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8 August 2017

Committee Secretary
Senate Standing Committees on Environment and Communications
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Re: **Inquiry into current and future impacts of climate change on housing, buildings and infrastructure**

Dear Secretary,
On behalf of the Centre for Sustainable Infrastructure of Swinburne University of Technology, we would like to make a submission to the above inquiry specifically addressing the first three items in the Terms of Reference:

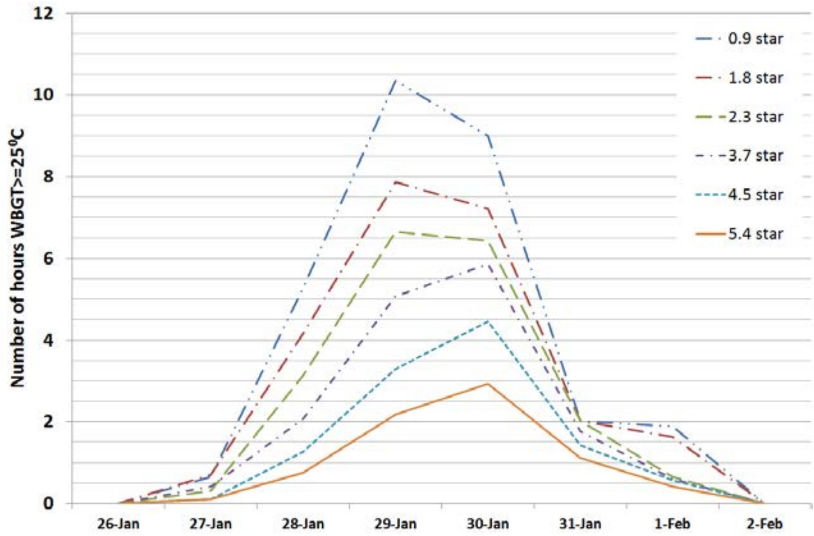
- the impact of these changes on private and public housing;
- the impact of these changes on health, education and social services infrastructure, including hospitals, schools and aged care;
- the adequacy of current state and Commonwealth policies to assess, plan and implement adaptation plans and improved resilience of infrastructure;

The Centre for Sustainable Infrastructure (CSI) provides a focus for multi-disciplinary research in the field of sustainable civil infrastructure. During 2012-2015, this centre was involved with five other Australian universities in a CSIRO Flagship cluster project "*Climate Adaptation Engineering for Extreme Events (CAEx)*" which was aimed at assessing the impact of climate change on the urban infrastructure and finding adaptation strategies. As part of this project, our research team investigated the impact and adaptation strategies of heatwave on the occupants of residential buildings.

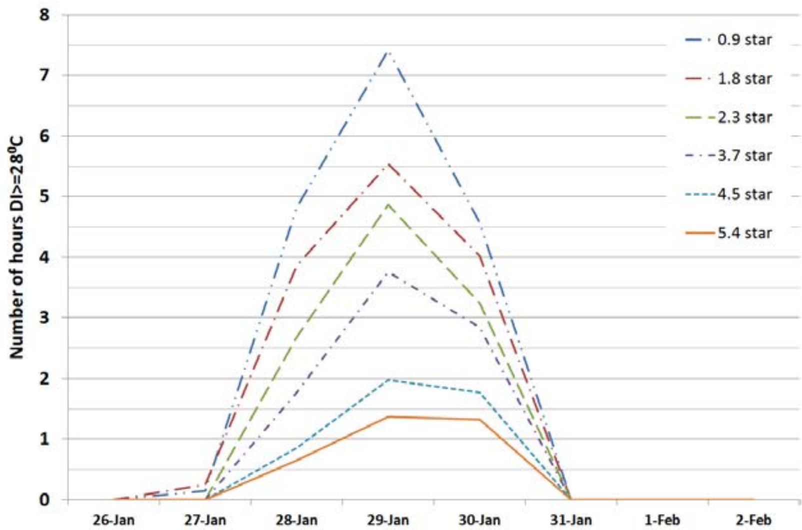
In Australia, heat events have killed more people than any other natural hazard experienced over the past 200 years [1]. Humans spend most of their time indoors during heatwave period, as such assessment of indoor heat stress is an important issue for public health care. During 2003 heatwave in Paris, 74% of excess deaths occurred among those who were staying at home [2]. The situation in Australia is similar to that in Paris considering that the most vulnerable population is the elderly people group [3]. In Australia, there is a growing dependence on mechanical air-conditioning to reduce the impact of heat stress. In March 2014, 74% of dwellings in Australia had coolers, up from 59% in 2005 [4]. However, this dependency on air-conditioning overloads the power grid and results in power outages during heatwaves as observed during 2009 and 2014 heatwaves in Melbourne and Adelaide [5]. Therefore, it is crucial to ensure that the dwellings are thermally comfortable in the absence of air-conditioning during a heatwave period. Upgrading the energy efficiency of the dwellings through increased external wall insulation, improved window glazing, proper night ventilation, etc. can improve significantly the indoor thermal comfort of a non-air-conditioned house during a heatwave.

This study quantitatively analysed the impact of building energy efficiency in mitigating the heat stress and heat-related mortality and morbidity during a heatwave in the absence air-conditioning. The city of Melbourne was selected for this study because heatwaves appeared to affect mortality more in

Melbourne than any other cities in Australia [6]. Two types of Melbourne dwellings were considered in this study: 1) a duplex and 2) single storey houses. Building simulation software EnergyPlus was used to simulate indoor thermal conditions of the different energy rated dwellings during a 2009 type Melbourne heatwave period. The energy ratings of the house were determined according to Nationwide House Energy Rating Scheme (NatHERS) of Australia. The developed simulation model was validated against the experimental data [7]. The experiment was conducted in a typical duplex house in Melbourne where the indoor temperatures were recorded for a period of three months. The Wet Bulb Globe Temperature (WBGT) index and Discomfort Index (DI) were used to calculate the indoor heat stress of the different energy rated dwellings [8]. The indoor heat stress condition is severe when the value of WBGT and DI was greater or equal to 25 and 28 respectively.



(a)



(b)

Figure 1 Number of hours over threshold limits of a) WBGT and b) DI heat stress indices in different energy rated house in Melbourne.

Figure 1 shows that during a three-day heatwave period (28th–30th January, 2009), the occupants of 0.9 star houses experienced extreme heat stress condition for almost 25 hours and 17 hours according to WBGT and DI heat stress index respectively. In contrast, the residents of 5.4 star houses were exposed to extreme conditions only for 6 hours and 3 hours respectively according to WBGT and DI index. Hence, the occupants of 0.9 star houses, without air-conditioning, are more likely to be exposed to the risk of heat stress during heatwave compared to the occupants of a higher star rated house.

Fragility analysis was carried out to determine the heat stress risks by the occupants of different energy rated houses [9]. Figure 2 shows that probability of experiencing 6 heat stress hours in a 0.9 energy star house is 58% compared to only 4% in 5.4 star rated houses when the outdoor mean outdoor temperature (Mean T) is 36^0C. Mean outdoor temperature is the average of daily maximum and minimum temperature. It was chosen here instead of daily maximum temperature only because it better represents the effect of the heatwave on human [10]. Mean outdoor temperature takes into account the minimum temperature of the day which is usually the early morning temperature of the day. The lower is the minimum night temperature; the higher is the comfort during the hot daytime. During 2009 Melbourne heatwave, the Mean T was around 36^0C. Therefore, when the Mean T exceeds 36^0C, it can be considered as heatwave condition.

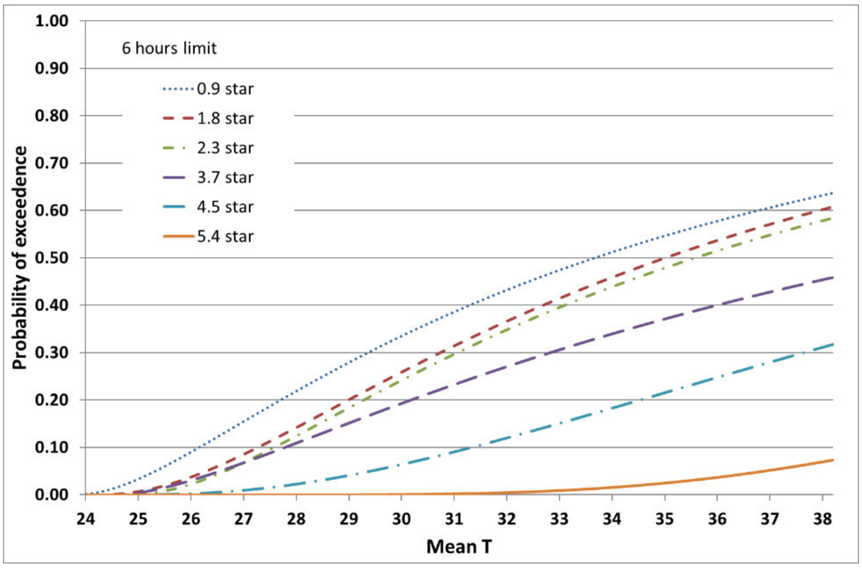


Figure 2 Probability of experiencing 6 hours of heat stress (WBGT>=25) in different energy star rated houses.

In Victoria, approximately 1.9 million (86%) of the existing houses were built before the introduction of mandatory energy efficiency requirements in 2005 [11].Through an on-ground assessment of 60 sample houses, Sustainability Victoria [11] reported that average NatHERS energy star rating of the existing houses constructed before 2005 is 1.81. Analysing the data from the on ground assessment, the existing distributions of different energy rated houses in Victoria were determined. The distributions were then used to calculate the percentage of total Melbourne residents exposed to heat stress condition during a 2009 type heatwave. Figure 3 shows that if the entire lower energy rated houses can be upgraded to a minimum of 5.4 star, the percentage of Melbourne residents exposed to 6 heat stress hours could reduce significantly from 50% to only 4% at 36^0C Mean T.

Upgrading building energy rating can also reduce the heat related mortality and morbidity. The calculated health impacts of heatwave on the occupants of different energy rated houses are presented in Table 1. The details of the calculation procedure can be found in [8]. The main assumption in this calculation was that the occupants of 0.9 energy star houses were the victims of 2009 heatwave in

Melbourne. If all Melbourne houses have at least 1.8 star energy rating, the number of excess deaths from a 2009 type heatwave may reduce from 374 to around 240. Similarly, if all Victorian houses can be upgraded to minimum 5.4 stars, the number of excess deaths from a 2009 type heatwave may reduce by 90% from 374 to around 37.

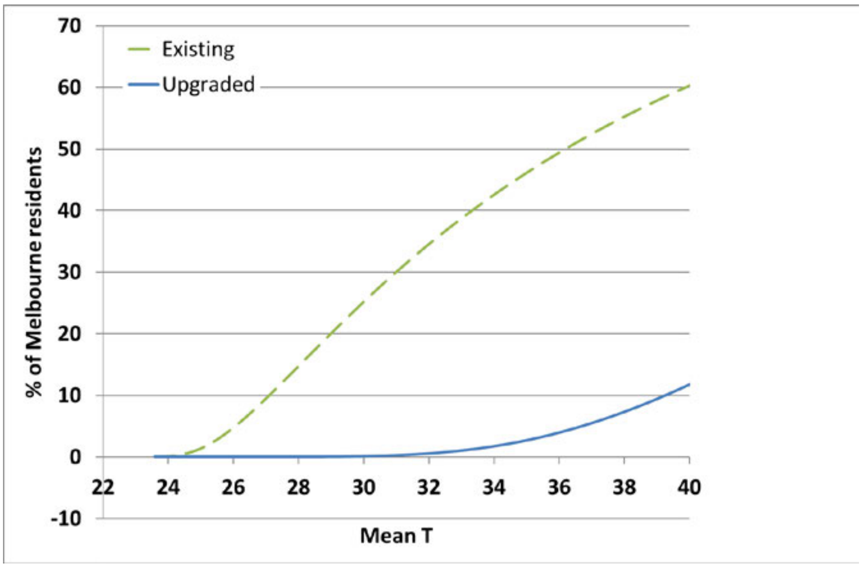


Figure 3 Percentage of Melbourne residents exposed to heat stress under existing and upgraded conditions

Table 1 Predicted health impacts of the 2009 Melbourne type heatwave in different energy rated houses

	0.9 star	1.8 star	2.3 star	3.7 star	4.5 star	5.4 star
Deaths	374	240	197	96	62	37
Ambulance calls	514	399	347	196	129	63
ED presentations	1055	864	774	511	394	280
After hour doctor consultations	71	59	50	28	20	13

The Climate Council of Australia reported that climate change is increasing the intensity and frequency of heatwaves in Australia [1]. Wang et al. [12] reported that average temperature in Melbourne will increase by 1^0C in 2035 and 2^0C in 2070. As a result, the heat related mortality and morbidity will also increase. Figure 4 shows that total number of deaths, ED presentations, ambulance calls and after hour doctor visits will increase significantly if the intensity of heatwave increases by 1^0C due to climate change. The residents of 0.9 energy star houses will be the worst affected by the climate change. The figure shows that if the heatwave intensity increases by 1^0C, the number of deaths will be nearly double (will rise from 374 to 727) if the minimum NatHERS energy rating of the houses remains 0.9 star i.e. no adaptation takes place. Keating and Handmer [13] reported that if no further adaptation to heatwave takes place, annual mortality rate due to the heatwave in Melbourne would be around 457-515 in 2020 and 820-1222 in 2050 depending on climate change scenarios. The predicted mortality rate of 712 in the present study due to 1^0C average temperature increase in 2035 is well within the range calculated by Keating and Handmer [13] for 2020 and 2050. Figure 8 also shows that number of death will be only 67 if the entire housing stock can be upgraded to minimum 5.4 energy star. A similar trend was observed for other heat-related health hazards.

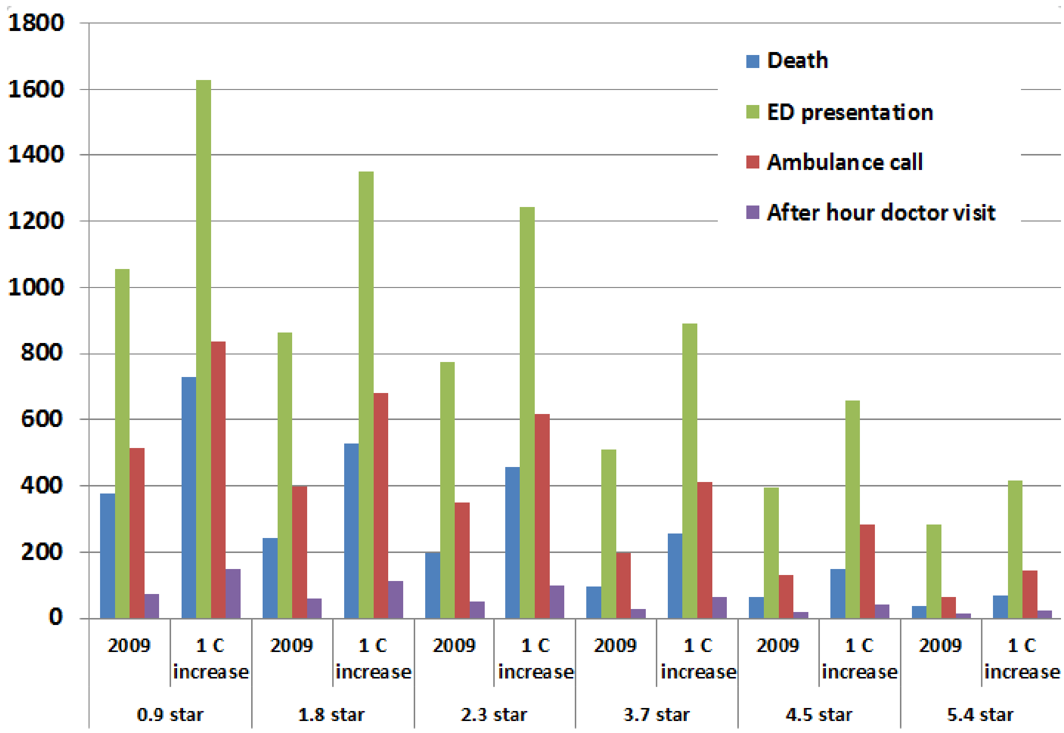


Figure 4 Predicted health impacts of the heatwave with climate change scenarios

The above is a brief outline of the work carried out at Swinburne University of Technology. We are interested in providing further information to the Inquiry, if and when it is required.

Thanking you for the invitation to provide this submission.

Yours Sincerely,

Dr Morshed Alam

Professor Jay Sanjayan

Professor Patrick Zou

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