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HVAC&R FOR A BETTER WORLD

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To the Parliament of NSW's Portfolio Committee No. 2 – Health,

The Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) appreciates the opportunity to respond to the NSW Parliament's clean indoor air inquiry. This is a vital conversation, and we applaud the committee's leadership on the topic.

AIRAH is providing input based on our technical knowledge and diverse skill set across indoor air management in Australia.

AIRAH is a professional body comprising over 4,000 professional members across the HVAC and built environment and from private and public sectors. Our membership includes refrigeration technicians, HVAC contractors and HVAC cleaning operatives, filtration and air purification specialists, mechanical engineers and designers, ventilation specialists, building physics specialists, mechanical, electrical and other engineers, architects and designers, occupational hygienists, laboratory operators and academic researchers.

This document was prepared by the AIRAH Indoor Air Quality Special Technical Group and its advisors, and complemented by AIRAH's team. Several frameworks and standards are referenced across multiple sections of this submission. This reflects the structure of the Terms of Reference, which require consideration of the same instruments in relation to distinct issues, including work health and safety, building design, standards development, and climate resilience.

We would welcome any further questions and would be happy to present evidence to the committee in person if required.

Many thanks,

Mark Vender

Advocacy and Policy Manager

AIRAH

(a) the impacts of poor indoor air quality due to airborne pollutants and pathogens on:

(i) health

Indoor air quality impacts health in a remarkably diverse manner.

Poor indoor air quality can lead to short-term illnesses including allergies, eye, nose and throat irritation, and breathing difficulties. It is also associated with increased susceptibility to infection, particularly due to exposure to chemical pollutants and some microorganisms. Long-term IAQ-related conditions include health conditions like Chronic Obstructive Pulmonary Disease (COPD) and asthma, neurological effects, life-threatening lung disease from asbestos- and respirable crystalline silica (RCS), cardiovascular disease, and various types of cancer.

Poor indoor air quality is often associated with increasing rates of spread of respiratory viruses, as well outbreaks of building-derived infections such as Legionnaire's disease and aspergillosis.

Providing detailed guidance on the individual metrics that relate directly or indirectly to specific adverse health outcomes is beyond the scope of this submission.

AIRAH proposes the following framework to ensure that important considerations are not missed in the recommendations of this Inquiry:

- Health risks from inadequate indoor air quality are attributable to pathogenic and non-pathogenic sources, including organic and inorganic pollutants in indoor air, so it is essential to ensure a balanced approach that considers:
  - Person-to-person infection.
  - Building-to-person infection, including pollutants originating from damp building materials or systems (such as damp surfaces or areas of high humidity and condensation), or situations where the building acts as a secondary source of microbial pollutants. These include surfaces where pathogens can accumulate temporarily, continue to grow, or in biofilms where they can evolve and become more virulent and resistant to antimicrobial treatments.
  - Preventing entry of outdoor air pollutants, such as those from traffic, or vegetation smoke from planned burning and bushfires.
  - Recognition that the compounding effects of climate change caused by a failure to control and reduce greenhouse gas emissions will inevitably worsen all the above risks, especially when implementing technologies to improve IAQ.
- We need sustainable indoor air quality that results in zero harm to its users.

- There are substantial health exposure risks during vegetation burning. AIRAH has provided guidance to the NSW Government on adopting the ASHRAE 44 standard for smoke infiltration.
- Air moves easily along invisible pathways in response to air pressure differences and / or pollutant concentration gradients. Understanding its behaviour relies on technical experience, advanced instruments or highly developed airflow prediction models. There is a resultant need for a high level of skills when assessing or managing chemical, physical, or microbial airborne pollutants to accurately assess health risks. Many members of AIRAH specialise in the high-skills areas required for implementing improvements in IAQ.
- Other health risks such as those arising from exposure to inhaled lead, asbestos, respirable crystalline silica, and PFAS-related substances are appropriately addressed under existing regulatory frameworks. We recommend however explicitly acknowledging these pollutants as IAQ hazards of significant health concern, with cross-reference to current advice, best-practice documents, white papers, relevant regulations, and legislative instruments.
- Recommendations may include convening a focus group and liaising with relevant organisations on prevention and management of dampness-related microbial illnesses, led by the Australian Centre for Disease Control.

(ii) productivity and economic output

Performance and productivity are impacted in multiple ways by IAQ. Some examples we consider worth highlighting for the inquiry are:

- The link between poor IAQ and reduced productivity and output is driven by adverse health outcomes associated with infection spread in the workplace and public spaces. Many other IAQ factors also need to be considered when assessing overall economic performance and workplace productivity.

Examples of productivity losses include:

- Productivity losses that are associated with poor IAQ such as illness associated with airborne infection, leading to increased absenteeism.
- Sub-optimal work performance due to cognitive impairment and low presenteeism (which may have a much greater impact than absenteeism) can lead to higher rates of workplace errors and injuries through impaired use of technology and equipment, and stress-related illness arising from concerns about exposure to indoor air pollutants and from chronic conditions such as long COVID.

Economic impacts include:

- Increased salary costs arising from the need to pay overtime or to engage more expensive temporary personnel to cover absent staff, for example engaging higher-cost relief or supply staff when a schoolteacher is absent.
- Reduced output and delayed delivery leading to lower return on capital investment and decreased productivity.
- In some cases, IAQ concerns can lead to partial or complete shutdown of business operations, singularly or collectively, causing interruption, lost revenue and downstream economic and associated social impacts. Downstream economic impacts can include direct damage to the performance of other businesses (e.g. suppliers or customers) or, when widespread, the dampening of consumer and business confidence leading to retardation in investment and broader economic performance. The imperatives created can cause product quality compromises and impair business decision making. Associated social impacts can include distress caused by shortages or delays in product availability or reduction in quality (and attendant health implications), delays to medical procedures, and increased costs arising from competition for scarce resource.
- Costs associated with out-of-budget relocation or decanting of staff. Costs include those associated with business interruption, loss of productivity and investigation and remediation expenses in response to IAQ concerns or complaints that are commonly related to mould, malodour or a perceived cluster of a particular illness or series of adverse health symptoms.
- The financial impacts of damp buildings, mould, and biofilms on respiratory health, and potentially on long-term inflammatory or autoimmune disease in the built environment including homes remain uncharacterised at a public health level in Australia (AIRAH, 2025).

Damage to the operation and reputation of an organisation arising from these impacts include:

- Reduced service quality and poor customer satisfaction leading to reduced customer confidence, loss of future revenue and diminished organisational value.
- Increased workplace injuries leading to higher worker compensation claims, insurance premiums, and associated legal and administrative costs.

AIRAH has observed more broadly that:

- While the economic impacts of the pandemic are well documented (e.g. AS, 2023; Risse, 2023), infection prevention and reduction are not currently being addressed by the same working groups addressing impacts of mould and dampness on workplaces.
- In the event of changes in our existing circulating diseases, such as from increasing virulence or antimicrobial drug resistance, economic and productivity impacts need to be considered. Preventing infection is critical to reduce the growing impacts of long-COVID on our economy and national productivity, as well as our families and communities.
- ASHRAE Standard 241 (Infection Control) (ASHRAE, 2023) uses the measurement of ventilation rate in units of litres per second per person. Reducing the density of infectious individuals in a space immediately increases the effective ventilation rate, achieving the targets set out under 241 at times of high risk (Infection Risk Management Mode) with little to no additional capital or operational cost. Education and reframing infection transmission as being firstly about preventing spread reduces the economic costs of increasing ventilation, treating larger volumes of air and reduces the impacts discussed on staffing costs.
- A further consideration is the choice of metrics used to assess health outcomes. We recommend consulting epidemiologists, public health and occupational hygiene specialists when selecting metrics such as Disability Adjusted Life Years lost (DALYs) in ways that can be incorporated into cost-benefit and productivity analyses, rather than relying on broader notions of “health”.
- Resources are needed to educate the public about the risks associated with poor IAQ to health and the resulting economic impacts. Increased awareness is essential to demonstrate that reducing harm and achieving financial success and economic productivity are mutually reinforcing outcomes.

(iii) work health and safety

- The factors impacting economics and productivity often arise from poor work health and safety practices.
- The health protection of healthcare workers is currently under-considered. There are frequent failures in ventilation and PPE, or screening (NNU, 2024). While healthcare settings, especially hospitals, have strong systems in place to protect patients, the systems are often not designed around worker protection. AIRAH has a Special Technical Group focusing on hospital infection prevention and supports a multi-layered approach to worker safety in clinical settings.

- Educating the workforce better on infection prevention by staying away or mask-usage when infective in public places should remain a mechanism for improved work health and safety. The absence of consistent, positive messaging focused on protecting others in the workplace and those they are in contact with represents a critical gap both now and in preparing workers for the next pandemic.
- An infection outbreak in a workplace should be viewed as a WHS incident arising from inadequate management of people, and design and management of ventilation, and air filtration or purification systems.

(iv) equity of access to public services and spaces

- AIRAH continues to support the Safer Air Project, the Australian Academy of Science, THRIVE and other organisations setting the pathway to clean air through regulation and with a strong focus on accessibility and public health protection, given the significant proportion of the population who are vulnerable to infectious disease or damp buildings. Consideration of the increasing number of individuals with chemical sensitivities may also be needed.

(b) indoor air quality standards and monitoring

- Indoor air quality has become a key driver for policy and regulation.
- AIRAH supports any initiatives to create and strengthen indoor air quality standards proposed to reduce mid- and long-range airborne pathogen transmission in the built environment and supports the pathway to clean air proposed by the Australian Academy of Science. AIRAH further supports the importance of developing standards and ratings systems targeted at IAQ improvements across all indoor and outdoor pollutants, not just focused on infection prevention.
- AIRAH further recognises that well designed, operated and maintained buildings by their nature can be highly protective for IAQ. We therefore consider that IAQ standards need to align with current and emerging standards governing building design and operation, and should reduce the introduction, spread and accumulation of air pollutants in the building. Practical, meaningful standards suitable for effective implementation across the range of building types will lead to better indoor air quality.
- When focusing on airborne infection control and prevention, AIRAH would look to mechanisms such as the ASHRAE standard 241 (ASHRAE, 2023). This is designed around measurement and achievement of sufficient equivalent clean air to achieve a desired level of airborne infection transmission reduction based on a building-specific and case-by-case basis rather than a blanket threshold.

- The inquiry should also consider the strong relevance of BS/EN 16798-3.25, which provides for risk-informed selection of air filtration and ventilation strategies based on the intended use of the occupied space. The standard classifies air quality performance in classes of I to V. Ratings are based on the WHO's 2021 $PM_{2.5}$-classification of outdoor air quality. Other relevant standards include the AS/ISO 16890:2025 standard for current air filter classifications in Australia.
- We also consider there to be high value in the BS EN 15665:2009 and CEN/TR 14788 standards for ventilation in domestic dwellings.
- We also wish to address the current indoor environment rating system in Australia that is based on building and occupant (tenant) performance. The National Australian Built Environment Rating System (NABERS) provides an established and internationally recognised structured tool for assessing building performance and includes a suite of IAQ indicators. NABERS offers a monitoring program that provides benchmarking and creates a platform for continual improvement.
- While the expansion of NABERS to incorporate real-time monitoring would require further industry and scientific development, and governance, we support NABERS as a foundational tool for standards development and a national approach for IAQ in Australia and strongly encourage investment in the development of a tailored IAQ tool. The additional benefit of taking a NABERS approach is that data is commonly collected on energy use in the building, providing the link between indoor air quality, sustainability and climate change prevention.
- International frameworks such as the WELL Building Standard place a stronger emphasis on occupant health and wellbeing outcomes, including indoor air quality, ventilation, and exposure management. Parallel development of such national and international approaches would highlight the value of aligning building performance metrics with health-focused outcomes.
- AIRAH also recommends maintaining a global perspective when setting the Australian IAQ agenda. Considerations may range from border controls to engagement in global research projects and standards development. Many AIRAH members are involved in key international developments, which Australia may wish to monitor. We would be happy to support any initiatives put forward in response to this inquiry.
- AIRAH recognises the opportunities ahead for our industry in supporting IAQ initiatives by our ongoing commitment and member engagement in the development of existing and new standards across physical, chemical, and microbial airborne pollutants and their prevention.

- Monitoring with correctly calibrated, accurate, precise, functioning and well-located sensors plays an important role in identifying IAQ performance issues, often reflecting shortcomings in operation, design, commissioning or maintenance. AIRAH therefore supports a layered approach that integrates design intent and performance outcomes, seeking solutions that allow monitoring and management practices to inform each other continually.

(c) solutions to improve indoor air quality, including but not limited to:

(i) building design, in particular schools, health services, and public buildings

As established above, IAQ impacts arise mainly in response to exposure to a pollutant source by inhalation, although surface-based contamination arising from airborne pollutants is also a risk in sensitive environments such as hospitals. Health risks also arise from reservoirs within a building where pollutants have accumulated, increased in concentration (in the case of microbial contaminants like dampness-related microorganisms) or transformed to a more harmful state (such as through undergoing secondary chemical reactions or in biofilms).

The opportunity for person-to-person transmission, as well as the release of hazardous residues from surfaces into the air, should be considered, as even modest levels of surface disturbance arising from normal human movement can substantially alter inhalation exposure and risk to occupants. Accordingly, understanding building use, occupant sensitivity and occupant density is essential.

Indoor thermal and moisture conditions can influence indoor chemistry and the survival and persistence of pathogens. It is therefore a particularly important consideration in certain settings.

These considerations are particularly important in schools, where dust accumulation, moisture and crowding influence exposure risks; health services where biofilms, *Legionella pneumophila*, non-tuberculosis mycobacteria, and antimicrobial resistance must be controlled in plumbing HVAC systems; and public buildings where the occupancy conditions may vary significantly between building types.

As previously noted, exclusion of external air pollutants (such as particulate matter and nitrogen dioxide or ground level ozone) is important at the design stage. This calls for coordinated planning of intake or clean indoor make-up air strategies, accurate filtration system and capacity requirements, and intelligent smoke-exclusion systems that communicate with building management systems.

Such considerations are critical in health services and public buildings. Again, AIRAH acknowledges the critical importance of standards such as ASHRAE 241 and the air ventilation standard BS/EN 16798-3.2025 in providing practical measures to achieve better quality air in existing built infrastructure, especially in schools, regional centres and facilities with older mechanical or building infrastructure.

There are plans for public spaces to be deployed as shelters at times of vegetation fires. It is important to manage human-generated pollutants such as carbon dioxide (CO_2) and respirable pathogens in situations where crowding is a likely issue, and to have available suitable supplemental or emerging technologies that minimise infection risks under high density occupancy for extended timeframes in facilities not designed for this purpose.

Design factors that influence risks from building dampness include the choice of insulation, waterproofing, drainage and the choice of building materials. Careful selection of materials in flood-prone areas that reduces wicking and moisture retention can significantly reduce the health impacts and economic cost of building closure, recovery and restoration.

We recommend treating healthcare as its own IAQ category. Changes to maintenance regimes may be required in healthcare settings due to a shift in emerging infection risks, including from antimicrobial resistance. In an increasingly moisture-challenged climate, more frequent servicing or greater protection of cooling coils, ducts and other HVAC components should be considered, with attention given to both cost and environmental impacts. Recommendations extend beyond building design into zoning, air movement control and verification, and worker-focused protection.

Public transport use represents a currently underestimated risk to both staff and travellers from poor IAQ that should be prioritised. Despite relatively short exposure durations when travelling, elevated levels of entrained dust from the external environment are brought into and resuspended in transport vehicles. All human-derived pollutants such as CO_2, volatile organic compounds (VOC), and respiratory pathogens can reach extremely elevated levels. We therefore recommend dedicated consideration of IAQ in public transport.

When managing school classroom environments for infection prevention, AIRAH highly recommends that the report references the use of real-time infection risk models, such as that developed by Mahmoud *et. al*. in 2025. Models should be capable of assessing ventilation and filtration system performance by using real-time particulate matter measurements for estimating infection risk and safe occupancy time. Such models support public health decision-making by defining maximum allowable class durations and break intervals, and support facility management in identifying zones where occupants can safely remain for longer periods, while highlighting areas that require intervention or restricted use. This enables optimisation of seating arrangements, allocation of high-risk activities such as speaking or group work, and evaluation of the impact of adding or relocating HEPA filters. From an engineering design perspective, these assessments provide quantified justifiable changes in system operation while demonstrating that infection-risk criteria have been met.

(ii) retrofitted measures, including but not limited to ventilation and/or filtration systems and emerging technologies.

When focusing on airborne infection control and prevention, AIRAH would look to mechanisms such as the ASHRAE 241 (ASHRAE, 2023), which provides a mechanism for deploying supplemental technologies or retrofit measures to achieve sufficient equivalent clean air to meet requirements.

We recognise the benefit of the approach of ASHRAE 241 as a protective instrument that provides accessibility to vulnerable people at all times. We also consider the value of EN 16879.2025 as a mechanism for considering retrofitting of air filtration for managing particulate pollutants.

A third section with the Terms of Reference may be warranted to cater for the role of building operation. Operational factors that may be necessary to avoid negative IAQ impacts on health, productivity, and economic costs include:

- A requirement for appropriately conducted building commissioning prior to handover, including airflow verification and ventilation effectiveness, especially for critical uses such as healthcare.
- Training for facility managers, HVAC engineers and other relevant personnel in selecting products and furnishings, and understanding and managing airflow, moisture control, and infection risk reduction.
- Training for relevant personnel in surface contamination prevention and control, necessary cleaning of the building and mechanical systems (including split system air conditioners), filter selection and replacement and maintenance of HVAC components.
- Training and education that supports an understanding of how IAQ pollutants are generated and transported, how they accumulate and transform under different conditions, and how these processes can be influenced through building design and operational controls.

(d) implications for climate resilience and pandemic preparedness

AIRAH operates across climate resilience, indoor air quality, and the design and operation of mechanical services.

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We consider that the Terms of Reference should include broader implications for harm prevention and long-term accessibility and sustainability, particularly at the intersection of climate resilience and pandemic preparedness.

The interaction of climate resilience with pandemic preparedness is complex and bi-directional.

There are numerous ways that being under-prepared for a pandemic would impact climate resilience, including:

- Expenditure required to respond to a pandemic could divert it from funding otherwise destined to design and provide resilient indoor spaces, renewable energy projects, climate-resilient private and public housing, waste recovery programs, energy efficiency and insulation improvement programs, and low-emissions refrigeration technologies.
- Surges in demand for large-scale vaccine and personal protection manufacture and associated logistics could create volatile supply chains. Rapid peak-demand-driven expansion may reduce oversight of emissions controls and environmental standards across the manufacturing, distribution and transportation networks, with increased overseas supply generating high transport-related emissions.

Climate resilience impacts resources for pandemic preparedness in the following ways:

- Convincing evidence is emerging that a change in climatic conditions is likely to result in a shift in the geographical distribution of infectious diseases in Australia. The World Health Organization has listed 19 priority fungal pathogens (WHO, 2022) and 24 antimicrobial-resistant bacterial pathogens (WHO, 2024) of increasing concern, with climate change recognised as a contributing factor to their expanding geographic range. Certain pathogens arising after climate disasters have been reported for the first time along the Eastern side of Australia (Notarus *et. al.*, 2025), with a sharp increase in serious flood-related melioidosis in 2025 demonstrating this risk in real time. This means that climate resilience should *include* pandemic preparedness as a core tenet of its definition instead of treating it as separate or competing policy objective.
- AIRAH considers that policy should emphasise pandemic prevention rather than preparedness. Prevention focuses on reducing the likelihood and scale of a pandemic response. We recommend that resources be directed toward air treatment and handling strategies across indoor spaces such as homes, workplaces, healthcare settings, transport systems and recreational facilities as a foundational measure to reduce population-scale transmission.

- Current climate forecasts predict a higher incidence and severity of vegetation fires, and fuel-reduction measures such as planned burning. Resultant outdoor air deterioration will likely increase demand to limit, exclude, filter, or treat incoming external air and reduce our ability to view outdoor air as a reliable sole mechanism to ventilate buildings without considering its quality. Consideration of the role of HVAC in providing climate resilience is pivotal when preventing or managing a pandemic.
- It is important that the inquiry examines approaches in Australia and internationally to reduce infection spread by delivering "effective" clean air that may assist in reducing large-scale infection spread while remaining climate resilient and lowering emissions. Deploying certified supplemental technologies or using air from a "clean" part of a building can make up shortfalls that would otherwise rely on outdoor air (ASHRAE, 2023). The reduction in the volume of outdoor air treated for ventilation further reduces energy load and can protect the indoor environment from unwanted extremes in humidity when cooling large volumes of humid air or heating large volumes of dry air that otherwise carry their own health risks.
- The inquiry should also consider the strong relevance of BS/EN 16798-3.25, which provides for risk-informed selection of air filtration and ventilation strategies based on the intended use of the occupied space. The standard classifies air quality performance in classes of I to V. Ratings are based on the WHO's 2021 $PM_{2.5}$-classification of outdoor air quality.
- Increases in bushfire frequency, extent, and duration may increase demand for HVAC filter replacement and upgrades, not only to protect occupants from incoming particulate matter, but to reduce the potential negative impact on infection transmission when external air intake rates are reduced. This will carry an increased climate and resource burden that warrants consideration and create potential for system failure when making inappropriate filter upgrades for a particular mechanical system.
- Increased bushfire activity may lead to more intensive crowding indoors for more extended periods, thereby creating a higher risk of transmission of airborne infectious agents.
- Controlling humidity and moisture in our HVAC systems and buildings is critical in providing high-quality indoor air. Poor humidity management may significantly reduce our ability to protect occupants from the outcomes of an airborne respiratory infection:
  - Warming increased outdoor air loads during cold periods in drier parts of the country will result in exposing occupants to very low humidity air, strongly linked to increased vulnerability to infectious illnesses due to drying of mucous membranes, reductions in aerosol particle sizes that allow deeper respiratory deposition, and the preference of some pathogens for low humidity conditions.

- Cooling a larger volume of outdoor air in humid parts of the country increases moisture levels in buildings. Elevated humidity is expected in many cases to increase the survivability of airborne pathogens, while increasing the potential for mould growth on surfaces and in dust, and for biofilm development in HVAC systems. As previously stated, biofilms have been associated with increased pathogenicity and antimicrobial resistance. These conditions may also increase the frequency of filter replacement required to maintain acceptable indoor air quality.

(e) any other related matters.

We suggest that the proposed Term of Reference may be missing a vital element, namely the impact of climate-driven changes in indoor environmental conditions on non-pandemic related diseases. Diseases where increased risk may be anticipated include Legionnaire's disease and other dampness-associated illnesses such as Pontiac fever, and broader health complaints such as asthma, allergies, and those associated with dysfunctional inflammatory and immune responses.

We would also like to raise awareness of risks in cold, dry environments where heating can lead to low humidity and increased infection risk.

We would encourage maintaining humidity within buildings in a way that meets both thermal comfort and minimises risks of infection, dampness and biofilm development.

We would request that existing frameworks and standards are further developed and leveraged to ensure humidity is treated as a key IAQ parameter.

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