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Submission to the Senate Inquiry on the impacts on health of air quality in Australia

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I welcome this opportunity to contribute to the discussion on air quality impacts on human health in Australia. In my submission I focus on my main area of expertise: smoke from residential woodheaters and open fireplaces. My comments are summarised in Section 1 below, with supporting details and citations set out in Section 2.

I have been involved in research, consulting, training, standards and policy review relating to residential firewood use since 1980: initially as an academic at the University of Tasmania from 1980 to 2002 and then as a consultant since 2002. I have worked with industry, with government, with Standards Australia and with community groups. I have published many articles on the subjects of wood-smoke and woodheaters (see Appendix 1).

In this submission I argue that the magnitude of the health impact of wood-smoke from residential heating is so large that a National Task Force to review and report on management options is warranted.

Section 1

It is my view that there are many aspects of woodheater use that are very relevant to this inquiry. I believe residential wood-smoke is a larger health problem than publically acknowledged by governments and that current regulatory approaches have several shortcomings. The summary, below, covers all my main concerns. The detailed justifications for these views are presented in Section 2. Unfortunately, time constraints have meant that I have not been able to fully cover the large number of reports and academic articles relevant to this inquiry.

Summary

(i) Woodheaters are a major source of fine particles and other pollutants, including polycyclic aromatic hydrocarbons (PAHs), in Australia throughout winter. In many rural cities and smaller towns they are the main reason for unacceptable air quality.

(ii) Wood-smoke consists of fine (<PM2.5) and ultra-fine (<PM0.1) particles made up of condensed organic compounds and elemental carbon. This complex mix of compounds is very similar in chemical composition to cigarette smoke – it contains carcinogens, respiratory irritants and other potentially harmful products.

(iii) All Australian studies into the health impacts and health costs of residential wood-smoke have resulted in quite alarming estimates of adverse health impacts. For example, health costs of hundreds of dollars per woodheater per year are reported (some much higher); a big number considering there are almost 1 million homes using firewood as their main heating fuel. An up-to-date study into the health impacts and health costs of residential firewood use in Australia is urgently required.

(iv) Given the likely adverse health impact of wood-smoke from residential heating in Australia, it appears that this source of air pollutants has been inadequately regulated.

(v) There has been little significant change in woodheater technology in Australia over the past 30 years. Effective regulation is required to stimulate innovation and reward manufacturers that produce cleaner-burning heaters.

(vi) Regulation of residential wood-smoke in Australia adopts two distinct approaches.
(A) The Australian/New Zealand Standard AS/NZS4013 has been called up in all States except South Australia. The Standard sets a maximum allowable emission factor of 4 grams of smoke particles per kilogram (dry) of firewood burnt (g/kg). Heater models achieving 4g/kg or better are then certified by the Australian Home Heating Association and this certification is recognised by authorities across Australia.
(B) Two States (NSW and Tasmania) have definitions of excessive visible smoke and provide for penalties for households emitting excessive smoke following a written warning.

(vii) The Standard (AS/NZS4013) was a useful starting point in 1992 when it was first published, but experience has shown it has serious shortcomings because the specified operation of the heater during testing bears little resemblance to the way heaters are operated in the home. This has led to a situation where a heater may perform well during laboratory tests but emit far more smoke when used in people's homes.

(viii) Enforcement of the regulations at the retail market level is inadequate (i.e. heaters are sold that either are not certified or, more commonly, heaters are sold that differ from the unit that was certified). This is a serious problem. In 2003/04 the government carried out an audit of 49 popular woodheater models obtained from retail outlets; 56% had serious design faults (i.e. the unit sold differed from the unit tested and the differences in design were likely to increase emissions). For models put through a full emission test, those with design faults had emission factors almost four times higher than those without the faults. In other words, more than half these popular heater models being sold on the Australian market had emissions far greater than their labels and certification suggested. The names of the non-compliant heater models were never released. Government asked the industry to try to do better in future but there has been no follow-up audit.

(ix) The excessive visible-smoke regulations have been less effective than they might have been because no one (to my knowledge) has been fined for emitting excessive smoke despite the regulations being in place since 2006.

(x) The problem of smoke from a nearby house blowing directly into another person's home is far more serious than the "nuisance smoke" label implies. Some people have to put up with shocking conditions despite complaints to local or state government authorities. The adverse health impacts are likely to be similar to those experienced by regular cigarette smokers.

(xi) Smoke spillage from the wood loading door into the living area of a home with a woodheater may cause unacceptable indoor air quality. Spillage may be worse with heater models with large doors. There have been no studies of smoke spillage in Australia but some preliminary work in New Zealand confirms the potential for adverse health impacts.

(xii) There are so many possible health and air quality problems associated with woodheaters in Australia it seems justified to establish a National Task Force to look into and report on the matter. In this submission I focus on the air pollution and resulting health impacts associated with woodheaters. But woodheaters also have social benefits so control measures need to be designed to achieve optimum social, environmental and economic outcomes.

Section 2

(a) Residential firewood use as a source of particles

Incomplete combustion is the curse of burning wood. Combustion conditions in woodheaters and open fireplaces are not ideal. In woodheaters the rate of combustion is slowed by reducing the air entering the heater, thus starving the fuel of oxygen and causing incomplete combustion. In open fireplaces the temperatures on the perimeter of the fire are too low to sustain good combustion. In both cases, gases released from the hot wood escape the flame zone unburnt and condense into tiny droplets of oils and tars as they cool. Millions of these tiny particles scatter light which makes the smoke visible.

The smoke from wood combustion creates health problems because of the physical size of the smoke particles (less than one micron diameter), the chemical composition of the smoke particles (complex mix of organic compounds, some of which are carcinogenic), and some of the gases in the smoke plume (carbon monoxide and others).

(a.1) Trends in woodheater use in Australia

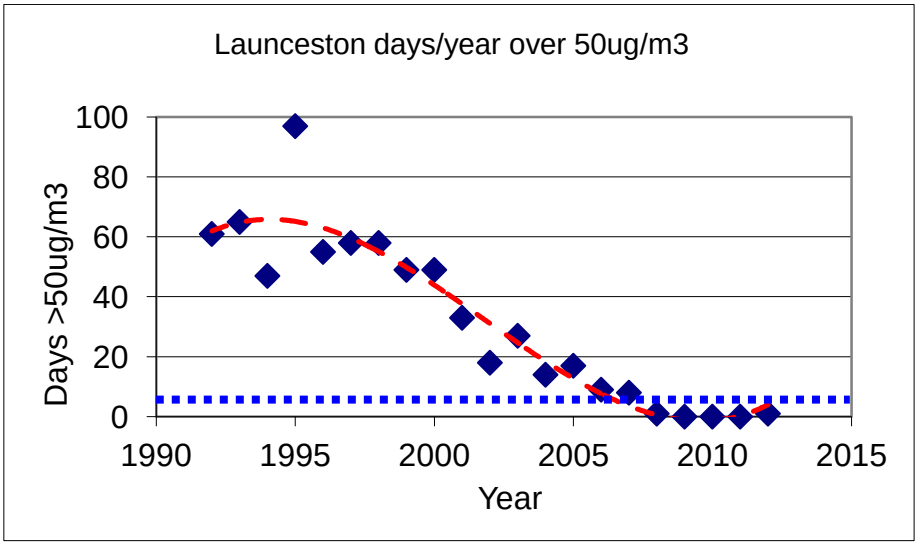
Residential firewood use in woodheaters and open fireplaces has long been recognised as a significant source of fine particles in Australian cities and towns. The lack of regulatory controls over this source of particles came to a head in Launceston Tasmania in 1996 with the release of a Working Party Report into air pollution and health effects (Lyons 2006). This study included systematic measurement of PM_{10} using high volume samplers and proved what many local residents already suspected: the smoke (particle) concentrations in Launceston had reached dangerous levels in winter and the source was the combined output of thousands of woodheaters. Particle concentrations greater than 200µg/m^3 (24-hour) were recorded on several days. The report concluded (selected quotes): *"This investigation has confirmed that there is a significant and potentially serious winter pollution problem in Launceston and the Tamar Valley environs."; "Particulates which are primarily derived from the combustion of wood ... constitute the principal source ... "; "Fine and ultrafine particles are a special danger."*

As a result of this study regular air quality monitoring was commenced in Launceston which confirmed unacceptable winter air pollution associated with woodheaters. In 2001 a combined Commonwealth, State and Local Government intervention led to a rapid decrease in the number of households using firewood for heating and a big improvement in air quality (a combination of public education, financial incentives to remove woodheaters, and patrols looking for very smoky heaters, largely Commonwealth funded) (see Figure 1). A recent study (Johnston *et al*. 2013) has shown that this air quality intervention led to measurable health improvements in Launceston (discussed below).

The importance of the Launceston experience is that it demonstrates that effective intervention can significantly reduce particle emissions from residential firewood use.

The graph in Figure 1 shows PM_{10} concentrations and suggest that concentrations of smoke in Launceston might now be considered acceptable (i.e. consistently below the 50µg/m^3 limit). However, wood-smoke is made up almost entirely fine particles ($PM_{2.5}$). Monitoring of fine particles in Launceston in recent years shows that there are still many winter days when fine particle concentrations exceed the NEPM reporting limit of 25µg/m^3: 16 days in 2012, 6 days in 2011, 10 days in 2010 and 12 days in 2009. Thus, it appears that further improvement in Launceston's air quality is desirable from a health perspective.

Figure 1: The number of days the 24-hour PM_{10} average exceeded 50µg/m^3 in Launceston each year since 1992. (Todd, unpublished – based on Launceston air monitoring data). Prior to July 1998 measurements were not made daily, the proportion of days exceeding 50µg/m^3 for this period has been used to estimate the annual total, leading to less certainty in these values.)



Throughout Australia woodheater use decreased in popularity between the mid-1990s and about 2010 (although not nearly as much as in the Launceston example, above). Recent survey data (ABS 2011) suggests the proportion of households choosing firewood as their main heating fuel might now be increasing (Figure 2), probably as a result of increases in residential electricity and gas tariffs. Figure 3 shows the average annual change in the number of households in Australia choosing wood-heating; this highlights the apparent shift in heating preferences that occurred around 2010. Increases in woodheater numbers will probably lead to measurable decreases in air quality in many urban areas.

Figure 2: The number of households using firewood as their main space-heating fuel based on Australian Bureau of Statistics (ABS) surveys

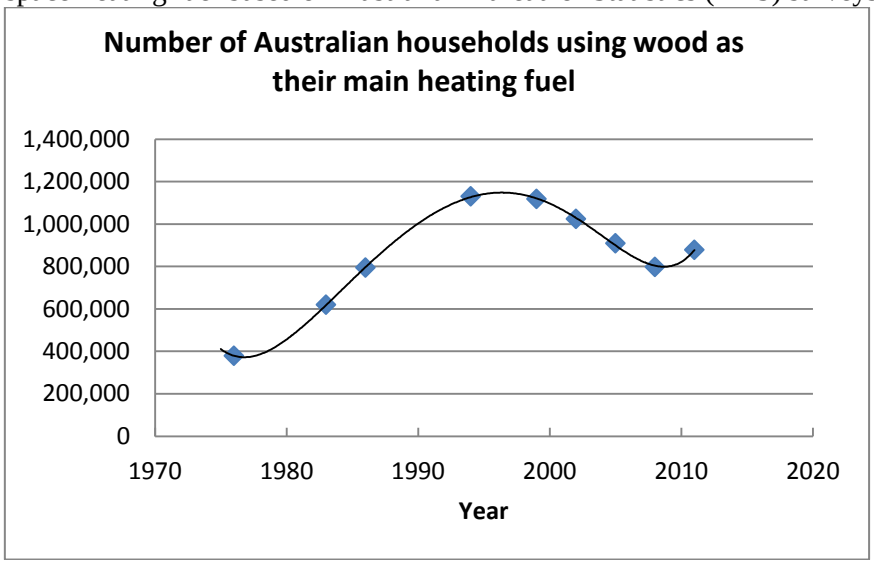
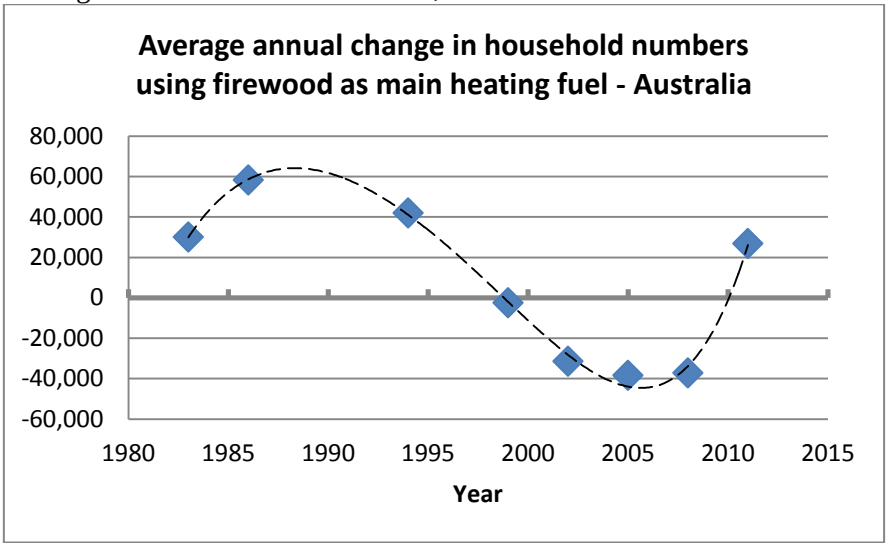


Figure 3: The average annual change in the number of households using firewood as their main heating fuel for the periods between ABS surveys. The 2011 survey (ABS 2011) shows a clear change with the average annual decrease of about 40,000 households in 2006-2008 replaced by an average annual increase of about 20,000 households in 2009-2001.



(a.2) Particle emissions from woodheaters

Woodheaters sold in Australia should meet emission limits set out in the Australian/New Zealand Standard (AS/NZS4013). The Standards was published in 1992 with a maximum allowable emission for compliant heater models of 5.5g/kg when tested according to the Standard method. The limit was lowered to 4g/kg in 1999. A review of the Standard is currently underway. The average emission factor for all compliant models in 2010 was 2.6g/kg.

There has only been one field study of woodheater emissions in Australia (Meyer *et al*. 2008). This study showed the average emission factor for woodheaters in Launceston was 9.4g/kg. The average emission factor for each of 18 houses monitored ranged from 2.6g/kg to 21.7g/kg. It might be argued that it would be unwise to place too much reliance on this one study; however, Meyer *et al*.'s results are broadly consistent with other field studies done in New Zealand (Kelly *et al*. 2007, Scott 2005, Wilton and Smith 2006) and the United States (Houck 2012). The overseas field tests suggested that real-world emission factors were roughly 3 to 4 times higher than average laboratory test emission factors, which is consistent with the Launceston study.

The field study data can be applied to estimates of total firewood used by households to determine total particle emissions from this source. Firewood is used as the main fuel for space heating by 880,000 households (ABS 2011) and as a secondary or occasional fuel by a further 310,000 households (Todd, unpublished). Average figures for Australia suggests about 3.75 tonnes of firewood are used per household per year for main space heating and 1.5 tonnes per year for occasional use (Todd, unpublished). After adjusting for moisture in the firewood, this gives an estimate of about 3.2 million tonnes (dry weight) of firewood burnt in Australia. **Annual emissions of fine particles are, therefore, around 30,000 tonnes**. Most of these fine particles are emitted in urban areas and smaller towns; they are emitted quite

close to the ground (typically less than 6 metres above the ground) and will be trapped under low-level temperature inversions that often occur on cold winter nights.

(a.3) Chemical composition of wood-smoke

There have been many studies of the chemical composition of wood-smoke. Published studies with relevance to Australia were reviewed in 2002 (Todd 2002). CSIRO measurements of the chemical composition of emissions when burning Australian wood species in Australian woodheaters are of particular relevance (Gras *et al.* 2002). Many of the chemical compounds in wood-smoke are toxic. In terms of general air quality management in Australia the most relevant (because they are quite high compared to other sources) include:

Polycyclic aromatic hydrocarbons (PAHs) usually characterised by benzo[a]pyrene
Benzene
Formaldehyde
Carbon monoxide

In regions with a high proportion of houses using woodheaters it is possible that these air pollutants will exceed acceptable concentrations. Of most concern are fine particles (discussed earlier) and PAHs.

(b) Health studies of wood-smoke in Australia

(b.1) Launceston study

The recent study by Johnston *et al*. (2013) is important for several reasons. Firstly, it demonstrates improved health in a city where air pollution has rapidly been reduced; secondly, it demonstrates improved health outcomes through a multi-pronged approach at reducing wood-smoke emissions; and thirdly, it shows that even in a small city it is possible to measure statistically significant health changes.

Between 1994 and 2000 the winter PM10 averaged 45.8µg/m^3 and between 2001 and 2007 the winter PM10 averaged 26.7µg/m^3 (Todd unpublished). The improvement may be attributed to an intervention program commencing in 2001. The program involved financial incentives to remove woodheaters from homes and replace them with electric or gas heaters. It also involved a high profile community education campaign explaining how to operate a woodheater to minimise smoke emissions, but also pointing out the adverse health effects of high smoke levels in Launceston. Another aspect of the program was the introduction of "smoke patrols" where Council officers and some volunteers surveyed neighbourhoods looking for flues emitting dense smoke. An education package was placed in the letter box of offending homes. The "smoke patrols' proved very effective with only a small proportion of houses continuing to emit high smoke levels (Ling 2005).

Johnston *et al.* compared mortality and hospital admission data for the 1994-2000 and 2001-2007 periods and found a reduction in winter cardiovascular and respiratory mortality. The data were corrected for various confounding factors and used Hobart data over the same periods as a control. The data require careful analysis, but we are looking at roughly 15 fewer deaths per year in Launceston after the intervention compared to before the intervention. This is consistent with theoretical estimates based on relative risk of mortality using the international studies reviewed by Pope and Dockery (2006).

(b.2) NSW study

The 2011 'Economic Appraisal of Wood Smoke Control Measures (AECOM[1] 2011) prepared for the NSW Office of Environment and Heritage reviewed earlier Australian and international studies of the health costs of wood-smoke and fine particles. AECOM chose a figure of $72,114/tonne of PM10 as a weighted air pollution cost for urban and rural NSW. A figure like this is dependent on many assumptions and variables, none-the-less it implies a huge environmental cost for the 30,000 tonnes of fine particles emitted annually from household firewood consumption (see (a.2) above): an annual cost of $2.16 billion. Could the environmental and health costs of woodheater emissions really be this large? Whether authorities believe the number or not, it would be most unwise to ignore it. This requires prompt, thorough investigation. This is, in part, why I feel a National task Force is urgently required to look into the urban wood-smoke issue.

(b.3) Other Australian health studies

There have not been many studies looking into the health costs of residential wood-smoke in Australia. In June 1997 a conference on particulate air pollution in Australian rural towns was held in Armidale, NSW. The focus was on wood-smoke. An edited volume of the presentations was published (Parton 1998).

The BDA Group (2006) prepared a cost benefit analysis for the Australian Department of Environment and Heritage which recommended tighter regulations governing woodheater emissions and efficiency.

Todd (2006) prepared a cost-benefit analysis of wood smoke reduction in Perth WA. The study showed that various management options had pay-back periods from 1 month to 5 years on the basis of avoided health costs.

(c) Woodheater design and emissions

The Australian woodheater industry might take exception to my view that there has been little technical advance in woodheater design in Australia over the past 30 years. There has been some cosmetic change and various changes to reduce manufacturing costs; but key design features aimed at reducing emissions and/or improving efficiency have not been introduced, in fact some have become less common.

In the early 1980s the Australian woodheater manufacturing industry was small but growing rapidly. The range of models on the market varied from very basic steel boxes with an adjustable combustion air supply to some relatively sophisticated models with pre-heated secondary air, automatic combustion air controls, catalysts to improve combustion and large baffles/heat exchanges to improve efficiency.

Most woodheater models now sold in Australia include a secondary combustion air supply (a good feature), but preheating of this air is inadequate in some models. Reduced baffle sizes to try to minimise smoke spillage reduce effective heat exchange areas and lower efficiency. Few, if any, woodheaters on the Australian market include automatic combustion controls.

[1] AECOM is a highly respected company providing professional and technical management advice worldwide. A report such as this should trigger a high level political response.

(d) Regulation of woodheater emissions

The present regulation of woodheaters in Australia provides no incentive for manufacturers to design or market cleaner burning heaters. The emission requirements of the Australian/New Zealand Standard (AS/NZS4013:1999) are easy to meet with old technology. The Standard is being reviewed at the moment, so this may change.

The lack of enforcement of even the very modest requirements for 'cleanish' burning heaters gives advantage to any manufacturer or importer that does not do the right thing and have new models tested and certified. It requires good quality control and retesting after any design modification if manufacturers are to ensure retail models also meet the regulations. In other words, having emission regulations for new woodheater models but not enforcing them is a disincentive to sell clean burning heaters.

The specified operating requirements of a woodheater during the Standard emission test bear little resemblance to the way people operate heaters in their homes (Todd 2008). For Standard testing it is assumed the heaters are operated very carefully to minimise smoke emissions. If the test method is changed to better reflect actual operation laboratory teswt emissions become much higher – however, design changes to the heater can easily reduce these higher emissions to more acceptable levels (Todd and Greenwood 2006).

One problem with regulation of woodheaters in Australia is the difference in approach between the States. In New Zealand the Ministry for Environment (MfE) has set national limits on woodheater emissions with provision for tighter limits in regions adversely affected by wood-smoke. The MfE has adopted the test method in the Australia/New Zealand Standards but applied tighter emission limits (1.5g/kg instead of the 4g/kg set in the Standard). The MfE also oversees occasional audits of retail heater models with a clear process set out for any models found to be non-compliant.

There would be significant advantages if woodheater emission regulations were dealt with nationally in Australia, perhaps through a National Environment Protection Measure (NEPM).

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Appendix 1 (December 2012)

RESUME SUMMARY – BIOMASS INTERESTS

JOHN J. TODD

Dr John Todd is an environmental consultant and educator. He has worked professionally in the environment field since 1975 and is a member of many State and Federal committees dealing with environmental issues. He has been providing consulting advice in environmental and energy fields in Australia and overseas for 30 years. He taught at the University of Tasmania from 1978 to 2002, reaching Associate Professor level and holding positions of Coordinator of Environmental Studies and Head of the School of Geography and Environmental Studies. He has BSc(Hons), MSc, and PhD degrees from Melbourne University majoring in physics. He is an Adjunct Professor at Edith Cowan University.

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Teaching and research interests

John Todd has taught many tertiary units at undergraduate and postgraduate levels covering a wide range of environmental fields. In recent years he has focussed his teaching on environmental technology and environmental impact assessment. Recent research and consulting has been directed at urban air pollution, residential heating and climate change.

The following paragraphs address Dr Todd's expertise and experience in the area of firewood use and air quality.

Biomass Expertise

Dr Todd first developed an interest in residential firewood use in 1978 and commenced testing woodheaters in 1980. Over a period of several years he established the Fuelwood Research Group and the Home Heating Laboratory at the University of Tasmania. He developed a strong interest in Australian safety and performance standards for solid-fuel burning residential heaters, receiving the 1994 *Standards Award*. The laboratory, which held NATA accreditation, operated for about 10 years to 1991 when it was closed due to other University priorities. Dr Todd maintained his research interest in biomass combustion through use of private laboratories and work with industry. Since leaving the University in 2002, he has carried out many consulting projects on biomass combustion and woodsmoke commissioned by industry and government. He has over 70 published conference papers and journal articles on biomass and has completed over 100 commissioned studies on biomass and wood-smoke (see selected list on next page). In 2011 he received the Clean Air Society medal for "effective and sustained improvements in particulate effects".

Professional affiliations with biomass/air quality responsibilities

Dr Todd was chairman of the Standards Australia Committee on Residential Solid-Fuel Burning Appliances (1980 to 1998) and remains an active committee member; he was the Australian Delegate to the International Standards Organization Subcommittee on Domestic Heating, a Member of the Environmental Industries Council (Tasmania), a Board Member for RISE (Research Institute for Sustainable Energy), a Member of the Clean Air Society of Australia and New Zealand, a Member of the Solar Energy Society of Australia and New Zealand (President 1998-2000); a Member Tasmanian Firewood Committee, and a Member of the Tasmanian Board of Environmental Management and Pollution Control (to March 1998).

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