Response to the Joint Standing Council on Energy and Resources

1. Terms of Reference and Assumptions

TERMS OF REFERENCE FOR GAS TECHNICAL REGULATORS COMMITTEE	RESPONSE TO TERMS OF REFERENCE AND GTRC DRAFT STRATEGY.
The Ministerial Council on Energy (MCE)[1] requests that state and territory gas safety regulators (the Gas Technical Regulators Committee (GTRC)) urgently consider the need to develop a gas safety strategy to mitigate the risks of carbon monoxide (CO) poisoning from household gas appliances and portable gas appliances use in confined (unventilated) spaces such as vehicles or caravans. The draft gas safety strategy will include an assessment of the risks, cost and benefits of the options and provide recommendations on the best way forward for consideration by MCE before the end of June 2011.	**Requirement.** This part of the ToR sets out the requirement for a **full review of CO poisoning associated with gas appliances** for residential and leisure use, including; A comprehensive plan of action or policy (Strategy) for; • household appliances, and • portable appliances used in confined spaces (Caravan/Vehicles) Strategy to assess: • Risk. • Cost/benefits. • Options. **Comment.** The GTRC report does not fully review these issues and is not strategic. Evidenced by; • S2.2 Gas Appliances, paragraph 2 states that exhaust fans are the subject if this report (the strategy)! • The report is acknowledged to be 'exhaust fan' centric, it places fans and their contribution to CO as the key issue! The report should be 'gas appliance' centric. Exhaust fans would be then correctly identified as one of a number of contributory issues. • S2. Paragraph 9 and S6.1.1. Asserting that as flueless and room-sealed are not affected by exhaust fans and therefore they are not considered! • The extended analysis of AS 4553 and no mention of AS 4552, AS 4558, AS 4556, AS 4551 and AS 2658.

[1] As at 10 June 2011, MCE will become the joint Standing Council on Energy and Resources in accordance with COAG reforms.

The draft gas appliances (carbon monoxide) safety strategy should, through the application of sound engineering and investigative methods, explore and fully consider all relevant factual information on the causes, scale and types of carbon monoxide poisoning events (as they apply to gas appliances), as well as the proposed methods for detection of carbon monoxide in residential premises and recreational vehicles. More specifically, this work should include:	**Requirement.** This part of the ToR requires the strategy to be soundly based and to fully consider all factual information upon CO poisoning associated with gas appliances; • Causes; • Scale; • Types of poisoning event. As well as; • CO detection methods. **Comment.** With respect to the general issues identified in the ToR GTRC has: 1. In S5 Fig1, not adequately mapped the causes of CO in Buildings (if this is indicative or not fully developed it should be stated). 2. Underestimate the scale CO harm (see Part 2 of **this** document, the response to the Strategy document S5.2). 3. Not identified or mapped its 'root cause' from investigative data (from 10 deaths) to support the scale, appliance classes involved and types of CO poisoning event. 4. With the exception of future energy efficient building design, failed to provide a strategic guidance on appropriate appliances or emerging CO threats. 5. Not described the mechanisms of CO production at the burner. I would evidence the failure of strategic vision in 1. & 4. above by noting the absence of: • Avoidance or mitigation measures from currently available gas burner technology. • Strategies for removing 'at risk' appliance groups from the current population of appliances. • Strategies in relation to gas appliance obsolescence. • Strategies to encourage appliance service maintenance. • Strategies to update gasfitter skills, servicing performance and the availability of information.

	• Strategies in relation to reporting CO Poisonings. • Strategies to influence better diagnosis. • Strategy for gas appliance maintenance in rental property and landlord safety checks. • Strategy for future of open-flue appliances in energy efficient housing. • Assessment if where future CO harm may evolve. With respect to the specific issues identified within the ToR GTRC has: 1. Adequately addressed issues a) to e). 2. Inadequately addressed issue f). 3. Inadequately addressed issue g). 4. Addressed issues h) and i) to the exclusion of the 'Gas Appliance' and the main requirement of the ToR. 5. Not addressed j).
a) a review of the range of commercially available carbon monoxide detectors to determine the reliability and effectiveness given the cost;	
b) examination of international practice concerning the compulsory use of carbon monoxide detectors;	
c) consideration of the service life, operational and maintenance requirements of detectors (including dual smoke and carbon monoxide detectors currently available on the market);	
d) the feasibility, costs and benefits for all residential properties and recreational vehicles with gas appliances to be fitted with approved	

	carbon monoxide detectors, including determining the minimum number of detectors per residence and the effectiveness of the detectors' outputs (after detection, raise alarm or shutdown of the gas supply, or both);
e)	the feasibility, costs and benefits of a requirement for detectors to be installed at all residential rental properties where gas appliances are installed, and the feasibility, costs and benefits of requiring that these appliances be inspected by qualified contractors at certain intervals [e.g. every 12, 24 or 36 months];
f)	ways to promote greater safety awareness, alerting all Australians to the dangers and symptoms of carbon monoxide poisoning and the need to regularly service household gas appliances;
g)	the identification of training and workforce requirements to meet any recommendations, such as increasing the number of trained gas fitters to undertake safety checks or licensing of tradespersons;
h)	the effects of lower than atmospheric (negative) indoor pressures on the performance of gas appliances created by bathroom and kitchen

exhaust fans and the effects on creating an environment conducive to carbon monoxide poisoning;	
i) if (h) finds that the installation of extraction fans in buildings contributes to negative pressures, the effectiveness of developing a requirement as part of the Building Codes of	
j) any other options that may mitigate the risks of carbon monoxide poisoning from household or portable gas appliances.	
Following MCE approval of the draft strategy, the GTRC will consult with affected and interested stakeholders to inform the preparation of a Consultation Regulation Impact Statement covering the contents of the draft strategy (items (a) to (j) above). This will allow the presentation of the final gas safety strategy and Decision Regulation Impact Statement, including a cost benefit analysis of the recommendations, to Ministers for consideration, noting that the Parliamentary House of Representatives considers this work urgent, and with a view to putting the strategy into effect at the earliest opportunity.	

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2. GTRC – Draft Gas Appliance (CO) Strategy.

GTRC Section Reference	Draft Strategy - Text	Comment
2.2.1	Carbon Monoxide paragraph 1	**Carbon monoxide** is a product of the incomplete combustion of hydrocarbon fuels. Carbon monoxide is a fuel gas and when burnt in sufficient air its combustion product is carbon dioxide. In the era of "Towns Gas" produced from coal, reticulated gas contained a significant percentage of CO that was burnt on burners that provided for complete combustion. Paragraph 1 correctly associates good combustion with sufficient aeration and in the absence of impingement. This section (and the report in general) does not explain the mechanisms of CO generation in relation to the gas appliance and gas burners in particular. The report goes on suggests that adverse flow in the secondary flue may produce CO at the burner. With regard to these issues please considered the case of two gas appliance burners, designed to operate at 40% and 100% primary aeration respectively. I suggest that the former would be potentially susceptible to adverse flow as a result of an ineffective draft diverter and any consequential disturbance of the secondary air mixing zone. This may lead to incomplete combustion and CO generation. In the later case there would be little or no secondary aeration zone to disrupt and consequently the burner may be less susceptible to disruption. If however combustion air is vitiated (depleted of oxygen) with the addition of the products of complete or incomplete combustion then both burners may generate CO in increasingly dangerous quantities. It may be concluded (from above example and a review of burner design) that gas burners can be manufactured that are not susceptible to disruption from high

		air flows) however; as combustion air becomes increasingly depleted of oxygen CO will always be produced[2] [*Carbon monoxide is an essential intermediate product of combustion. It is not a stable end-product of balanced combustion but you cannot have combustion without the intermediate formation of CO. Carbon Monoxide is consumed by reacting with free hydroxyl radicals. With sufficient combustion air complete combustion will take place, usually involving some excess air*]. It can be further concluded that the adverse flow (of air) is a contributory factor in the 'vitiation' of a gas burner system. The literature identifies two causes of vitiation (oxygen depletion); • Where combustion products are discharged into the room thereby depleting oxygen levels, for primary and secondary burner air, and • The recirculation of combustion products within the appliance.
2.2	Para 6	**Point of clarification please.** Where is atmospheric pressure established? Or alternatively "negative to what established datum point" (the flue terminal or the external environment for instance?) **ASNZ5601 2010.** Is the "Literal interpretation" of AS5601the view of GTRC? AS 5601 is mandatory in Australia therefore if this is the position it would an offence to install an open-flued appliance or a fan where a negative value (of pressure) between the

[2] http://www.hse.gov.uk/research/crr_pdf/2001/crr01384.pdf

http://www.hse.gov.uk/research/crr_pdf/2001/crr01379.pdf

Reed S.B. A Unifying Theory For The Blow-Off of Aerated Burner Flames. Gas Council Research Communication GC141 & The work of; Heap M.P. & Edmondson H. (On the same subject).

		appliance and some other point may exist! Spillage[3] testing can confirm Normal Flow with fans in operation (at the time and under the environmental conditions of the test). Are such tests acceptable to GTRC members? Are they to be standardised and form an auditable record for the responsible authority? AS 4575-2005 Gas appliances – Quality of Servicing recommends this in 2.3 & its associated checklist Appendix A.
2.3	Exhaust Fans Paragraph 9.	**ESV Information Sheet etc.** Information sheet No 28 accepts the transition from static to normal flow at appliance start it does not imply the acceptance of adverse flow. The test makes allowance for the transition period and then confirms normal flow has been established. **Air pressure.** With or without any fan or appliance operating air pressure, measured at the draught diverter, may be neutral, negative or positive to that at the flue terminal or other external reference.
	Appliances with input <3MJ/(M3.h) Paragraph 10.	As buildings get "tighter" the assumptions that gave rise to the <3MJ also must reviewed and changed. SA Committee referral. Note: Increasing energy efficiency performance of buildings may require controlled mechanical ventilation for the maintenance of human comfort, health, hygiene and to ensure air supply for building services. Resultant air change control will (in the respondents opinion) lead to a gas appliance market, for internally installed appliances, dominated by or exclusively of the 'room sealed' balanced flue type (save cook tops). No reliance on advantageous ventilation and no technical opportunity to perforate buildings to provide direct of communicated ventilation for open-flued appliances!
	HSE Investigations and Section 4 p12. Page 7.	These tests confirm that the very low forces produced by the buoyancy effect of hot (less dense) products of combustion are easily overcome by mechanical

[3] Spillage may be loosely defined as either 1) Issuing of products of combustion (or partial combustion) from the appliance/primary flue into the space in which the appliance is installed (Normal flow not established - Stalled or Blocked Secondary Flue. or 2) Issuing of products of combustion and air from the appliance/primary flue and draught diverter into the space etc (adverse flow due to aerodynamic effects or induced by mechanical air extraction.

		devices in the proximity of open-flue gas appliances and, as a consequence, adverse flow can be expected within the secondary flue.
2.4	Wind effects	See comments on 2.2 above.
2.5	Residential Housing Design • Fans and Ventilation • Table 1.	Extract fans. The primary use for these fans are within; • Bathrooms; • Toilets; • Laundry's; and • Kitchens (Extractor Hoods). For the removal of water vapour and odours. Irrespective of any gas or fuel burning appliance extract fans are complemented by fixed ventilators to ensure the room is ventilated without drawing air from adjoining rooms creating draughts (considering air change rates as high as 10 per hour quoted by fan manufacturers). Unless associated with poor or irrational design spaces, heated for comfort, do not have extract fans fitted and have average air change rates of Unity (Table 1.).
5.2	Carbon Monoxide Related Fatalities	Observations. 1) Tasmania has little gas penetration (LPG until recently interconnected with reticulated natural gas from mainland Australia). 2) NSW has an established gas network and on the basis of the figures in Table 2 are likely to have 3 deaths! 3) State and territory energy regulators (GTRC members) require gas incidents (harm) to be reported and then undertake investigations. 4) Incident investigation includes root cause and in the case of fatality reports to Coroners. Whether involving fatality or injury incident reports are maintained by Regulators. 5) There is no requirement for reporting of CO poisoning by the medical profession to Regulators in Australia.

		6) There is little medical practitioner knowledge of the symptoms of CO poisoning leading to misdiagnosis. *The Council may wish to request information from the department responsible.* *7)* A recognised treatment for serious CO poisoning is the use of hyperbaric oxygen. *The Council may wish to request information on such facilities and on how many occasions this treatment has been given in Australia, since near misses will significantly outnumber fatal outcomes.* 8) The final paragraph states that other sources attribute significant fatal and non-fatal harm in addition to that officially reported! Given a generally equivalent safety performance between Australia and Northern Europe[4] has Australia under reported harm? *The Council may wish to consider underlying CO poisoning rates in Australia, drawing upon:* *a) Its enquires into the current state of knowledge of medical emergency and general practitioners[5]:* *b) Its enquiries into the use of Hyperbaric Oxygen (or other methods) in treating CO poisoning:* *c) A review of International experience of near misses (poisonings) that did not involve a fatal outcome and the ratio of death to injury in those jurisdictions.*
5.3	Probability and the Causal Effect Tree	Incomplete.
	5.3.1)	Agree with design but not installation practice. Comment

[4] Overseas and Australian Statistics and Benchmarks for Customer Gas Safety Incidents Report 03/11/OGS/C – 14 January 2004.
[5] In a recent Victorian Fatality (Kelly Tierney) the victim sought medical advice on two occasions in the weeks leading to the incident that led to her death!

	• Ventilation requirements are not well understood by gas fitters in particular the requirements for 'communicated' ventilation between spaces. • The effect of high extraction rates upon appliances in or within the proximity of Bathrooms, Toilets and Laundry's in not understood or taught. • Gas fitters rarely have the knowledge, skill or materials to inspect and test a flue system. Access to smoke matches or smoke pellets (two very different indicators) is required. Smoke pellets are not available in Australia!
5.3 2) paragraph 1.	Air flow within the burner injector annulus that mixes fuel gas with air for combustion on the burner. Not to be confused with air flows associated with flues!
5.3 2) paragraph 2.	Not enforceable requirement, Comment. *The Council may wish to consider the UK safety regime where gas safety legislation controls not only Installation but also Use. Although servicing is not enforced in the UK upon the private residential sector the Use element focuses responsibility upon owners and operators of appliances including service maintenance however; to knowingly use an unsafe appliance is an offence.* *The Council may also wish to consider the Australian rental sector, service maintenance, CO incidents and the UK experience in mandating annual Landlord Safety Checks[6].*
5.3 2) paragraph 4.	There may be a reasonable argument for a 'midrange probability that an appliance (that) has not been serviced' producing CO. High levels of CO would lead to high occurrence of harm. This would seem at contradict table 1! *The Council may wish GTRC to establish empirical evidence for this assertion through field combustion testing a sample population of open-flue gas appliances.*

[6] http:/hse.gov.uk/gas/domestic/faqlandlord.htm

	5.3 4)	Alternatively increased density of building may not lead to this outcome however, in accepting this point, modern and renovated housing is unlikely to include high energy input open-flue type appliances within Bathrooms. In any event Instantaneous open-flue water heaters are Prohibited by AS/NZ 5601 2010 from installation in Bathrooms, Bedrooms, Toilets or combined living/sleeping areas. *The Council may wish to consider the justification for allowing storage water heaters not exceeding 40 MJ/hr (11 kW) to be installed in Bathrooms or Toilets etc? These spaces being subject to very high extraction rates. NB: a) Such spaces may be subject to air change rates of ten per hour. b) See AGA test and the test appliance input.*
	5.3 5)	Comment. If a flue is suspected of being blocked or partially blocked inspection in the literal sense will not confirm the blockage. The flue performance needs to be physically tested.
	5.3 6)	Comment. Yes in cold climates we need more space heating resulting in longer run times. Intentionally limited ventilation is assumed to mean either that the adequate ventilation, forming part of the gas installation, has been blocked to prevent a local draught or that advantageous ventilation has been reduced by weather stripping doors! Instances of tampering with fixed ventilation are recorded however; it cannot be assumed as the norm. Weather stripping doors etc to reduce heat loss is and will be an issue going forward e.g. reducing air changes significantly below 1 per hour(should Standards rely on this for combustion air).
	5.3 7)&8)	The rate and concentration of CO will affect vulnerable groups more quickly however; CO is so poisonous and through vitiated combustion air concentrates very quickly. Where CO is produced in sufficient quantity its effects are catastrophic and if untreated will lead to death or very serious injury (brain damage). So whether young, old or an adult in excellent health the outcome is not good! See comment on Section 5.2 above.
6.	Existing Controls	

6.1	Design Code	AS 4553-2008 Gas space heating appliances. No assessment for other relevant appliance classes i.e., AS4552-2005 Gas fired water heaters for hot water supply and central heating!
	6.1.3 Operation Under Adverse Draught AS 4553-2008 Section 2.10.5 States etc... In (a) and (b) respectively.	Although provided for in the Standard no (from the respondent's enquiries) appliances have been certified against this clause in Australia as CO detection devices of the required accuracy and stability are not economically viable or available. Discharge safety devices generally respond to increasing temperature at the draught diverter inferring adverse flow. Such devices must not respond to short duration down draught or static/low flow conditions since they would consistently fail the nuisance shutdown test.
6.5	Recommended Periodic Service	Assuming competent installation to AS 5601 Service Maintenance represents a significant if not the most significant barrier to CO Poisoning events. GTRC have not identified AS 4575-2005 Gas appliances – Quality of servicing. This Standard has not been recognised by Australian Regulators (called up in legislation as AS/NZ 5601) although it was written with this purpose in mind. Although this Standard is deficient in such areas as Combustion Analyser use, CO detection and detailed flue tests, it does contain the essential requirements to ensure the continued safe operation of Type A gas appliances. Appendix A contains a service checklist that 'covers off' on many concerns raised in the GTRC CO Strategy, including; • Checking flues and draught diverters; • Checking Ventilation air; • Ventilation fans for adverse flow; • Appliance cleaning (burner lint issue 5.3 2) para1); and

		• The recording of service outcomes with records to be kept for 7 years. This last point should not be underestimated since it provides a basis for ongoing regulatory oversight and audit. Gas safety regulations in Victoria[7] were last amended to include a similar provision for Type B gas appliances. Apart from the beneficial aspects of periodic service and the associated regular safety checks, inspection by a skilled service technician serves another key safety function in identifying appliance redundancy! Like most consumer goods gas appliances wear-out and need replacing. As they wear safety may be undermined and compromised. *The Council may wish to consider these benefits and mandating service standards.* *The Council may wish to consider these benefits and;* • *Landlords duty of care;* • *Age and population of appliances in rental accommodation;* • *Operational life of type A gas appliances and associated systems of flue and ventilation.*
7	**Possible New Controls**	
7.1	**Carbon Monoxide Alarms**	Agree.
7.2	**Spill Switches (open-flue appliances)**	Disagree. Comment. • Assumes all open flued appliances may be subject to fan induced adverse flow. • Assumes that space heaters are usually exposed to fan induced adverse flow. • Spill switches are not currently utilised on certified Australian appliances (although certain standards may provide for this). • Doesn't address the issue of the existing population of open-flue

[7] Victoria. Gas Safety (Gas Installation) Regulations 2008 r 35

		appliances. Impractical to retrofit (appliance certification invalid). • Devices measure temperature and not CO, so in practice they may not afford protection!
7.3	**Ventilation design and installation** **Paragraph 5.** "The inclusion of a ventilation opening in the exhausted area would decrease the negative pressure in the space. There is also the option to install actuated dampers on the ventilation opening such that they open when the fan is turned on. Due to the very low negative pressure required to reverse the flow in the flue these openings will need to be relatively large."	Space heaters in rooms. With respect to space heaters directly heating a room; is serious consideration being given to a solution combination of make-up air and extraction? The combination is likely to be very inefficient, bizarre! In any event if you push the room the flow rate in the secondary flue will be excessive (not normal) and may have adverse affects on combustion? Bathrooms etc... With regard to highly ventilated spaces and open-flue appliances; I would rather apply the estimated cost to replacing the appliance with a room-sealed appliance or and external appliance! Recent changes to Victorian Regulation[8] (mandated in Victoria and called up in AS 5601-2010) indicate the general difficulties in providing sufficient natural ventilation to dilute concentrations of poisons. The ventilation required renders such appliances ineffective as space heaters (or alternatively so inefficient that you wouldn't bother). If you extend the same generalised argument to push/pull mechanical ventilation, open-flue room heaters and the capacity of the secondary flue, the same outcome is possible! Within the limit the same argument may be run for open hearth log effect fires that are 'decorative'.
7.4	**Oxygen Depletion Sensors**	Agreed. ODS are inferential and it's not possible to retrofit them.
7.5	**Appliance Servicing**	New Control. This is not a new control it's an existing control that is partially implemented. Manufacturers recommend service maintenance for individual appliances. Since

[8] [8] Victoria. Gas Safety (Gas Installation) Regulations 2008 Division 6 Special requirements for flueless space heaters.

these vary (usually every 1 or 2 years) Regulators appear to have a default recommendation of 2.

Extent of Service Intervention.

Open-flue appliances require more extensive servicing than room-sealed appliances since the flue and ventilation system need inspection and in some cases testing. For many modern room-sealed appliances service maintenance requirements are focused on safety checks and combustion efficiency/safety performance measurement.

Specialised Class of Gasfitting Work.

Service maintenance is a specialised skill recognised by Regulators as a 'Specialised Class' and therefore restricted. Within this subset of gasfitting additional competence is required in electrical work requiring restricted licensing.

The Council may be wish to be informed on the numbers of specialised gasfitters and the status of update programs with particular emphasis on safety checks or combustions analysis?

Combustion analysis for safety & efficiency.

The testing of appliance combustion performance is a significant factor in establishing appliance safety. Test equipment is an essential part of the tooling required for this activity. Regulators and Australian Standards recommend test equipment however; Regulators have failed to mandate combustion testing as part of the service / fault finding process (I suggest it's not mandated due to the perceived cost impost and the RIS implications).

The Council may wish to be informed of the availability of combustion analysis equipment and the numbers of registered or licensed persons who have this immediately available in their tool kit?

Access to Manufactures Service Instructions.

Following the restructuring of the Australian Gas Industry the servicing activities of large state controlled enterprises have devolved to much smaller organisations often individual servicemen providing direct or contract labour arrangements.

The legacy State organisations generally provided the systematic and auditable

		control outline in AS 4575 – 2005. This approach is rarely seen in practice today. The systematic approach recommended in the Standard reflected the extensive records held and made available to servicemen. With the exception of 'Manufacturers own' service support organisations there is minimal access to the required service schedules to support effective service maintenance. Much historical data has been lost and this has a significant impact on the quality of gas appliance servicing. *The Council may wish to be informed by Regulators on this matter.* *The Council may also wish to be informed of the cost to make available this data to specialised gasfitters. In this regard the Australian Gas Association (AGA) holds manufacturers service instructions for appliances as part of its Certification process. This information could be catalogued and converted to electronic form and published (on the web) by Regulators or AGA (NB: AGA is a not for profit organisation and therefore may need assistance in this endeavour).*
7.6	**Room-sealed Appliance**	**Dwellings, Energy Efficiency and the future of Gas Appliances.** **Natural Gas** Natural gas represents the most important transition fuel to an optimum 'low carbon' future. It follows that natural gas will be a significant player if not predominant fuel where it is available for use. The market for natural gas is secure for Australian society including consumers, utilities and appliance manufacturers. Natural gas will remain the fuel of choice to heat new homes built to ever higher standards of energy efficiency. **New housing** The transition requiring changes to building design and construction will also require similar change in how houses operate i.e., low energy lighting, efficient water use. It follows that gas appliance design and will need to stay relevant to these requirements. It should come as no surprise to the gas industry that the place of open-flue appliances within internal living spaces is inconsistent with future building requirements. The obvious conclusion is that room-sealed appliances and externally installed appliances (high efficiency or condensing) will replace internally installed open-flue types, going forward.

7.7	**Exhaust Fan Timer**	For high capacity appliances with faulty flues 10 minutes may still kill! For kitchens it would be impractical and would just involve the resetting of timers. If the lockout option is used the function of the fan is nullified! With regard to heated spaces why the fan?
7.8	**Public Awareness Campaign**	If Regulators don't inform then others will. Please note the UK situation where concerned and injured parties have set the agenda for many years. I sense Australia may approach the tipping point of public outrage (warranted or not). State regulators should run a media campaign annually before the heating season. The media campaign should be supported by updated and relevant information including service maintenance, safety checks and ventilation.
8.0	**Conclusions**	
1.	There has been an increasing tendency to make dwellings ever more air tight as an energy saving measure. This is reflected in the introduction of the highly thermally efficient 6 Star Rating for buildings. At the same time there has been a concurrent growth in the installation and power of exhaust fans. Unlike overseas standards, the National Construction Code does not appear to reflect the importance of correctly engineered ventilation systems when pursuing higher thermal efficiencies of buildings. This becomes a major contributing factor in the development of negative pressure in residential buildings.	Accepted.
2.	Use of exhaust fan(s) in a dwelling or part thereof in which a conventionally flued natural draught gas appliance is installed can lead to a situation where normal flow does not develop (at least not for an unduly long period) or may be reversed (adverse flow) if normal flow had been established prior to the fan being	Accepted in the general. Insufficient detail i.e., which rooms, what appliance types and what capacity of fan or air change rate... Current average air change in normally occupied room is 1. Bathrooms may experience 10! Where is this differentiation explained and where is the analysis?

	turned on.	
3.	If adverse flow persists for a sustained period this can result in excessively high concentrations of combustion products accumulating in the indoor environment. Under some conditions these may include sufficiently high concentrations of carbon monoxide as to represent a hazard to health and even to life	Generally agreed however; empirical evidence to back up this assertion is desirable i.e., number of installations that operate under 'adverse flow' the % of these where CO is measure and in what concentration...
4.	There is a large body of literature showing that negative pressures can result in adverse flow. While the reported values necessary to cause this condition vary from as low as one to a few Pascals they are all much lower than the negative pressure capability of a typical modern exhaust fan in a space with limited ventilation. This was also the result of work commissioned by the Energy*Safety* Division of the Western Australian Department of Commerce and conducted by the AGA in Melbourne.	Accepted. Since the buoyancy forces of normal flue operation are very low the fan force (effect) required the reverse the flow, and create adverse flow, can also be low (they just need to exceed buoyancy).
5.	Adverse flow may result in spillage of high levels of CO as a result of either of two scenarios: □ Products from a poorly adjusted or maintained appliance producing CO, are spilled into the indoor environment, or □ The down draught (that is, the adverse flow) affects the appliance's combustion	Generally accepted. See comment upon 3 above. The second bullet point assumes the failure of the Draught Diverter to fulfil its primary function! Down draught is air. Is the physical process being described here 'flame chill'? A significant mechanism in CO generation is the burner ingesting its own products of combustion (vitiated air). It is this process that leads exponential CO concentration!
6.	Wind effects can also produce adverse flow conditions but these are expected to be much more transient than those produced by an exhaust fan(s) under an extended period of operation.	Agreed. The management of 'wind effects' is part of the primary function of the Draught Diverter (to protect combustion from adverse flow). That's why it's there.

7.	The potential safety issues associated with adverse flow have been recognised by gas authorities and others for many years, though the increased prevalence of exhaust fans and tighter dwellings has made the problem more critical. Some gas authorities and regulators (Including Energy Safe Victoria) recommend a test for a newly installed appliance under the most severe conditions of depressurisation as essential.	Generally accepted. There are a number of issues that need to separated and noted here for clarity; • Short duration adverse flow is part of the normal operation of an open-flue gas appliance. • A small number of open-flue appliance installations, installed in accordance with AS 5601-2010 (or legacy versions) and correctly terminated will never work. This is due to local wind / aerodynamic conditions that cannot be anticipated. The only practical test for gasfitters is to test for spillage after transitory 'start-up conditions' e.g. the flue just continues to spill... • The combination of degraded ventilation and the addition of exhaust fans detrimentally affect flue performance and may lead to adverse flow. The ESV test has its roots in UK standards for gasfitting practice. The test will confirm, at the time and conditions of the test, that Normal flow occurs under expected operating conditions (it identifies the exhaust fan as a risk factor). Appropriate testing will also confirm that the flue has not stalled due to external aerodynamic factors.
8.	After conducting a wide range of tests into the issue of adverse flow caused by exhaust fans, it was concluded in a report commissioned by the UK regulatory authority HSE, that tests were required on each installation to establish the suitability to avoid adverse flow situations arising.	Agreed. This was broadly the practice described above and recommended by ESV.
9.	The use of CO alarms is sometimes advocated as a desirable measure to eliminate the threat of CO poisoning in dwellings – regardless of how it may be produced. However, there are significant issues related to the reliability, useful life, number required, positioning and cost of CO alarms. CO alarms are not linked into the gas supply of the	I accept this conclusion and note... At the current performance and cost it would be unwise to mandate CO detectors. It is likely that technology improvements may provide accurate, stable and cost effective indicators of built environment CO (going forward)! This needs a watching brief and an appropriate Standard!

	appliance and to do so would require a more complex and costly design involving multiple trades. Retrofitting such a link would also be a major challenge on the scale required, considering there are an estimated 4.2 million dwellings in Australia where negative pressure conditions could affect combustion appliances. The cost of installing CO detectors in these would be 3.5 to 4 billion dollars as a base figure and up to $12B if a 10-year period is considered.	Is a one size fits all approach appropriate? CO detectors for open-flue appliances [space heaters and/or water heaters] or cookers or indirect warm air heaters room-sealed appliances etc etc...
10.	The use of CO alarms in recreational vehicles, which may use gas for space heating, water heating and refrigeration appears to be a slightly more suitable and cost effective solution. However the cost could still represent $100M per potential fatality.	Accepted. The individual unit cost per new RV compared to the overall and discretionary spend on such vehicles is small however; accuracy and stability of devices may be an issue.
11.	Spill switches are devices that are linked into the gas supply and will shut down the appliance in the event of a flue blockage or partial flue blockage. However, in the event of a strong adverse flow spill switches may not be as effective. Depending on the situation, it is probable that the flue products may be excessively diluted by the outside air and not reach the required trip temperature.	Agreed.
12.	Increasing the ventilation (free area of ventilators directly leading to the outside) can reduce the tendency for adverse flow to develop but may be incompatible with requirements to improve the thermal efficiency of buildings (such as under the 6 Star Rating scheme). Any additional ventilation installed will need to be large to ensure the pressure does not exceed this threshold pressure values as indicated in point 4 above.	Disagree. Experience with CO and NOx emissions from flueless space heaters suggest that (depending from which end of the telescope you observe) the appliance becomes grossly inefficient by virtue of safe ventilation or alternatively the appliance ceases to perform the comfort space heating role... The same argument applies to open-flue space heating appliances if you believe it will, in practice, operate as a flueless appliance (no functioning flue as it's in adverse flow) I suggest that all the indicators point to the obvious conclusion that strategic

		plans be made to mandate room-sealed appliances for space heating in new energy efficient homes.
13.	Oxygen depletion sensors (ODS) have a metastable pilot flame which extinguishes if the level of vitiation of the combustion air becomes excessive (and regardless of how this occurred). They have been required on unflued space heaters in Australia for over 25 years. ODS's are robust devices that are inherently linked into the gas supply, which is cut off on activation of the ODS. They could be fitted to new models of gas appliance and appear to have merit as an option for addressing the issue of excessive adverse flow with future gas appliances. However ODS's are inferential devices that do not measure CO concentrations directly and may not provide protection in a case where an appliance was spilling combustion products containing an excessively high concentration of CO. Also retrofitting ODS's into existing appliances on the scale required appears impractical.	Agree that ODS are inferential do not directly measure CO and may not perform a useful function.
14.	Appliance maintenance is recommended for all gas appliances every two years and, while not a measure to prevent or limit the development of negative pressures, it should ensure that CO emission from appliances so maintained is minimised.	Disagree with this conclusion. Regulators could do much more to encourage service maintenance and quality additionally they could confirm appropriate outcome by audit. Quietly recommending service maintenance on a 'vanilla' 2 year cycle is not good enough. Regulators should be pro-active and: • Request that Standards Australia to revise AS 4575-2005; • Ensure update training of specialised classes (Type A appliance servicing); • Facilitate the availability of Certified Appliance maintenance requirements and seek funding to support AGA in establishing 'soft copy' information and web-hosting.

15.	The use of room sealed or forced draught appliances would, in all but the most unusual fault circumstances, ensure protection against the spillage of combustion products into living areas. However such appliances are expensive and retrofitting them in place of existing installations is impractical.	Qualified agreement, however; The unusual circumstances would not be spillage as that condition is a function of an open–flue incorporating a draught diverter. There is no real cost differential for replacement or new appliance installations. By definition new build is primarily associated with lower air changes therefore why not mandate room-seal appliances! I agree that there is little case to require or retrofit room-sealed appliance in existing housing stock however; replacement is not impractical for the majority of appliance types (traditional hearth fitted fires accepted).
16.	.A timer inserted in the electrical circuit of the exhaust fan(s) appears to be a viable option in reducing the possibility of extended periods of negative pressure caused by fan operation. It is envisaged that the timer would allow fan operation for a period of some ten minutes before being restarted. A further option is for a lock out period following a run. However such a control may be seen as an inconvenience by users.	Impractical and would be tampered with because it would be an unacceptable nuisance!
17.	A public awareness campaign on the potential hazards of situations, in which negative pressures are developed, while not effecting any physical protections, would be a method of raising awareness of the issues. Such a campaign would be expected to include advice that adequate ventilation must be provided (open doors and/or windows) during periods while exhaust fans are running or simply that exhaust fans and flued gas appliances must not be operated simultaneously. The campaign may include newspaper advertisements and bill inserts to gas customers and possibly stick-on notices for exhaust fan switches and gas appliances	It is perfectly feasible to design a campaign to inform gas consumers on these issues. They are not complex!

	warning of the potential hazards. It may also note that the potential hazard extends to natural draught open flued combustion appliances that burn fuel other than gas.	
18.	Addressing the higher priority safety related items (engineering controls) is in accordance with recognised risk mitigation engineering techniques. It also avoids the issues associated with professional liability aspects of addressing lower ranked procedural controls (such as CO alarms without interruption to gas supply) before, or in isolation to, engineering controls are implemented. To illustrate the point, if there was a CO related fatality in a dwelling fitted with CO alarms then a subsequent coronial inquiry would most likely consider the risk model followed. CO alarms being a non-preferred control, also given the technical difficulties in their application and when used in isolation to other controls are not likely to substantially reduce the potential of CO fatalities. If it is then established that such non-preferred controls were (only) implemented the coroner would be well justified in making negative findings against the individuals who implemented such inappropriate risk model.	Notwithstanding the logical approach to risk mitigation that is accepted, I'm left wondering if this conclusion has moved on from risk of CO poisoning to the consider the reputational risk to Regulators. Before second guessing future coronial reports I recommend that for the Ten fatalities, where the root cause was established by investigation, all coronial recommendations and required action are revisited. This may provide an initial check list against which to compare this report.
19.	Implementing CO alarms overseas was only introduced after other, more effective means of achieving safety outcomes were pursued. These include improvements in appliance maintenance, appliance types and ventilation.	Agreed noting APPLIANCE MAINTENANCE APPROPRIATE APPLIANCE SELECTION VENTILLATION AS A PART OF THE GAS APPLIANCE INSTALLATION
9	**Recommendations**	

	It is therefore recommended that a consultancy with access to suitably qualified personnel should be engaged to review the present report and other relevant literature and produce a quantitative risk assessment (QRA) of the issues raised. A QRA is required to fully understand regulatory impacts of the implementation of any potential mitigation measures. For this reason it is recommended that an RIS be deferred until the completion of a QRA. It is recommended also that GTRC will be involved in the selection of this consultancy and that the terms of engagement are extended to include a review of the National Construction Code and its relationship with overseas construction standards and AS/NZS 5601.1:2010 Gas Installations.	The single recommendation of this Strategy is to undertake a Quantitative Risk Assessment to establish the regulatory impact of any mitigation measures. In response. GTRC have not established a strategy rather a report skewed to the impact of exhaust fans (fan centric) supported by testing a wall furnace (open-flue space heater in a test room). The ToR has not been answered since the risks of CO poisoning need to place the appliance installation at the centre of the analysis and appropriately weight all relevant factors. This has not been done. The ToR has not been answered since the breath of the CO issue has not been addressed.