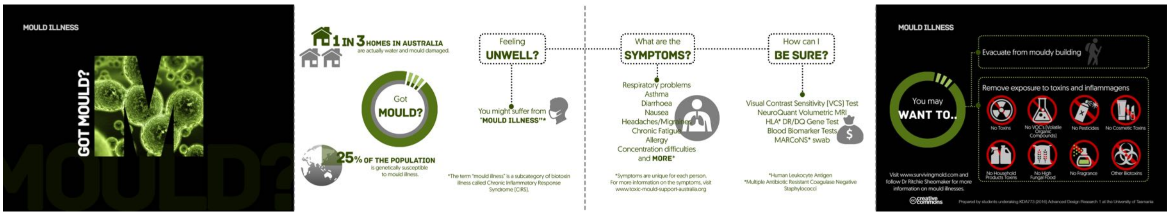

Figure 5: Mould illness infographic. Prepared by UTAS students working with me on an Advanced Design Research module 2016.

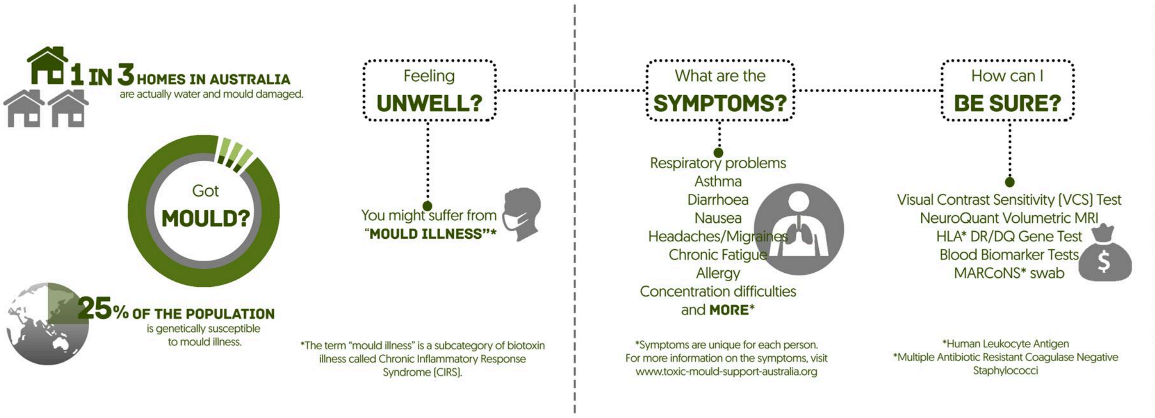

Figure 6: Centrespread of infographic enlarged for clarity

Essentially, according to Shoemaker, genetically susceptible patients suffer more from the friendly fire of their overactive defence mechanism than from the invader itself. He has created a protocol around the diagnosis and treatment of the syndrome termed CIRS-WDB, (Chronic Inflammatory Response Syndrome in Water-Damaged Buildings) and estimates that 24% of the population have the genetic disposition to develop CIRS if they were exposed to a WDB. Given that up to 40% of buildings in some countries have mould (Sivasubramani, Niemeier, Reponen, & Grinshpun, 2004) there is a high likelihood that susceptible patients will encounter problematic buildings on a daily basis.

Although there is general consensus that damp buildings are deleterious to health, the actual mechanism is still unclear.

Two years after Hurricane Katrina, detailed sampling and identification were carried out in houses heavily contaminated with mould (Bloom, Grimsley, Pehrson, Lewis, & Larsson, 2009). Although the researchers established a case for the requirement for personal protective equipment for retuning residents, they found that the amounts of fungi in a house did not correlate with the amount of mycotoxins. The ability for moulds to create different mycotoxins at different rates under different conditions has made it very difficult to establish the health impact under the conventional understanding of toxicology: that the poison is in the dose. If one were to proceed on this trajectory, trying to establish objective measures of health effects associated with mycotoxin exposure in comparison with a control population, one would invariably come to this conclusion: no definitive or causal relationship. This we see repeatedly (Page & Trout, 2001; Kelman, Robbins, Swenson, & Hardin, 2004) and confirmed by Täubel & Hyvärinen (2016) who state, "Support from epidemiological studies in clarifying potential health effects upon indoor mycotoxin exposure is almost completely absent." Shoemaker also opines that mycotoxins are a very small component of the total biotoxin load, far overshadowed by a factor of a thousand to one by beta-glucans and mannans arising from bacteria and actinomycetes (Kresser, 2015; Toxic Mould Support Australia, 2015).

If the Committee is looking into CIRS, then it needs to be understood that mycotoxins are only a part of the entire biotoxin load an occupant is exposed to. Moreover mould is not the only problem, but an indicator of excessive moisture that permits the occurrence and continuation of an entire microbiological ecology that contributes to the total biotoxin load of a WDB. Due to the ubiquity of cellulose-based nutrient sources in timber-framed buildings lined with paper-faced plasterboards, moulds can grow anywhere in a building with enough moisture, and especially in the dark areas. By the time an occupant sees the mould appearing on the painted walls it is most likely there would be much more to be found in the dark interstitial spaces behind the wall and ceiling lining. Mould is always an indicator of damp, and if the cause cannot be traced to a cladding or plumbing leak, then condensation should be seen as the most likely culprit.

Moisture is the main problem, and mould is our clearest indicator of this problem.

Moisture is the main problem, and mould is our clearest indicator of this problem.

Biotoxin illness in WDBs

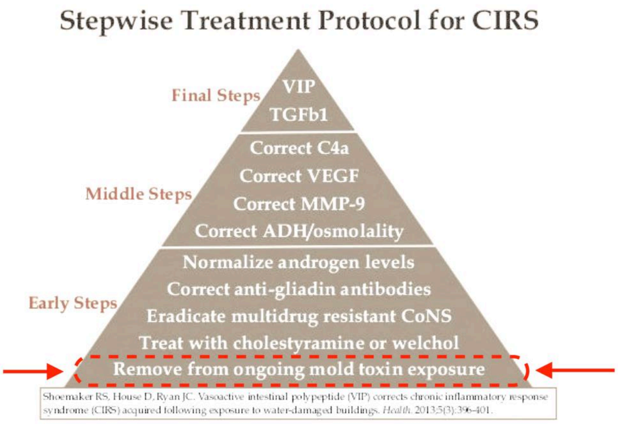

Figure 7: Shoemaker treatment protocol for CIRS

For a CIRS patient, the need to vacate from WDBs is the non-negotiable prerequisite for treatment (Figure 7). In an experiment involving 14 patients in a double-blind, placebo-controlled, clinical trial (Shoemaker & House, 2006), patients were (1) exposed to a WDB, (2) treated with CSM, (3) ceased CSM, (4) re-exposed to the building that caused the sick building syndrome and (5) treated with CSM again. The researchers note, "Health status continued to show marked improvement following CSM therapy while the study participants avoided re-exposure to the WDBs. However, all participants relapsed within 7 days of re-exposure to the WDBs." In this study and many anecdotal accounts from the Facebook group *Toxic Mould Support Australia*, exposure to WDBs has been causative to the recurrence and persistence of symptoms characteristic of CIRS.

The need to vacate from WDBs is the non-negotiable prerequisite for treating biotoxin illness.

In their comprehensive literature review on the deleterious effects of biocontaminants, Thrasher and Crawley (2009) reach a similar conclusion, urging that the "medical profession must recognize the importance of immediate removal of occupants from the toxic environment." The infographic of Figure 8 illustrates the various sources of toxic exposure a CIRS patient needs to avoid.

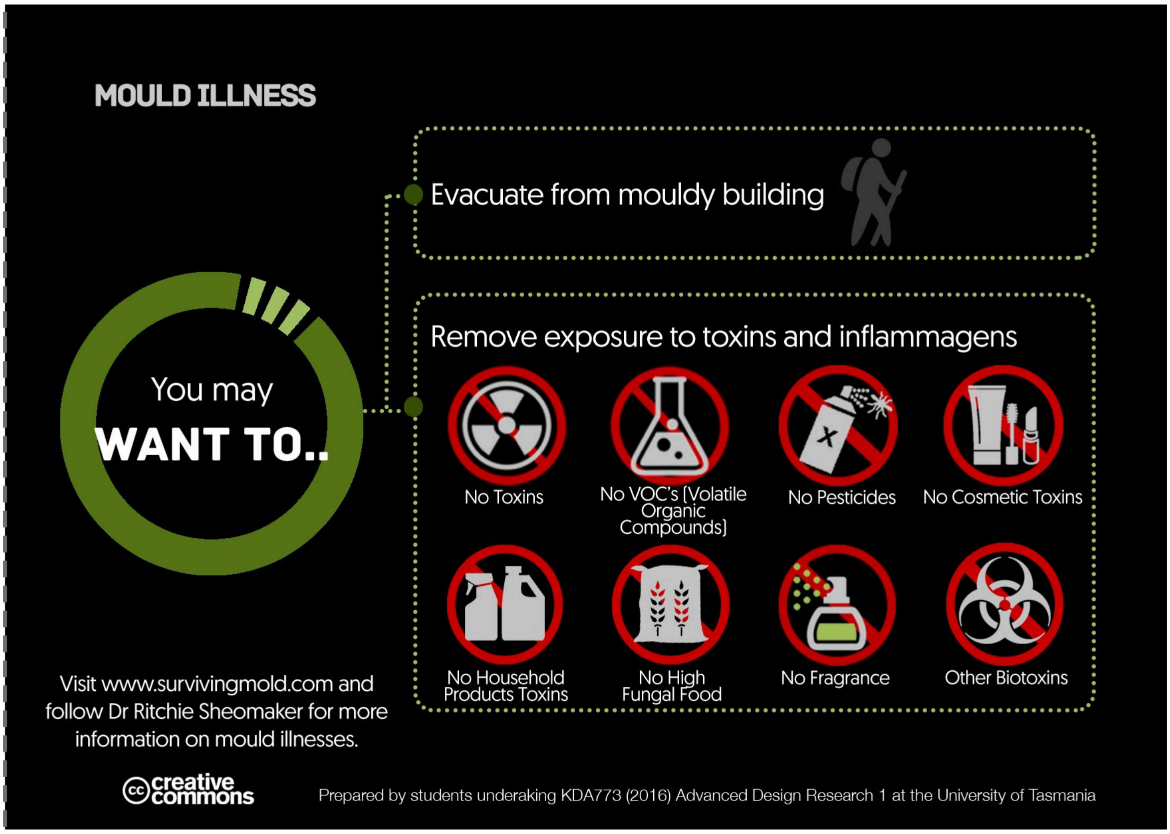

Figure 8: Infographic 'What to do if you have a mould illness'.

To understand the distribution, spread and occurrence of CIRS, we need to look at the source of the problem, which is the occurrence of mould in Australian buildings as an indicator of moisture problems in them. How long does a building need to stay damp to be a problem? Shoemaker's assessment is that 'there is decent evidence that if water intrusion wasn't dried out in 48 hours, we will find about 24% of people ill from the water-damaged building.' (Shoemaker, 2011)

Terms of Reference 1. The prevalence and geographic distribution of biotoxin-related illnesses in Australia, particularly related to water-damaged buildings;

It has been estimated that dampness can affect up an estimated 10–50% of buildings in Australia, Europe, India, Japan, and North America (WHO, 2009). However it was not until a few years ago has there been a nationwide survey into WDBs in Australia. The *Condensation Stakeholder Survey* was conducted by the Australian Building Codes Board (ABCB) in Dec 2015 "to gather evidence and feedback on the extent of condensation problems and the likely causes, as well as gain an understanding of industry's capacity to manage condensation risk in new residential buildings." (Purpose of the survey)

The survey polled the building industry on the prevalence of condensation in buildings over different time periods (2–5 years and 10–15 years prior to survey) and building Classes (Class 1 houses and Class 2 apartment buildings). It covered the extent of the condensation problem in the building stock, parts within buildings where condensation occurred, attribution of responsibility, effects, design factors, awareness and education.

There were 2,662 usable responses (a notable high response rate, since previous surveys typically receiving about 200 responses) submitted between December 2015 and February 2016. The ABCB Survey in Figure 9 shows respondents estimate an overall one third of new Australian buildings suffering from condensation problems. Further analysis showed minor variations across climate types and states. In terms of houses, there was more condensation problems perceived in Tasmania and practitioners across multiple climate zones. Less was perceived in QLD, WA and Climate Zone 2.

The result of the survey has been analysed by myself and a team of statisticians, published alongside the main report that scopes the research and changes to the National Construction Code in comparison with those of other countries (Dewsbury, Law et. al. 2016). The essential finding is that condensation is a very common problem to encounter in residential buildings, the problem is very widespread across Australia, our codes are decades behind international best practices in managing and responding to condensation problems, and, when we factor in CIRS, the health implications we have on hand is potentially very serious.

> *...condensation is a very common problem, and very widespread across Australia*

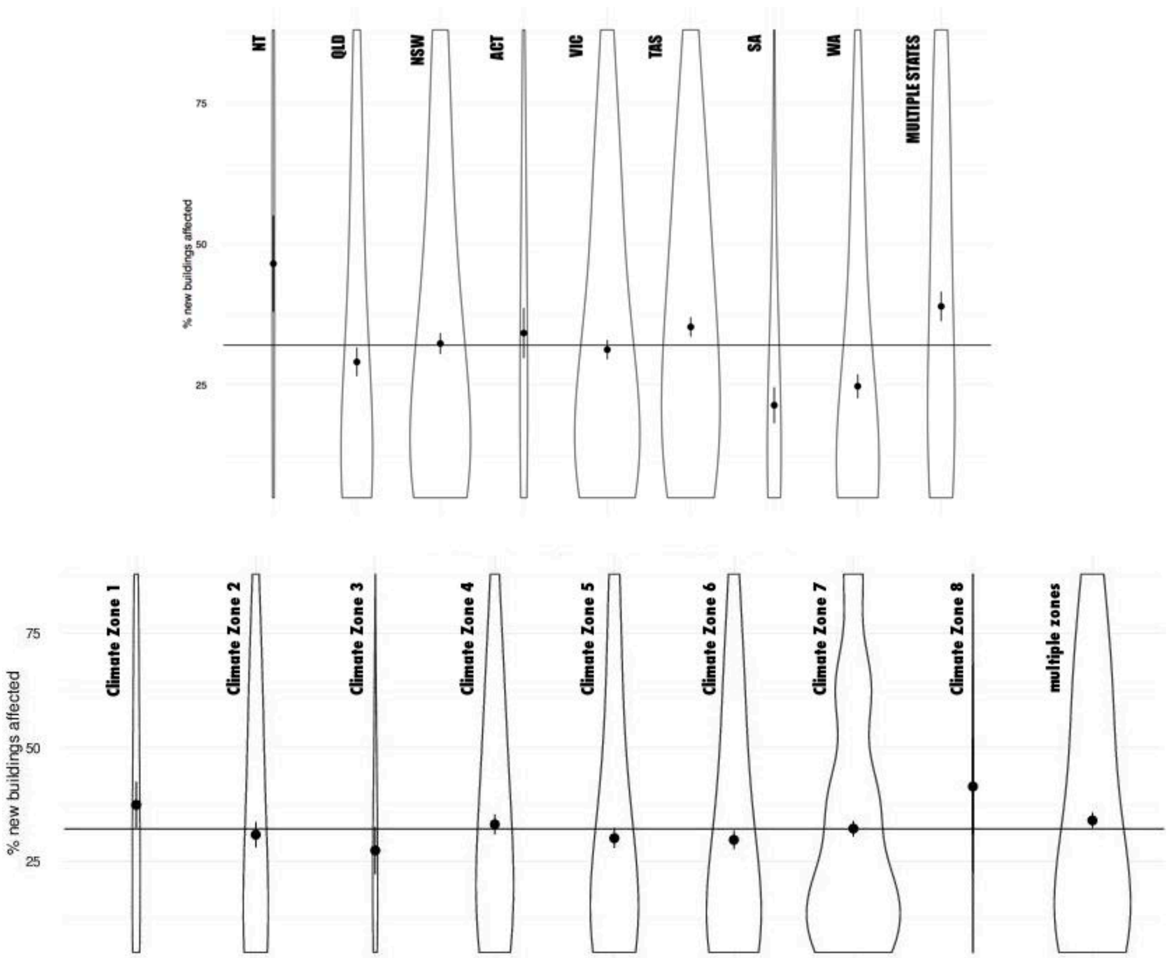

Figure 9: Distribution of responses by Australian states and climate types to the question, "What do you believe is the overall proportion of new residential buildings (both houses and apartments) affected by condensation?" Respondents categorised by state (top) or climate zone (bottom). Climate zones are defined by ABCB as follows: Climate zone 1 - High humidity summer, warm winter; Climate zone 2 - Warm humid summer, mild winter; Climate zone 3 - Hot dry summer, warm winter; Climate zone 4 - Hot dry summer, cool winter; Climate zone 5 - Warm temperate; Climate zone; 6 - Mild temperate; Climate zone 7 - Cool temperate; Climate zone 8 - Alpine; Multiple - Respondents that work in more than one climate zone. Each "violin" shows the distribution of state estimates, similarly to a smoothed histogram. The breadths are proportional to the subsample sizes; the central dot and bars show the estimated mean and its standard error. The horizontal line indicates the overall mean.

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Housing Minister under attack over claims toxic mould threatens tenants' health

Updated 21 Aug 2013, 3:22pm

A Government backbencher has raised concerns that Housing Tasmania homes are riddled with toxic mould, saying the problem is heading towards epidemic proportions.

Labor MP Brenton Best is maintaining his attack on Greens government colleague and Human Services Minister, Cassy O'Connor, begun in Parliament yesterday, that she is failing Housing Tasmania tenants.

He says inadequate heating of the public housing is exposing tenants to dangerous black mould, which he says causes significant health problems, especially for pregnant women.

"It can lead to birth defects or miscarriage in some cases," he said.

Cassy O'Connor has defended her record and says Housing Tasmania is dealing with the issue, with a limited budget.

The Opposition Leader Will Hodgman says open sniping between government members is not healthy.

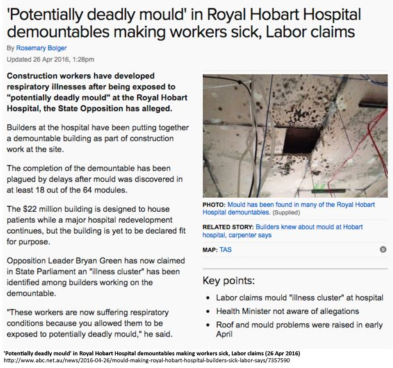
"Doesn't this just highlight Premier, how chaotic and dysfunctional your Labor-Green experiment really is?" he said.

PHOTO: Human Services Minister Cassy O'Connor has defended heating for Housing Tasmania tenants (ABC News)

RELATED STORY: Labor MP Brenton Best targets the Greens again

MAP: TAS

Housing Minister under attack over claims toxic mould threatens tenants' health Updated 21 Aug 2013, 3:22pm
http://www.abc.net.au/news/2013-08-21/housing-minister-defends-her-record-on-looking-after-housing--t/4901964



'Potentially deadly mould' in Royal Hobart Hospital demountables making workers sick, Labor claims

By Rosemary Bolger

Updated 26 Apr 2016, 1:28pm

Construction workers have developed respiratory illnesses after being exposed to "potentially deadly mould" at the Royal Hobart Hospital, the State Opposition has alleged.

Builders at the hospital have been putting together a demountable building as part of construction work at the site.

The completion of the demountable has been plagued by delays after mould was discovered in at least 18 out of the 64 modules.

The $22 million building is designed to house patients while a major hospital redevelopment continues, but the building is yet to be declared fit for purpose.

Opposition Leader Bryan Green has now claimed in State Parliament an "illness cluster" has been identified among builders working on the demountable.

"These workers are now suffering respiratory conditions because you allowed them to be exposed to potentially deadly mould," he said.

PHOTO: Mould has been found in many of the Royal Hobart Hospital demountables. (Supplied)

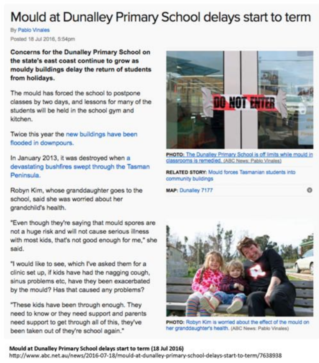
RELATED STORY: Builders knew about mould at Hobart hospital, carpenter says

MAP: TAS

Key points:

- Labor claims mould "illness cluster" at hospital
- Health Minister not aware of allegations
- Roof and mould problems were raised in early April

'Potentially deadly mould' in Royal Hobart Hospital demountables making workers sick, Labor claims (26 Apr 2016)
http://www.abc.net.au/news/2016-04-26/mould-making-royal-hobart-hospital-builders-sick-labor-says/7357590



Mould at Dunalley Primary School delays start to term

By Pablo Vinales

Posted 18 Jul 2016, 5:54pm

Concerns for the Dunalley Primary School on the state's east coast continue to grow as mouldy buildings delay the return of students from holidays.

The mould has forced the school to postpone classes by two days, and lessons for many of the students will be held in the school gym and kitchen.

Twice this year the new buildings have been flooded in downpours.

In January 2013, it was destroyed when a devastating bushfires swept through the Tasman Peninsula.

Robyn Kim, whose granddaughter goes to the school, said she was worried about her grandchild's health.

"Even though they're saying that mould spores are not a huge risk and will not cause serious illness with most kids, that's not good enough for me," she said.

"I would like to see, which I've asked them for a clinic set up, if kids have had the nagging cough, sinus problems etc, have they been exacerbated by the mould? Has that caused any problems?

"These kids have been through enough. They need to know or they need support and parents need support to get through all of this, they've been taken out of they're school again."

PHOTO: The Dunalley Primary School is off limits while mould in classrooms is remedied. (ABC News: Pablo Vinales)

RELATED STORY: Mould forces Tasmanian students into community buildings

MAP: Dunalley 7177

PHOTO: Robyn Kim is worried about the effect of the mould on her granddaughter's health. (ABC News: Pablo Vinales)

Mould at Dunalley Primary School delays start to term (18 Jul 2016)
http://www.abc.net.au/news/2016-07-18/mould-at-dunalley-primary-school-delays-start-to-term/7638938

Figure 10: News features on mouldy Tasmanian buildings in recent years.

Tasmania featured conspicuously in this survey, accounting for 23% of the respondents. In comparison Tasmania accounts for about 2% of the national building industry by market share. This is indicative of a high level of awareness and interest in condensation in the state. From housing, to hospitals and schools, mouldy buildings can be found making news across the state, see Figure 10.

> *Tasmanians exhibit a higher than typical awareness about condensation in buildings.*

There has been much work undertaken by the Tasmanian building regulator and the architectural scientists (myself included) at the University of Tasmania to raise awareness about condensation and mould in buildings. We have given talks across the state and nation, endeavouring to show that condensation inside a building can be as bad as water ingress arising from a building defect or faulty plumbing. We alerted architects, building designers, builders, building surveyors, and environmental health officers that, as opposed to such problems occurring in an ageing stock of buildings, most home owners would not expect their brand new houses to have a moisture problem of this nature. Unless something catastrophic happens, many will not even be aware they are experiencing a moisture problem every bit as serious as a leak. Hence the high response and over-representation of Tasmania in the survey should be seen not as higher than usual occurrence, but a higher than typical awareness.

For instance BSOL (Building Standards & Occupational Licensing), the Tasmanian building regulator, published a guide for architects and building designers to mitigate against condensation, Figure 11. The guide offers construction details as alternatives to what is typically done. Although the implementation of these details cost more upfront, there has been a marked improvement in the vapour management of houses with the adoption of this guide. The guide has been so successful it has been widely circulated and adopted unofficially but voluntarily by practitioners across Tasmania and Victoria.

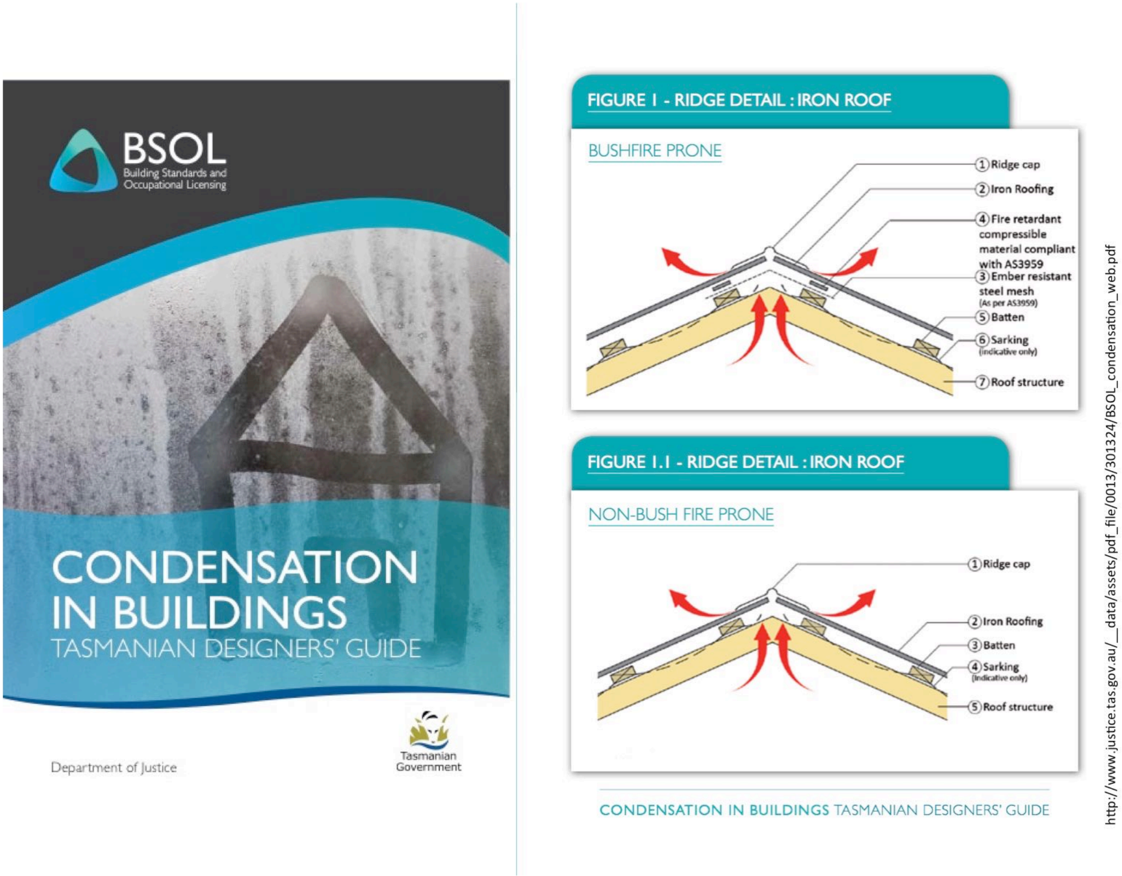


Figure 11: Cover and sample content page from the BSOL guide

Terms of Reference 6. Research into biotoxin-related illness caused from water damaged buildings

Although the term here may suggest that water in the form of a liquid is the problem, there is much to indicate that high humidities, and the phase change of water vapour to a liquid affects all buildings across Australia. Much of the work I have undertaken has been in Tasmania, and this has been looking at WDBs by virtue of the interest taken by the state building regulator and the availability of PhD level architectural scientists to undertake the research. Here is some of the research undertaken to date:

- 2014 *Investigation of Destructive Condensation in Australian Cool-temperate Buildings.* Department of Justice Tasmania: Contract Research. $56,000
- 2016 *Scoping study of condensation in residential buildings.* Australian Building Codes Board: Contract Research. $53,295
- 2017 *Condensation Risk Mitigation for Tasmanian Housing.* Department of Justice Tasmania: Contract Research. $62,067

Energy efficiency in Australian houses

In Australia the building codes ensure that there are minimum standards for residential dwellings. Indeed when the codes were first written in 1988, structural sufficiency, fire safety, health and amenity were the listed objectives. Home occupants could have a legitimate expectation that any house bought should be safe, healthy and have sufficient amenity. Subsequently, energy efficiency provisions were introduced into the Building Code of Australia in 2003, starting as a requirement for housing (ABCB, 2010). Various states within Australia would introduce different stated values of star ratings developed by the Nationwide House Energy Rating Scheme (NatHERS) for residences. Australian states independently and incrementally moved from the initial 4-star to the current 6-star requirements for energy efficiency. Table 1 illustrates the introduction of the requirements over time. The star ratings ascertain the amount of energy required to condition a house (and to a lesser extent artificially light or heat pools) in MJ/m² per annum and is determined at the design and specification stage of a house.

	Housing	Multi-residential	Non-residential
2000	*Announcement to mandate minimum energy efficiency requirements in the BCA*		
2003	Housing Provisions introduced		
2005		Multi-residential buildings provisions introduced	
2006	Housing stringency increased (5 star minimum)		Non-residential buildings provisions introduced
2009	*Announcement to increase stringency for all buildings*		
2010	Housing stringency increased (6 star minimum)	Multi-residential buildings stringency increased	Non-residential buildings stringency increased

Table 1: National Construction Code (NCC) energy efficiency requirements timeline for various building types (ABCB, 2016).

After a major bushfire in the state of Victoria in 2009, also called "Black Saturday" a new national standard (AS3959, 2009) was introduced to specify how new buildings were to be designed around bushfire prone areas. Currently in Victoria, without exemption all houses need to have some measure of bushfire attack resistance. Part of the strategy involved preventing cinders from entering roof spaces and a common construction method to deal with that has been to lay glasswool insulation blankets under the ridge and eaves of a metal roof to fill up the voids under a profiled metal roof, reducing the chance of ember entry. However, this approach also eliminated the option of naturally ventilating the roof space.

Increased energy-efficiency and bushfire regulation has prompted the construction industry to respond by constructing residences which were more airtight.

In the 2010 update to the Building Code of Australia (BCA), besides increasing the stringency of energy efficiency provisions, the new standard was included for construction in bushfire-prone areas. The industry, in response to making buildings more thermally efficient, had to also make them tighter. Air tightness of buildings not only contained heat better, it was also better at keeping cinders from blowing into the buildings. One might assume that these trends marked progress for both the environment and the homeowners.

However with increased air tightness, the industry started noticing a disturbing new trend: many new residential buildings were encountering copious amounts of condensation. The persistent damp from condensation has led to other problems with mould and its deleterious effects on human health. Condensation is a complex phenomenon and requires as a background some understanding of the psychrometry of air, vapour permeability and the temperature of the condensing surface.

Psychrometry of air

Where air moves freely it will carry moisture with it. Where air is stopped by a barrier, moisture may still move through, assuming the air barrier was vapour permeable. To understand the moisture content and transport through building elements we turn to psychrometry, the study of moist air. With any combination of two variables (typically being any combination of dry bulb temperature, wet bulb temperature or relative humidity) one can locate the coordinates on the psychrometric chart, and from there determine the dew point temperature, the point at which air reaches saturation and any further cooling will result in precipitation.

Psychrometry is one of the principle tools building mechanical engineers use to size and select air-conditioning equipment, and balance the loads between *sensible heat*, where heating or refrigeration causes temperature change; and *latent heat*, where energy is accounted for by a phase change like evaporation or dehumidification without a change in temperature. However other fields have very limited knowledge of psychrometry, if any at all. In the 2015 ABCB Condensation Survey, less than a third of the respondents were aware of how to apply a hygrothermal (condensation) analysis at the design stage.

Without a common understanding in psychrometrics it would be difficult to appreciate the significance of air tightness, vapour permeability and thermal bridging. Building scientist Lstiburek (2010) explains how a building envelope has four principal functions which, in order of priority, will be: rain control, air control, vapour control and thermal control. It would seem self-evident that an occupant in a cool climate would rather a house that was cold but dry, then one which was warm but damp. Unfortunately the contrary is largely observed which could derive from the emphasis on energy efficiency instead of vapour management in many Australian houses.

...once the droplets formed they did not dry out during the day. This persistence of moisture is observed throughout the months of winter

To illustrate this, in Figure 12 we see psychrometric measurements during early spring of a house in Tasmania, here coded House-BN. The heat pump is run 24 hours a day at a thermostat setting of 18°C, a typical heating system and setting for most houses in the temperate climates of Australia. Measurements in the roof are coincident in time but presented separately for clarity. Outdoor air, after being heated, increases in temperature and absolute humidity before entering the roof space. In this space, the absolute humidity increases further, indicative of moisture accumulation, and condenses against the sarking, resulting in precipitation under the roof. A snippet of time-lapse photography (Figure 13) cross-referenced against the temperature logs (Figure 14) provided a visual confirmation of the persistency of condensation, showing that even though condensation was not continuously occurring, once the droplets formed they did not dry out during the day. This persistence of moisture is observed throughout the months of winter on time-lapse photography.

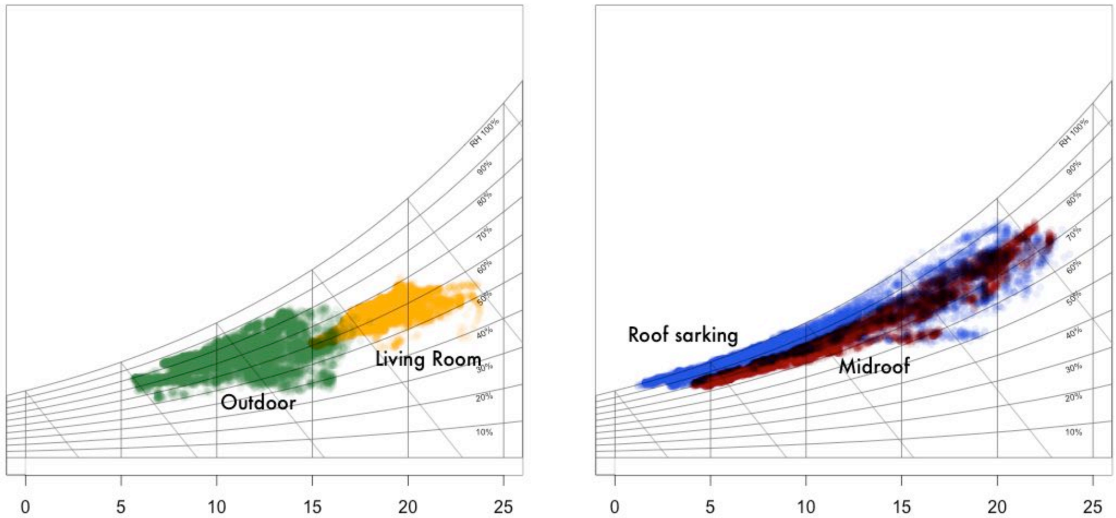


Figure 12: Psychrometric charts of House-BN in Tasmania measured during late winter.

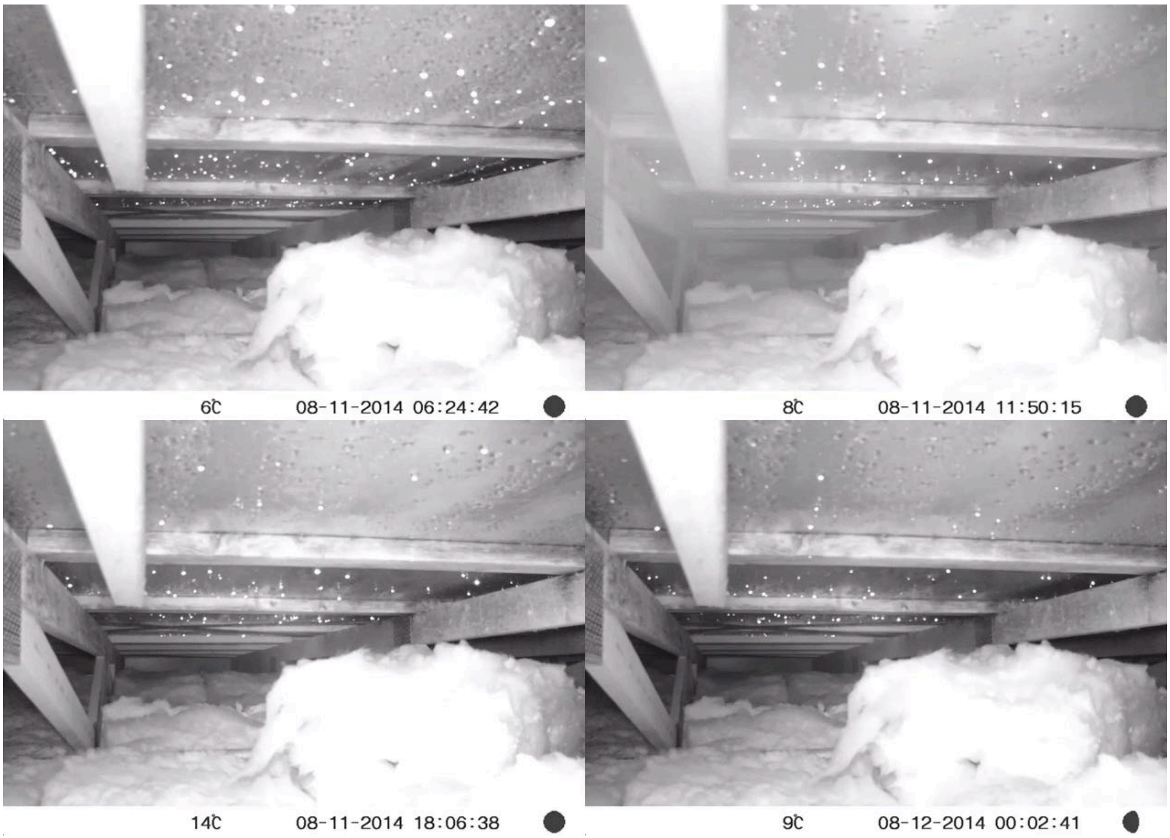


Figure 13: Selection of time-lapse photography to show persistence of droplets throughout the day

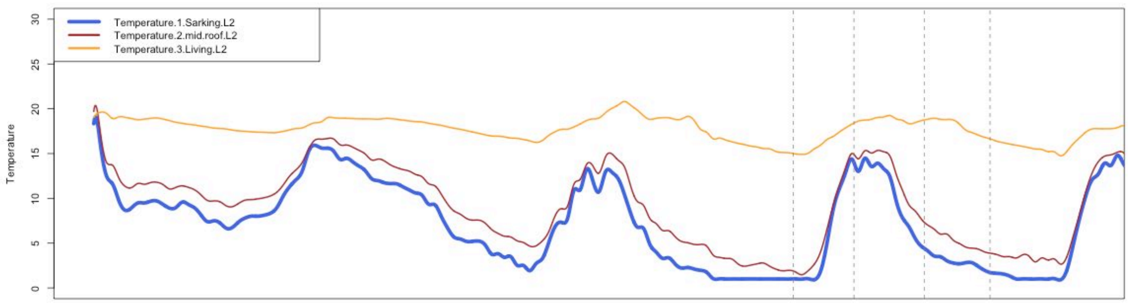


Figure 14: Temperature measurements in House-BN during same period, grey lines indicate timing corresponding to above time-lapse photographs

Vapour Diffusion, Air-tightness and Permeability

When still air has different amounts of moisture, indicated by its Absolute Humidity (AH), diffusion occurs naturally from higher to lower concentration. AH is calculated psychrometrically from measurements of temperature and RH and the values in the living room compared to the site AH is illustrated in Figure 15. The delta AH shows that living AH is almost always higher than site AH with the mean difference about 2.5g of vapour per kg of dry air. This difference in AH highlights a need for ventilation and a building fabric designed to manage vapour.

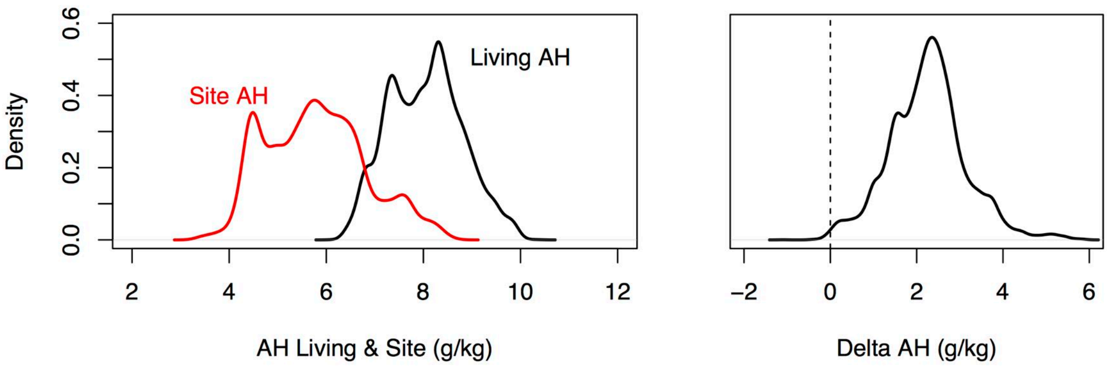


Figure 15: Frequency distribution of absolute humidity of site and living room air, and the difference between the two values for House-BN

In House-BN the house occupant, typical of most Australians during winter, does not ventilate the house at anytime throughout the day. We have corroborated our measurements with an interview with the owner. Besides security and privacy, the common conception is that it is most energy-efficient for the heat pump to be run continuously instead of only when occupants are present. This also corresponds to many occupants expectation that the house should already be comfortable before they return home, without having to wait for the air and surface temperatures to be comfortable. In Australia, although there are no code or national standard stipulations for space heating/cooling temperatures, there is an indication of expectation of a range between 18–26°C, in the context of how energy consumption is to be calculated for a performance-based verification method (Section JV3, ABCB 2016). To meet this expectation of round the clock comfort, the most energy-efficient heating system are heat pumps. Hence a cycle of self-reinforcement is produced, with the impression that continuous space conditioning with heat pumps is the most energy-efficient and cost-savvy approach to modern comfort.

Whilst this thinking is arguably reasonable, it leads to an important caveat, that in a continuously conditioned space without ventilation, the entire burden of vapour management is transferred to the building fabric of walls, floors and ceilings. Here, the vapour can be managed by either infiltration at junctions and penetrations, or allowed to permeate through the fabric. On a national average, Australian houses reportedly achieve 15.4ACH@50Pa (air changes per hour at a pressure difference of 50 Pa) with houses in Hobart significantly more airtight, with an average 7.9ACH@50Pa (Ambrose, 2013).

In a continuously conditioned space without ventilation, the entire burden of vapour management is transferred to the building fabric.

Uncontrolled infiltration is clearly not a viable way of managing moisture in cool climates. So instead of having indoor air replaced by the relatively drier outdoor air, the vapour from indoor air has to be allowed to diffuse through the building fabric of plasterboards, insulation, building wrap and then exhausted by a ventilated cavity.

The most commonly used building wraps in Australia are foil-based, the cheapest wrap to install. When punched with holes they are often advertised as ‘breathable’, a purely marketing term that carries no definition or control under the relevant standard (AS4200, 1994). However when the space between studs is filled with insulation batts, there is no free movement of air, so vapour does not ‘find’ its way to those openings. Instead when vapour reach the foil wrap, it encounters an impermeable surface and condenses against the wrap as it cools. In many cases, like the common brick veneer wall construction, once the house is completed it is prohibitively costly to replace a foil wrap with a vapour permeable one.

Ventilated cavities are not always required by code or by manufacturer’s details. Thus even when a selected wall cladding is vapour impermeable, like sheet metal or exterior insulation finishing systems (EIFS), many builders opt not to include wall battening to create a ventilated cavity, fearing that the additional work will price them out of a competitive tender. They in turn blame the architect or building designer for not requiring battens in the drawings, who in turn claim they are not required to know about the phenomenon of condensation, nor is there any legislative stipulation to ventilate the wall cavity. Most owners are not cognisant of this problem as the mould develops in the interstitial spaces. Even a borescope is of limited use as the walls are packed with insulation. The cladding has to be peeled back (Figure 16) to reveal the extent of damage at House-MW2, which was newly built and occupied for less than 2 months.

Figure 16: Often the true effect of condensation happens inside the wall framing. A builder helps dismantle the sheet metal cladding that is hard fixed against the studs (no battens) causing the wrap to be thermally bridged with the cold exterior. Indoor vapour, unable to pass through the foil wrap condenses on the insulation which acts as a reservoir, keeping the studs and bottom plate a moist breeding ground for mould.

Condensing surfaces in buildings

Whilst psychrometry analyses the condition of moist air in a space, condensation frequently occurs on surfaces with a temperature difference. The warm space (like a heated living area) supplies the energy for air to hold more moisture in vapour state. When this vapour laden air encounters a cold surface below its dew point it will condense on it. In Figure 18 the mid-roof and site (verandah) temperatures of House-BN are compared against the dew point of the living room. The frequency distribution show that for almost half the time, site temperature is below living dew point so building components in thermal communication between these two spaces, like aluminium window frames, will result in condensation (Figure 17). Similarly, the uninsulated part of the ceilings will allow cold roof space to cause condensation on any uninsulated part of the ceiling. Australia's experience with the poorly managed Home Insulation Program (Parker, 2014) has raised awareness to the importance of leaving a clear 200mm around down lights to avoid fires (Standards Australia, 2007). This however leaves an uninsulated area around the down light where mid roof temperatures were below living dew point, which for House-BN was 76% of the time (Figure 18). Two of these dripping down lights were directly above the master bed (Figure 19).

> *In winter, outdoor air temperatures are predominantly below indoor dew point, so any thermal bridge between the two will create an internal condensing surface.*

Figure 17: An example of what happens when there is thermal bridge between site temperature and living dew point: condensation on the aluminium frame of a south facing window.

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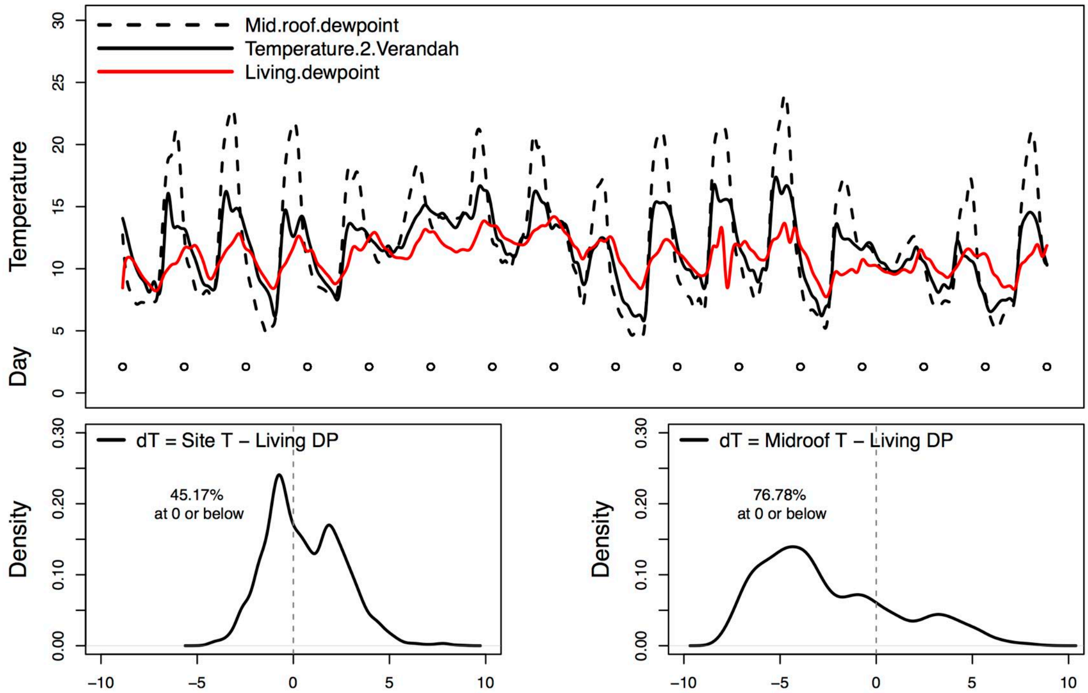

Figure 18: Top: Time series plot of midroof temperature, site temperaure and living room dew point. Bottom: frequency distribution of difference in temperature, where a negative value indicates condensation: site temperature vs living dew point, and midroof temperature s dew point.

Figure 19: An example of what happens when there is thermal bridge between mid-roof temperature and living dew point: condensation around the uninsulated downlight.

Roofs have been observed to be a particularly problematic area as the ceiling plenum covers many sources of moisture ingress and is itself one of the coldest surfaces, especially with the radiative losses on a clear night. Figure 20 charts the monthly average amount of radiation and daily measurements. However when overlaid with temperature of the roof sarking there is little correlation between radiation and roof temperature, i.e. a day with higher than average radiation does not appear to result in a higher than average roof temperature. Throughout winter, the roof is colder than the living room, even on sunny days.

With a roof so cold, even the conventional thinking of ventilating the roof space needs to be critically reconsidered. Figure 21 shows how the sarking is below site dew point more frequently (18% of the time) than it is below the roof dew point (7% of the time). In other words if more ventilation were to be encouraged, this particular roof would suffer even more condensation. Of particular concern is that any air from the living room leaking into the roof cavity would most likely meet a condensing surface (63% of the time). When the blower door apparatus was modified to pressure test the roof (Figure 22), we found major internal air leakages in powerpoints and pocket doors. When the roof cavity was tested at 50Pa it measured 71.2 ACH before 4 roof vents were installed and 72.7 ACH after

(2.1% increase). The roof vents, an example seen in Figure 23, thus had little effect on the leakiness of the roof. We can surmise that the source of moisture was primarily from the habitable areas travelling through service and construction penetrations into the roof cavity and condensing on the underside of the cool roof (figure 24).

Figure 25 compares the BN roof (white colour, sarking foil) with MW2 (green colour, insulated foil blanket). Both roofs experience unshaded sun. It is apparent the effect of roof colour where MW2 is able to benefit from solar absorptivity, even with a foil blanket. Without this insulation, the peaks would be even higher during daytime to assist in drying the roof cavity. So a common pitfall is that white roofs are particularly problematic around condensation in a cold climate.

White roofs are particularly problematic in cool climates.

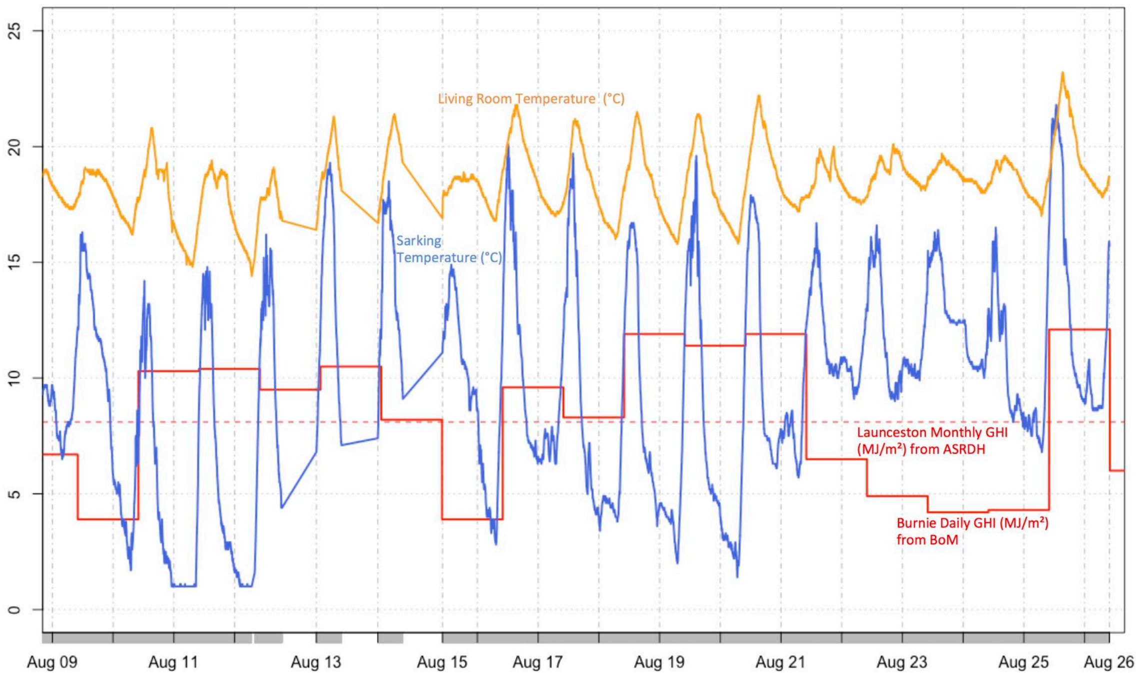

Figure 20: Time series of solar radiation: dotted red line shows monthly average from the Australian Solar Radiation Data Handbook (2006) of the nearest city Launceston, solid red line are measurements by the Bureau of Meteorology, Australia (in MJ/m²). Temperatures measurements in House-BN at roof sarking and inside living room

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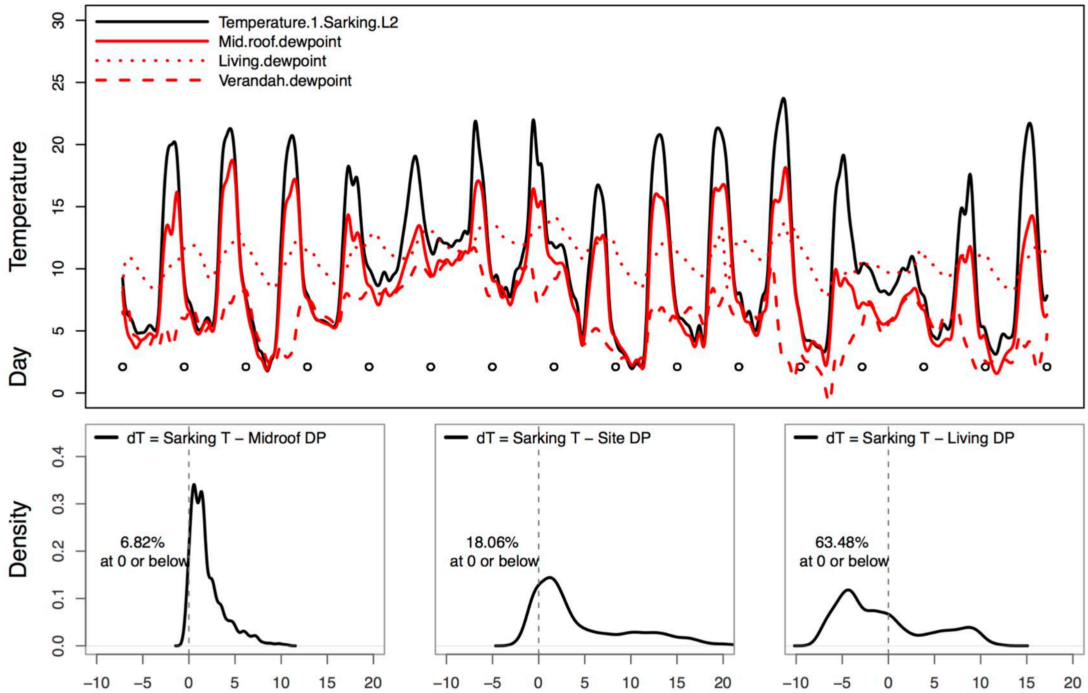

Figure 21: Top: Time series plot of sarking temperature, against the dew points of midroof, site, and living. Bottom: frequency distribution of difference in temperature, where a negative value indicates condensation: sarking temperature vs living dew point, sarking temperature vs site dew point, and site temperature vs living dew point.

Figure 22: Blower door apparatus modified for testing roof cavity,

Figure 23: Installation of roof ventilation, In total 4 of these vents were installed.

Figure 24: The constantly wet, and often dripping underside of the roof.

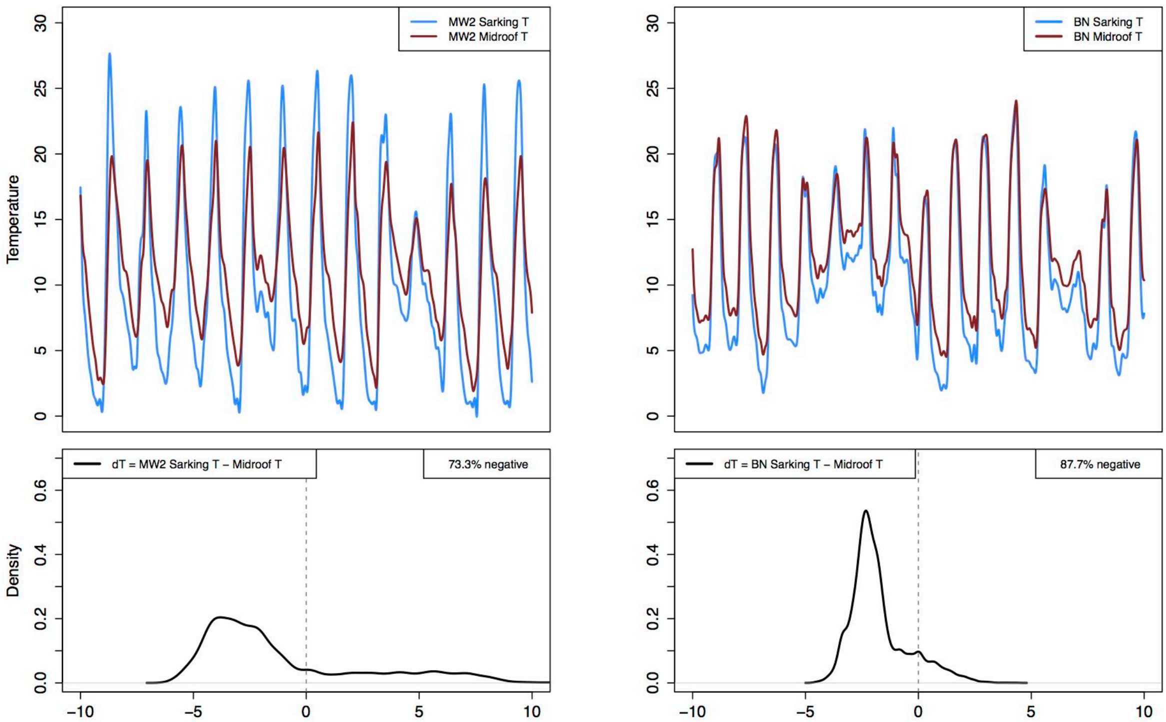

Figure 25: Time-series and frequency distribution of (left) MW2 mid-tone coloured roof and (right) BN white roof

The role of the roof to minimise condensation is not well understood, and attempts to increase energy efficiency by adding insulation to ceilings result in a variety of problems that exacerbate condensation. A number of common roofs are illustrated in Figure 26.

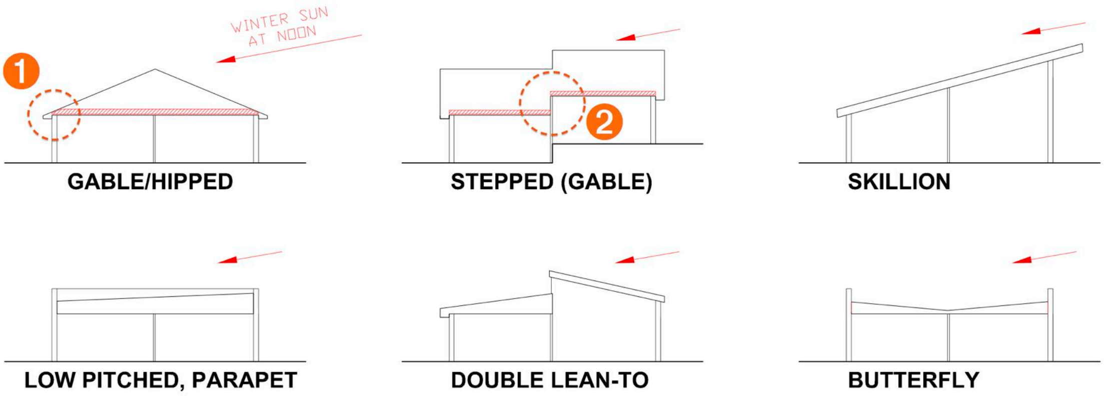

Figure 26: Common roof types in houses, each can be potentially problematic with condensation in winter.

There are may common mistakes with roofs, which can be avoided with an appreciation for condensation.

For the double pitched roofs like gable or hipped, orientation of the roof to the winter sun is immaterial as there will always be part of the roof exposed to the sun and this will increase the drying potential of the roof space, as long as it is well ventilated. The standard pitch of 22.5° allows moisture to run along the underside of the roof and drain at the gutter, assuming it is not blocked by ceiling insulation. When the roof is fitted and insulation installed after that, the installers are not able to determine where the edge of the walls are and typically push the insulation hard against the underside of the roof, creating a path for moisture to run into the ceiling. Particular care also needs to be given to instances where vertical surfaces appear in a roof, like when the ceiling is stepped in line with the site. Insulation installers often forget to insulate the vertical surface as they should the entire ceiling with the same level of insulation. Single pitched roofs like skillion roof are often used to allow higher walls on the sunny side, but this orients the roof away from the sun and limits its drying potential. Double lean-to roofs separate the two roofs and, for the shaded side, limits both the solar exposure and ventilation opportunities. This similarly affects the low pitched roof and butterfly roof, which has the same disadvantages and the additional problem of creating suspended droplets that will not flow down into the gutter.

Mould growth

Mould occurs on surfaces, thus water activity of the material is a far more accurate predictor of mould growth compared to relative humidity of the air.

The conditions that affect the rate of growth of mould is a combination of available moisture and available nutrient. Figure 27 shows isopleths for the germination and growth of mould from the Australian Institute of Refrigeration, Air-Conditioning and Heating (AIRAH, 2016) and the World Health Organisation (WHO, 2009). Although we see that in both cases, relative humidity (RH) has been presented as a determiner of growth rate, it should be noted that the RH of air is an indirect predictor of mould growth, microbiologists recognising that 'the effects of relative humidity on airborne microbes are complex and involve phase changes at the molecular level' (Kowalski, 2005, p.157). With so many aspects of aerobiological behaviour not fully understood it is no wonder that in the *ASHRAE (American Society for Heating, Refrigeration and Air-conditioning Engineers) Position Document on Airborne Infectious Diseases* , the only mention of humidity is that "humidity affects survival of the infectious agent although not always in predictable ways." (ASHRAE, 2009, p.5) Hence merely controlling RH in a space is a rather blunt and energetically costly way of controlling microbes like moulds, and I have investigated into the RH recommendations with much criticality (Law, 2013).

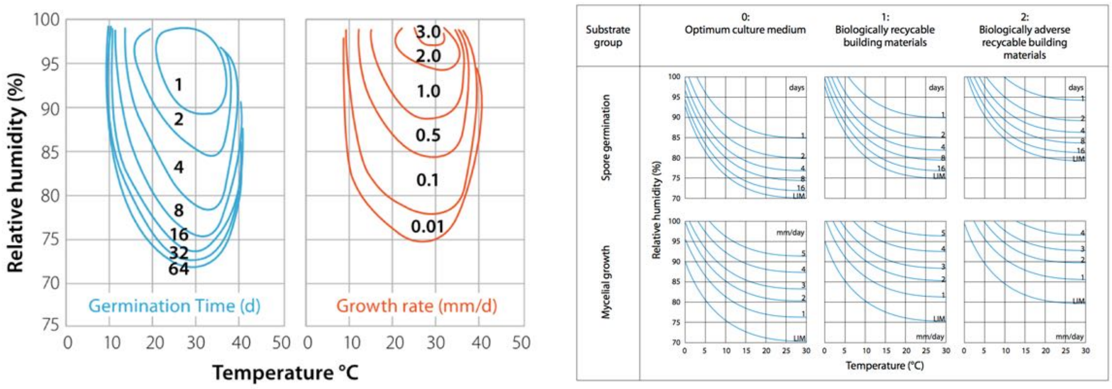

Figure 27: Typical conditions that affect germination and growth rates for moulds as established by AIRAH (2016) in its application manual "DA20 Humid Tropical Air Conditioning" and the WHO (2009) "Guidelines for indoor air quality: dampness and mould"

Rather than RH of air, fungal growth is predominantly controlled by the moisture content of a substrate and is likely if the water activity of a material exceeds 0.76–0–96, depending on fungal species, temperature, time and composition of a material (Pasanen, Juutinen, Jantunen, & Kalliokoski, 1992). Barbosa-Cánovas, Jr, Schmidt, & Labuza, (2008) provide the mathematical formulation to determine the water activity a_w based on substrate temperature T_s and the dew point temperature of the air T_d around the sample. This has been used to project water activity levels in the parts of the house subject to thermal bridging (Figure 28).

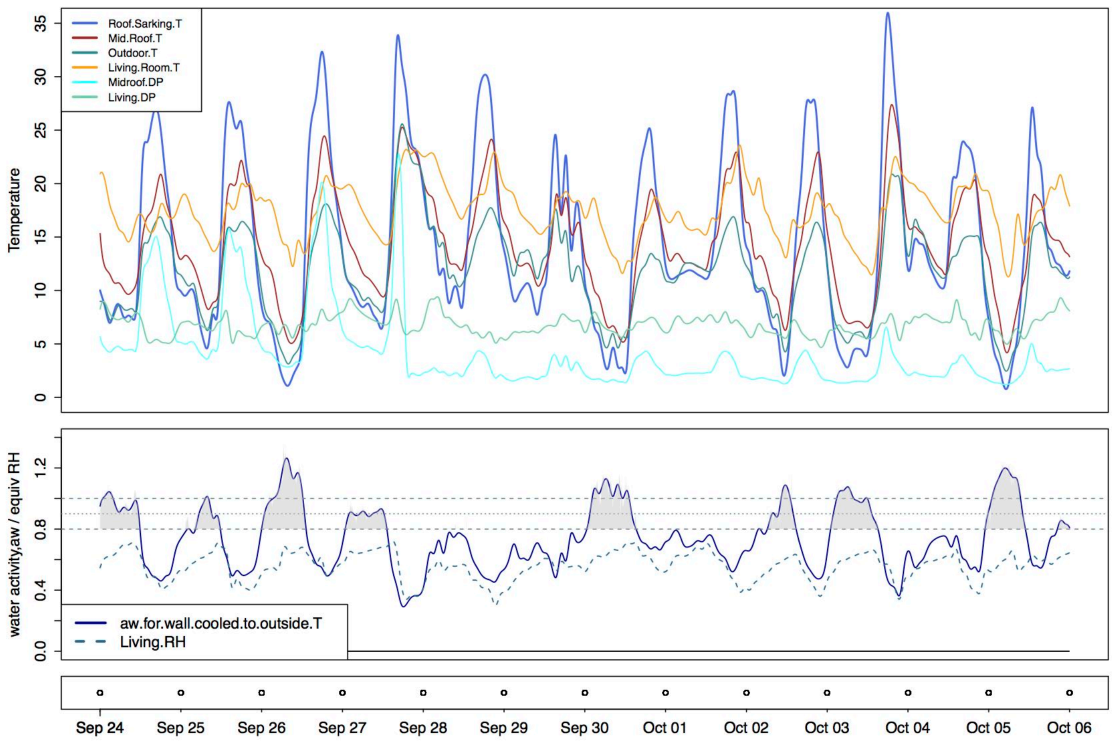

Figure 28: House-MW2 in Tasmania, measured in Sep 2014

In Figure 28 measurements were made of a House-MW2 in Tasmania. Based on the living room temperature and dew point there would have been no instance when the RH would have exceeded 80% (or 0.8 equivalent RH), let alone experience condensation. However since the sheet metal cladding was not constructed with a cavity, i.e. it was hard-fixed against the timber studs with a layer of vapour impermeable wrap in-between, it would be valid to assume there was large amount of thermal bridging occurring around the timber frame, especially the top and bottom plates of the wall structure. Using the outdoor temperature as T_s we see a very different profile of the *water activity* a_w for parts of the wall that were uninsulated, with frequent occurrences of a_w exceeding 0.8; and even exceeding 1.0 indicating the availability of 'free water'. If this water was not evaporated by the next day it will accumulate, and over time provide a continuous period of dampness to permit mould growth. In this house, condensation was visible around the windows and on the kitchen vinyl flooring (see Figure 29). Mould was observed in many instances on walls (especially behind furniture (Figure 30) and inside the walls and ceiling (Figure 31). Spore samples were collected on MEA (malt extract agar) settle plates and incubated. The following genera were identified: *penicillium*, *zygomycete*, *cladosporium* and *aspergillus*. After occupying this house for about a month after construction, occupants of this house were unwell with varying symptoms which were not present prior to occupation: one parent had laryngitis and a child had constant headaches. Unfortunately then and now, there are still no CIRS/Mould-Aware Health Professionals listed for Tasmania in the Toxic Mould Support Australia website.

The measurement of water activity corroborates with the evidence of mould occurrence much better than relative humidity measurements.

The family asked me, "Who had the authority to tell us to move out of their house?" This was so they could use that as grounds for a claim against the builders professional liability insurance. This question has troubled me much, and the more I looked into it, the more I felt this is call that has to be made by the highest levels of government.

Figure 29: Condensation forming on the kitchen flooring due to poorly installed insulation and a vapour impermeable vinyl finish. Around the window reveals the thermal bridging of the structure results in condensation.

Figure 30: Under the bed, the wall and carpet have limited exposure to the heating and experience thermal bridging to the external walls.

Figure 31: Inside the roof and walls where there is extensive condensation and mould growth on the timber strucure in the house that has been occupied for about 2 months.

So I have a WDB, what do I do?

Option 1: Have the occupant take responsibility

Allocating responsibility to the occupants is increasingly becoming the trend in Tasmania. Take for example the state's public housing's position on *Damp, Condensation and Mould* (Housing Tasmania, 2016) which states:

> In Tasmania, the weather in winter can be very cold and damp. This might cause problems with damp, condensation and mould in your home. You need to make sure there is no mould in your home. This is one of your responsibilities as a tenant.

CBOS (Consumer Building and Occupational Services), the building regulator in Tasmania, demarcates the responsibility between the builder for any lack of compliance with the code, stating that condensation is deemed to be a building defect if 'the builder has not complied with the relevant clauses of the BCA'. However there is little guidance or prescriptions in the code that directly relates to condensation. The bulk of the recommendation of the ABCB Scoping Study (Dewsbury, Law, et. al., 2016) have not made their way to the 2019 draft version of the National Construction Code. So if there is little requirement for compliance, who should be responsible?

> Where the requirements of the Building Code of Australia (BCA) have been complied with, the responsibility for controlling condensation by maintaining adequate natural or mechanical ventilation through the use of openable windows, exhaust fans, or other means, is the responsibility of the owner. (CBOS, 2017)

So the irony of pursuing energy efficiency has left occupants with having to manage ventilation by opening windows — and thereby negating the benefits of comfort and/or energy efficiency.

Option 2: Adopt international best practice

The lack of commitment to the injurious presence of mould contrasts to other countries where definitive positions have been taken. In the United States, the National Association of Home Builders has stated that "growth of any type of mold in a home is never acceptable" (Small, 2003). In Canada, the National Building Code (NRC CCC,2015) stresses that energy performance compliance "is not dependent on occupant interaction" (Section 9.36.5.3, clause 5), but on the building fabric and any associated automated mechanical systems. Health Canada, even as it acknowledged the lack of consensus with established exposure limits, was still able to recommend the following:

- to control humidity and diligently repair any water damage in residences to prevent mould growth; and
- to clean thoroughly any visible or concealed mould growing in residential buildings.

The management of condensation by any construction code, like all its other aspects, should be a robust standard with enough of a safety factor to accommodate foreseeable practical use of buildings. Rather than delegating responsibility — or more accurately abrogating responsibility — to the occupants, national regulation and state regulators should have systems of compliance that will produce resilient buildings. For instance, thermal bridging can be controlled by legislating a minimum thermal factor f_{Rsi} for every junction in every building, as has been done in Ireland (Government of Ireland, 2017). In the ABCB Scoping Study, we cited ample evidence from other countries so as to show that a happy balance can be reached between thermal comfort, energy efficiency and the proper management of vapour. We can still achieve all these objectives if we are clever and determined about it.

And why shouldn't we? As a nation we have shown the resolve to deal with big problems such as asbestos through regulation, enforcement, training and public education. I think mould is in many ways as serious as asbestos and deserves similar, if not more, attention. We can leave asbestos alone, and for the most part it would not trouble us. Not mould. It cannot be left alone. And neither will it leave the occupant alone.

Option 3: Use legislative powers

How sick does an occupant need to be before a house is uninhabitable? How mouldy does a building need to be before it is considered irreparable? And who should make the call?

In Tasmania, the Public Health Act (State of Tasmania, 1997) places these two responsibilities, of ascertaining unhealthy premises and issuing rectification notices, on the Environmental Health Officers (EHOs) and Building Surveyors respectively. The EHOs in particular have "very broad powers of entry and inspection" (Workplace Standards Tasmania, 2009) and the authority to issue rectification notices. In the event those notices are not complied with by the owner, they have the mandate to follow up with closure orders. Despite efforts to introduce guidance in understanding and remediating mould in Australia, like by Kemp & Neumeister-Kemp (2010a, 2010b) there are still no mandatory standards for the determination of the severity and required remediation of mouldy premises. Mould severity guidance to EHO's (Department of Health and Human Services, Tasmanian Government, 2015) is superficial, based largely on visual inspection of visible areas. Without understanding that the interaction of dew point and water activity is most severe in the interstitial spaces, most EHOs will not be able to look in the right places, much less require that the builder remove cladding and lining for a proper evaluation. Moreover the lack of detailed guidance places substantial responsibility on the EHO to make a subjective determination with enormous consequence to the property developer, builder, surveyor, designer and occupant. It is unsurprising then that to date, closure orders and rectification notices have not been known to be enforced for mould problems in Tasmania.

There is a significant resistance to the enforcement of the *Public Health Act* on unhealthy premises. It not only impacts the building design and construction industry, but the banking and insurance industries as well. If a home is rendered uninhabitable by mould, what would that mean for its resale value to the bank and insurance?

None of us would like to be in the position of an EHO ascertaining an *unhealthy premise*. There are no exposure standards, be it in Australia or internationally, offering a pass/fail standard in terms of colony forming units (CFUs) per m^3 of air. There is no consensus on the methods of mould sampling, the common ones being: tape lifts, surface sampling, air spore count, and culturable air sampling. Each of these methods has inherent variability, and are hard to repeat with consistent results (Connell, 2013). Each method has its use, and alludes to the overall moisture problem. However it takes much training to gather these insights into an overall picture. Thus when faced with such high stakes and little guidance, one can understandably be inclined to shy away from making any absolute determination against a WDB as being an unhealthy premise. This is an unsatisfactory situation, but this is the status quo.

> *Faced with such high stakes and little guidance, one is disinclined to diagnose a WDB as an unhealthy premise.*

Alternatively, we can equip EHOs with guidance and standards to make the call. The verdict should not be binary (healthy-unhealthy), otherwise the consequences are so immeasurably high that developers and landlords will contest every unfavourable verdict. Instead there should a graded scale, where the severity of the mould contamination upon inspection is commensurably met with the urgency and extensiveness of the remediation to follow.

This is what is currently lacking and is of utmost expedience. Failing here we fail everywhere.

Let me explain.

Option 4: Avoid or abandon buildings that fail us

Until the governing bodies take some definitive position, occupants are left to fend this on their own. Figures 32–33 show the options that tenants and homeowners face. Clearly, none of the choices offer them any assurance that the matter will be resolved satisfactorily. Even in a building with systemic water damage, many occupants would not see an urgency in leaving, and many owners would rather remediate it than to abandon it entirely. However to a CIRS patient in a severely water damaged building, the following excerpt is noteworthy:

> “I made contact with a leading toxicologist in the field, Dr. Jack Thrasher, and he explained that even with remediation, a systemic mold problem like ours was virtually impossible to eradicate. On October 4, 2008 we vacated our home. As advised, we treated the home like a fire — bringing nothing with us.”
>
> http://wholenewmom.com/health-concerns/black-mold-

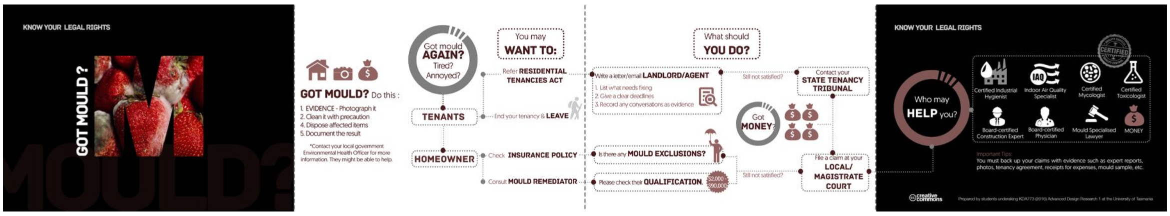

Figure 32: Infographics ‘What are your legal obligations and rights if you have mould in your house’.

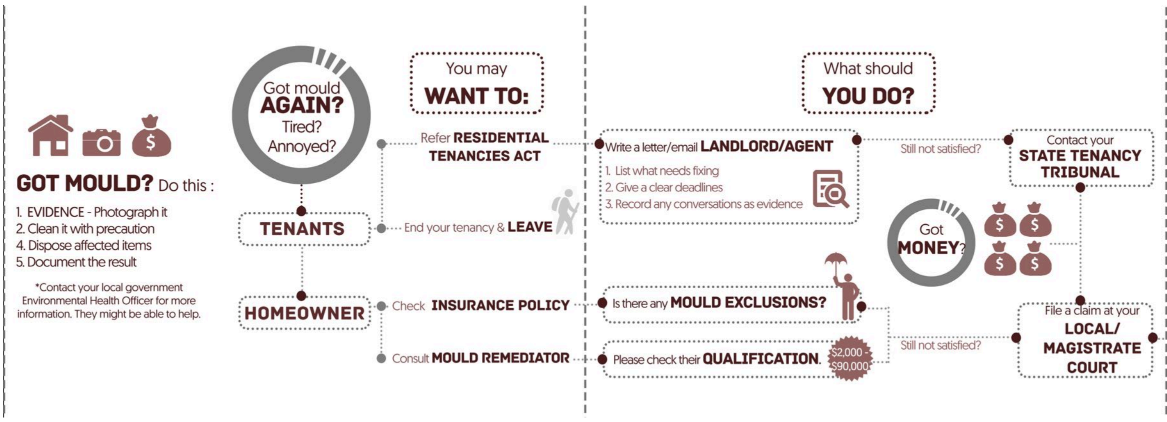

Figure 33: Centrespread of infographics enlarged for clarity.

Unless the underlying moisture problem is resolved, mould will simply recolonise.

It is of immense consequence that a house can not only be deemed uninhabitable, but irreparable as well. Tenants are facing landlords who will strenuously resist any admission of guilt that their buildings are the cause of illness. On the other hand, homeowners who live in a mouldy house are faced with an unregulated restoration industry. Restorers constantly battle against the loss adjusters estimation on the scope of works. To make matters worse, most insurance policies have exclusion clauses for mould occurrence aside from listed events. So mould arising from condensation in buildings would most certainly have no insurance coverage. Any form of remediation must needs be taken by the homeowner through an unregulated restoration and cleaning industry, where there are no Australian standards. However, even with thorough removal of the mould contamination, known as *source removal* in the trade (IICRC, 2015), unless the underlying moisture problem is resolved the mould will simply recolonise in a matter of days.

To take the American experience with hurricane Sandy, "Since there is no current standard requiring that mold workers be trained and mold remediated to evidence-based standards, residents in mold-infested homes are left largely to fend for themselves—not just to remediate mold, but potentially to rebuild for a second time." (ALIGN, 2013)

Or to explain this by a rephrase of the familiar story of Everybody, Somebody, Anybody and Nobody:

Water damaged buildings have such important health implications that Everybody assumes Somebody would take responsibility. Anybody could see the problem: Somebody should be responsible, but Nobody would. Anybody could have helped, because as long as Somebody told Everybody what to do, then Nobody would have the problem. So even though it affects Anybody and Everybody, it always ends up as Somebody's problem and Nobody's business.

Mould: somebody's problem, nobody's business

I anticipate you will be getting many submissions corroborating detailed personal experiences of mould being *somebody's problem and nobody's business*. It is important for the Committee to understand that CIRS is extremely debilitating and the impact on a CIRS patient to have access to work, medical treatment, mould sampling, remediation, renovation and reconstruction are all intertwined with their lack of legal recourse to hold anyone responsible for the state of WDBs.

Further research

The Committee has commenced an inquiry into biotoxin illness, this itself is a momentous step to address a national problem, and I applaud you in that. I would like to suggest that if the parliamentary inquiry can be accompanied by a research inquiry, it would make for a more successful outcome.

Even before the inquiry commenced, the Committee would have been aware that the medical community has had doubts whether biotoxin illness, or CIRS, was a medical entity. There is a gap between a condition occurring, and a condition being recognised. Where there is no recognition, research funding is unattainable, and data will remain scant, if any. We would all like to have answers, but answers needs research, and research needs funding.

You need to be aware that under the current research funding regime, CIRS will not be researched into, based on the opinion that it lacks sufficient scientific credibility. The problem is, that without research, it will continue to be regarded that way. The lack of research, and the unwillingness to fund research, maintain a joint stranglehold to keep a hidden illness invisible. As such, we cannot rely on the current funding bodies and institutions to provide the answers.

The lack of research, and the unwillingness to fund research, maintain a joint stranglehold to keep a hidden illness invisible.

Yet without a systematic and statistically representative sample, the inquiry will only have anecdotal answers to the terms of reference coming from personal submissions. There is a need for the Committee to provide research funding so as to obtain robust and representative data to the matter you are inquiring into, as part of the report that eventually gets tabled in parliament.

As opposed to research that is specialised, the nature of this research is extremely generalised in that it involves broad interdisciplinary effort, yet targeted in that it focusses on the impact of WDBs on health. In order to understand the significance of this problem, there is a need to bridge three distinct disciplines and uncover the interactive mechanisms between three profiles: the building profile, microbiological profile, and occupant health profile. Buildings need to be understood in the building physics of psychrometry and vapour management from design to construction. This physical environment needs to be studied with its impact on the biotoxin producing micro-organisms and their effect on human immunology.

Concluding thoughts

Condensation is a complex and systemic process in buildings, and poses serious health repercussions. Many of the complexities cannot be understood by a single discipline — we need a multidisciplinary approach. Condensation and subsequent mould growth appears to be a longstanding problem with indications that it might have been recently exacerbated in Australia by increased air tightness and thermal differentials that resulted from the construction industry's response to increased energy-efficiency and bushfire legislature, and also increased market-driven demands for thermal comfort.

The competitive building industry has led to inadequate consideration of vapour management at the design stage and improper installation during construction. Although there is acknowledgement of the condensation problem, there is widespread reluctance by any party from the construction or healthcare sectors to take a decisive and categorical position.

US photographer, Thilde Jensen, travelled across her country to document people who had extreme chemical and electrical sensitivities. Her photobook, aptly named *The Canaries* (Jensen, 2013), documents the stories of people who have had to make extreme adaptations to continue living in their houses, or have had to live in car, caravan or tents away from civilisation. Most people with CIRS also manifest a measure of either, or both, sensitivities. Her work is a visual insight into a world we do not often encounter, of what a CIRS patient has to similarly endure with when buildings fail them. The following figures 34–36 illustrate her work.

Figure 34: Jensen (2011) Everything Makes Them Sick, NY Times http://www.nytimes.com/interactive/2011/09/18/opinion/sunday/20110918_OPINION_ALLERGYGOBIG.html?emc=eta1&_r=0#1

Figure 35: Understanding Environmental Illness: A Photographer Documents Life Outside the Man-Made World http://www.featureshoot.com/2014/06/thilde-jensen-canaries/

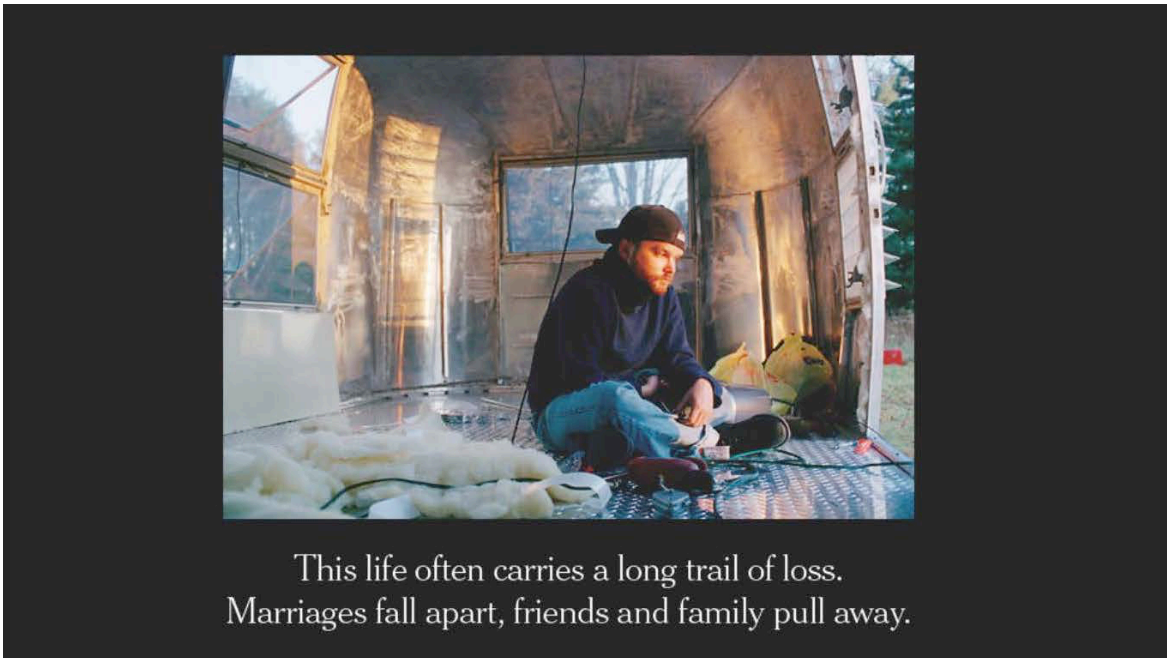

Figure 36: Everything Makes Them Sick http://www.nytimes.com/interactive/2011/09/18/opinion/sunday/20110918_OPINION_ALLERGYGOBIG.html?emc=eta1&_r=0#1

I trust we all can empathise with the loss. In the iconic 1997 Australian movie *The Castle* the protagonist says, "It's not a house, it's a home. A man's home is his castle… You can't just walk in and steal our homes." There is due indignation when one is robbed of his own home. Water damage threatens to do exactly that. The irony with condensation is that this was far more infrequent before energy efficiency standards pushed for higher thermal performance. The insertion of sustainability considerations into the mission of the ABCB now appears to challenge the prior objectives for safety, health and amenity. In extreme cases, these new houses can become uninhabitable within their first winter. When one in three Australian houses can trigger one in four people to have a chronic inflammatory response, we need to rethink if we had been too preoccupied with one sustainable development goal and completely forgotten that the house is our home, our castle. It is ultimately supposed to be a place to feel safe and healthy.

A man's home is his castle… You can't just walk in and steal our homes.

As I started out saying, this is a major and challenging issue of our time. I have applied a measure of personal exertion in this submission in the hope it will be receive by you with reciprocating interest, as you read and be roused. I have tried my utmost to stay within the terms of reference without glossing over the modulations of water damaged buildings on biotoxin illness and the much bigger picture.

I wish you the best in your inquiry, and would be happy to be contacted if necessary.

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