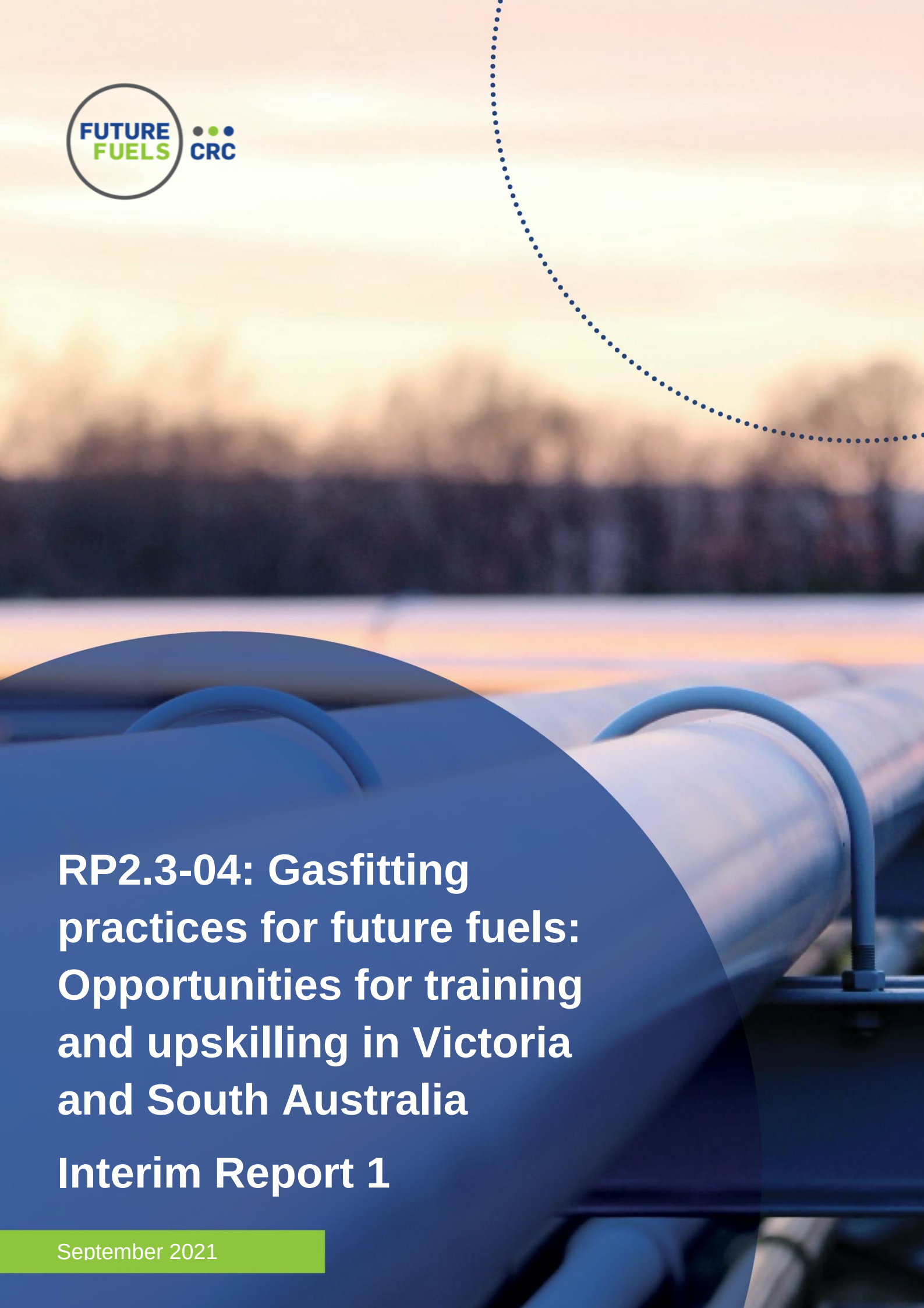

RP2.3-04: Gasfitting practices for future fuels: Opportunities for training and upskilling in Victoria and South Australia

Interim Report 1

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Project number: RP2.3-04

Gasfitting practices for future fuels: Opportunities for training and upskilling in Victoria and South Australia

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Description	Practical delivery of future fuels to the public requires that appropriate trade resources (i.e. gasfitters) are available. This project assesses the current state of the gasfitting trade in terms of numbers, registration and continuing professional development, identifies the evolving knowledge base to develop the necessary skills for future fuels and assesses the capacity of the existing training, certification, registration and reregistration of gasfitters in Victoria and South Australia to deliver the necessary workforce capabilities and capacity for a successful transition and ongoing sustainability of a future fuel economy.
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List of Acronyms

AASN	Australian Apprenticeship Support Network
AISC	Australian Industry and Skills Committee
AIS	Australian Industry Standards Limited
ASQA	Australian Skills Quality Authority
CISC	COAG Industry and Skills Council
CPD	Continuing professional development
ESV	Energy Safe Victoria
GTOs	Group Training Organisations
IRC	Industry Reference Committee
JGTP	Joint Group Training Program
MOOC	Massive Open Online Course
NCC	National Construction Code
PICAC	Plumbing Industry Climate Action Centre
RTO	Registered Training Organisation
SSO	Skills Service Organisation
TAC	Technical Advisory Committee
TAFE	Technical and Further Education
VBA	Victorian Building Authority
VRQA	Victorian Registration and Qualifications Authority
VET	Vocational Education and Training

Summary of Report

Appropriately trained gasfitters are critical to the transition to hydrogen as a future fuel within the domestic energy market. This report explores the emerging knowledge and skills required for gasfitters in the transition. The research specifically focuses on the capacity of existing training, certification and licensing frameworks for gasfitters in Victoria to deliver the emergent skills required. In order to address this research focus, this interim report brings together the results of a document review and stakeholder interviews to explore the relationship between licensing and regulation, associated training deliverables, outcomes and experiences. The key findings of interviews conducted with engineers, technicians and researchers working on hydrogen pilot projects (n=6), industry regulators (n=2), Victorian gasfitters (15), Vocation Education and Training (VET) sector trainers working in Victoria (n=7) and ACT (n=1), and four plumbing industry associations (n=4), provide first hand insight into the existing structures and processes in Victoria to inform recommendations to be delivered in the final stage of the project.

The report explores three key areas: Emerging knowledge and skills required for gasfitters working with hydrogen; the existing capacity of training, certification and licensing frameworks to deliver hydrogen training and associated skills to gasfitters in Victoria, and; the identified challenges with the changes required within these existing frameworks.

Emerging knowledge and skills required

Based on the desktop review of hydrogen strategies, published research and interviews with those working on hydrogen pilot projects in Australia, this report presents three potential end use scenarios based on differing implications likely for gasfitting work and associated training. These are:

1. Low percentage hydrogen blend of up to10 per cent in existing reticulated gas networks
2. 100 per cent hydrogen in reticulated networks
3. Home electrolysers and fuel cells

In the first scenario, the impact on gasfitting work will likely be small as existing appliances, fittings and materials can generally accommodate low percentage blends of hydrogen. In this scenario, awareness of the properties of hydrogen gas would be advantageous for those working with hydrogen. In the second scenario, gasfitting practice will broadly remain the same because hydrogen will substitute natural gas as the domestic combustion fuel. However, knowledge of hydrogen properties and their impacts on associated gasfitting practices will be critical. This will include, but is not limited to, working safely with hydrogen, suitable materials and fittings, knowledge and skills for installation, maintenance, and conversion of appliances. In the third scenario, traditional gasfitting work is expanded with new emergent technology such as electrolysers and fuel cells. This emergent field is likely to require multidisciplinary knowledge and skills across areas such as chemistry, electrolysis, electrical, and water and gas plumbing. This in and of itself may require a new area of work practice and associated certification. The associated implications for training for each of these scenarios are shown in Table 1.

Table 1: Training Implications of different hydrogen end use scenarios

Scenario 1: ***Up to10 per cent hydrogen blend with natural gas***	Based on education research, increasing knowledge of hydrogen properties can be achieved through a transmissive training approach such as an information session, video, short online course or other materials that can be studied by gasfitters to achieve the required knowledge outcomes.
Scenario 2: ***100 per cent reticulated hydrogen***	In the 100 per cent hydrogen scenario, hydrogen would need to be included in initial gasfitter training and also in upskilling training for gasfitters that will be working with hydrogen fuel. Depending on the approach taken to the hydrogen roll out, some gasfitters who wish to undertake hydrogen gasfitting work may complete additional training. If 100 per cent hydrogen was supplied in all existing gas network to homes for domestic end uses, then all gasfitters would need to undertake training to expand their knowledge of hydrogen properties and the skills needed to safely work with hydrogen and hydrogen appliances and/or undertake appliance conversion work, if and where, this is needed. This raises the question

	of the number of existing gasfitters currently in Victoria and the number of Victorian homes that would require appliance upgrades or conversion in the 100 per cent hydrogen scenario. As stated in Section 6.2.1, by 2030, between 2 and 2.5 million homes in Victoria are likely to be connected to gas and currently there are 20,262 gasfitter plumbers which includes 8,8676 plumbers licensed and 11,586 plumbers registered in gasfitting work. Depending on the hydrogen roll out, some or all of these gasfitters would need to be competent in working with 100 per cent hydrogen.
Scenario 3: ***Fuel cells***	Based on the interviews and desktop review, those undertaking work with residential electrolysers/fuel cells will need specific training in areas traditionally outside of gasfitting units of competency. As a fuel cell is an appliance which is installed in a home and under the current market based approach, would be the choice of the home owner to install or the housing developer, it is not necessary for all gasfitters to be trained in such work, however upskilling is likely required for existing gasfitters who wish to undertake work with fuel cells.

Of significance, and a key finding of this project so far, is the limited existing research on hydrogen in end use appliances and still many unknowns regarding end uses of hydrogen in the residential sector and impacts on work practices and associated training requirements.

Capacity of existing training, certification and licensing frameworks for gasfitters in Victoria

The research identified that if 100 per cent hydrogen is introduced into the domestic gas network, Victorian gasfitters would need upskilling and require further training and support. All participants supported the need for further training as long as it was specifically targeted to those undertaking hydrogen work and delivered in a variety of ways to meet differing learning preferences and time constraints of gasfitters. The VET sector was recognised as appropriate to deliver the new competency units for hydrogen work for both apprentices and registered and licensed gasfitters. It was also recognised the new competency units should be a licensing requirement for working with hydrogen and required by the regulator. The VBA, ESV and manufacturers were also recognised by all stakeholders as having critical roles in both sharing information on the emergent training requirements for existing practitioners and supporting ongoing learning through continued training, collaboration with the VET sector and regulatory oversight of ongoing hydrogen gasfitting practices. The complexity of multiple stakeholders involved in supporting ongoing learning highlights the need and importance of having a coordinated approach between information sources with the introduction of hydrogen.

Current challenges

From the interviews and desktop review of existing publications, this report identified a number of challenges for the training and upskilling of gasfitters for hydrogen linked to the way the existing training, licensing and certification systems function.

Some of these challenges relate to the complexity of the development and delivery process for units of competency. They are established at a national level in a National Training Package, and delivered by both private and public registered training organisations (RTOs). Development of the National Training Package for plumbing, which includes gasfitting, involves a range of national and state actors from the training sector, industry, government and state regulators of gas, gasfitting and training. Complicating the process further is the yet to be established hydrogen industry which will create the demand for skilled services. Given the VET sector is designed to respond to deliver skills based on market needs, this poses a challenge for the emerging hydrogen industry. Developing initial and ongoing training for hydrogen, therefore, differs significantly from the usual factors that prompt updates to National Training packages or even professional development programs run by industry associations and regulators. Leadership, planning and coordination at a macro level to encourage the development of the hydrogen industry was noted by all stakeholders as critical to avoid a ‘skills lag’ and ensure that all stakeholders and aspects of industry development, such as standards and appliance development, work in unison.

Furthermore, the diversity of RTO types (such as public, private and industry based) and differing access to resources has implications for the readiness of different RTOs to delivery hydrogen training. Several interviewees reported that demand exceeds the supply of specialist training in gasfitting servicing. Introduction of hydrogen may create a similar situation with regards to demand for hydrogen training. Manufacturers and regulators play a role in supporting the readiness of the sector, for example, providing access to emerging technologies for training purposes and to upskill trainers in hydrogen. Inclusion of hydrogen in the National Training Package for plumbing will require consideration of the preparedness of different RTOs to deliver training and the support needed from industry and government to upskill trainers, provide facilities and appliances for training.

It is important to note that because licensing requirements include the successful completion of a selection of national units of competency, these above challenges affect both initial training of gasfitters and also any potential licensing requirements for upskilling for those working on hydrogen.

When it comes to licensing and registration requirements, existing arrangements will ensure that newly licensed and/or registered gasfitters in Victoria will be trained once the National Training Package has been updated. The situation is very different for gasfitters who are already qualified. There is currently no legislated requirement in Victoria for qualified gasfitters to update their skills to take into account changing work requirements in their field. Multiple initiatives are underway in Victoria to address competency in building trades including plumbing/gasfitting. The transition to 100 per cent hydrogen will require those working with hydrogen to develop and demonstrate the new competencies to undertake such work. The alternative of grandfathering all currently qualified gasfitters into the new system and relying on voluntary upskilling is not in the best interests of public safety if the state is to develop a substantial renewable hydrogen industry as is the current government plan. If fuel cells are prescribed as Type A appliances, it would result in all existing gasfitters being able to install such appliances – under this scenario, there will be a need to upskill gasfitters in such work to ensure it is safely carried out.

A related competency issue is regulatory oversight of the standard of work. Some interviewees expressed dissatisfaction at the current system of regulatory oversight which, in their experience, fails to deal effectively with practitioners who deliver sub-standard work. With the introduction of a new fuel into the sector, the importance of regulatory oversight is compounded and vital to ensure works are compliant with regulation and so safe for households. Further, regulatory oversight was identified as key to maintaining current skills amongst gasfitters and those emergent in a new hydrogen market. It is likely there will be a need for enhanced regulatory oversight in the hydrogen space in the initial years of implementation to ensure consumer safety standards are maintained and in recognition of industry's unfamiliarity with hydrogen. With the transition to a new fuel, areas of non-compliance in hydrogen work can be used to also inform ongoing learning initiatives.

This report concludes with potential training options for gasfitters. The suitability of the options identified depends on the type of learning required for working with hydrogen. Options include: Information via updates, guides and online videos regarding any changes to standards and licensing/registration requirements; Massive Open Online Courses (MOOCs); Hydrogen units added and amendments made to include hydrogen in the National Training Package; Training from appliance manufacturers and distributers; hydrogen pilot projects as training facilities, and; professional development sessions run by associations and government. All training options were supported by gasfitters however preferences differed depending on learning style and time constraints. There are also cost considerations but it is beyond the scope of this study to address this.

Regardless of the training approaches taken, training content and skills development is dependent on having a better understanding of the implications of hydrogen on appliances and end uses, updated standards, appliances to deliver training on, and updated licensing requirements to guide the selection of units of competency or any other additional learning requirements.

1 Introduction

Significant changes are facing Australia's domestic energy sector to date however much of the planning has focused on technology requirements. In order to successfully transition to a new energy future, skilled practitioners are essential. The potential transition to hydrogen as a future fuel means gasfitters are an essential trade and are therefore the focus of this study which seeks to: 1) investigate the capacity of gasfitters to respond to such a transition in terms of numbers and existing skills 2) identify the emerging knowledge and skills required for the transition to future fuels and 3) assess the capacity of the existing training, certification, registration and licensing of gasfitters in Victoria and South Australia to deliver the these skills for a successful transition to future fuels. This interim report brings together the results of a document review and stakeholder interviews to draw initial conclusions for Victoria.

In Australia almost seven out of ten homes use reticulated or bottled gas (ENA, 2018), accounting for 21 per cent of residential and commercial end-use energy consumption (Department of the Environment and Energy, 2018). While natural gas produces only one third to one sixth of the emissions produced by the Australian electricity grid depending on the state (ENA, 2018; ENA, 2017), natural gas still produces emissions in all stages of the supply chain (Commonwealth of Australia, 2019). With the total number of residential gas connections growing in Australia (AEMO, 2020; ENA, 2017), hydrogen has received attention as a natural gas replacement given its potential to be produced from renewable electricity and its function as a seasonal storage medium for energy (Palmer, 2018; Finkel et al., 2018). Australia's Gas Vision 2050 report (ENA, 2018) and the CSIRO's National Hydrogen Roadmap (Bruce et al., 2018) state that hydrogen can be used in the existing gas supply networks to heat, cool, cook, and generate electricity in the home. Currently, numerous trials are being undertaken in Australia to test domestic end use appliances with hydrogen and inject hydrogen into the natural gas supply for use in homes[1]. Current Australian domestic appliances have been shown to be compatible with natural gas that is enriched with up to 10 per cent hydrogen (Smith et al., 2020: 11), however, higher percentage blends of hydrogen will require new appliances or significant upgrades to existing appliances specifically in relation to their burner designs (Bruce et al., 2018).

Another future low carbon fuel proposed for use in existing gas networks is biomethane, a purified biogas that contains at least 95 vol per cent of methane (Vrbová and Ciahotný, 2017: 9393). Under Australian regulations, biogas that is upgraded to biomethane must meet natural gas specifications in order to be injected into the gas network. Currently, there are plans to blend biomethane with natural gas in the reticulated gas network or blend biomethane with renewable hydrogen to displace natural gas (ARENA, 2020).This study takes the position that injection of biomethane into reticulated gas networks for residential combustion use will have no notable effect on gasfitting practices, however, we acknowledge that there are some considerations for using biomethane as a combustion fuel in domestic appliances. These include concerns that an increase in oxygen with biomethane can cause higher levels of corrosion than natural gas leading to fouling of copper piping. This issue however can be addressed if biogas is upgraded to required specifications for natural gas. Another issue is the potential for the combustion of biomethane to cause a build-up of silica at the point of combustion also leading to fouling. This however would occur in appliances after years using biomethane. It is likely that regulations regarding siloxane levels will be introduced to ensure that this impact is minimal. Therefore, this is not viewed as a significant issue that would affect appliances or their installation from a gasfitting perspective. Based on this information, this report focuses on hydrogen as a future fuel which, even at low percentage blends of 10 per cent can have implications for gasfitting practices and associated knowledge and skills requirements for gasfitters.

The transition to hydrogen will affect the gasfitting trade and associated work practices. Thus far, research has focused predominantly on technological challenges and costs of changing to hydrogen as a fuel, rather than skills and resources implications for the installation and maintenance of associated household appliances. Furthermore, the implications for gasfitting practices of emerging technologies associated with hydrogen such as fuel cell technologies for domestic uses is also under researched. Key stakeholders such as the Australian Industry Standards (AIS, 2019), state and Commonwealth governments (COAG Energy Council, 2019), and more recently Master Plumbers Australia and New Zealand (Master Plumbers Australia and New Zealand, 2021a) argue that a successful transition to a hydrogen based future fuel economy requires sufficient trades resourced with the necessary skills, a key trade being gasfitters. Improving workforce skills and establishing

[1] For example see Deakin University's Hycel facility in Wollongong, Victoria (Deakin University, 2021), AGIG's Hydrogen Park in Tonsley, South Australia (AGIG, n.d), ATCO's Clean Energy Innovation Hub (CEIH) in Jandakot, Western Australia (ATCO, 2020), Evoenergy and the Canberra Institute of Technology's Hydrogen Test Facility in the Australian Capital Territory (Evoenergy, 2021) and Jemena's Western Sydney Green Gas Project (Jemena, n.d).

training regimes form part of the first foundational phase of the Australian Hydrogen Strategy (COAG Energy Council, 2019).

1.1 The gasfitting trade

In Australia, gasfitting is a subset of the plumbing trade. Australia-wide, gasfitting accounts for 23 per cent of the total revenue generated by plumbing (Kelly, 2021). The main driver for plumbing services is new residential development which includes gasfitting work; however, gasfitting in particular, is also influenced by the extension of natural gas distribution into new regions. Due to an increase in access to natural gas, the share of industry revenue from gasfitting has increased over the past five years (Kelly, 2020). Gasfitters (and plumbers) are defined as skilled trades, also known in Australia as “manual trades” or “the crafts” in the UK. ‘The term “skilled trades” carries with it an understanding that an apprenticeship is required for entry and that qualifications are gained through formal vocational education and training (VET) (Bridges et al., 2020: 914). Thus, gasfitting is a specialist licensed trade that requires training, accreditation and registration.

There are different categories for plumbing work, which form the basis for different classes of licensing and registration. These categories include Gasfitting, Type B Gasfitting, and specialised classes such as Type A Appliance Conversion work, Type A Appliance Servicing work and Type B Gasfitting advanced work.. According to the Australian Standard for gas installations, Type A appliances are those for which a certification (a certificate number to demonstrate compliance with a Standard or Australian Technical Specification) scheme exists while Type B appliances are those appliances with a gas consumption in excess of 10MJ/h for which a certification scheme does not exist. This would include a Type A appliance used in an industrial application for which it was not intended (Standards Australia, 2013). In less technical language, Type A appliances are largely off the shelf domestic appliances such a hot water heaters, warm air heaters (space heating) and cooking appliances. Type B appliances are bespoke-designed, larger energy use appliances which are mostly industrial in nature but may include some large domestic space heating and hot water systems.

In Australia, gasfitting work is defined by each state and territory by their respective legislation (Standards Australia, 2013). However, as an example, Victoria, under Part 4, Division 3 of the Plumbing Regulations 2018, defines gasfitting work as:

> the construction, installation, replacement, repair, alteration, maintenance, testing or commissioning of any pipe, appliance, flue, fitting, apparatus, control or other item that is involved with the supply or use of gas and that is fitted downstream of the gas supply point and includes— (a) any gas appliance in, or on, a caravan or a vessel; and (b) any roof sheeting and roof flashing that is necessary for the purpose of any work described in this subregulation; and (c) any design work that is incidental to, or associated with, any work described in this subregulation.

While there is a large body of research into apprenticeships and also vocational training, significantly less research exists on plumbing/gasfitting as a profession and training needs linked to technology changes. Plumbers have been researched in Australia to determine their views on changes to hot water regulation in New South Wales. The study undertaken by Harvey et al. (2011), surveyed 110 plumbers, 30 regulating authorities and 151 plumbing students to investigate ‘the impact of the regulations on the knowledge, attitude and practice of workforce professionals responsible for their uptake and enforcement’ (Harvey et al., 2011: 234). Plumbers have also been researched in the context of ‘green plumbing’, and their role in reducing resource use through water efficiency measures (Thomas et al., 2010) or energy use through solar hot water systems (Elton et al., 2012). Using semi-structured interviews and surveys, Elton et al. (2012) investigated the experiences of plumbers who undertook the GreenPlumbers Program (a United States training and accreditation program for plumbers). In recognition that ‘New knowledge will need to be transmitted about emerging water efficient technologies, public policies and practices, as well as the rationale for use in residential and Industrial, Commercial, and Institutional (ICI) sectors’ (Elton et al., 2012: 595), the GreenPlumbers Program aimed to transmit such information. The research investigated participants motivation and use of learning from the Program. From a training perspective, Gordon et al. (2009) provide an overview of the role of the plumber in Scotland and how apprentice training assessment of has moved away from an examination led to a competence based approach over the past three decades. The authors find that a competency based assessment model for plumbers is dependent on good relationships between the training sector and industry but that it also better ensures that ‘training is aligned to the current and projected needs of industry’ (Gordon et al., 2009: 479).

Based on this preliminary literature review, research on the perceptions and work practice contexts of gasfitting work, and the skills needed for the installation and maintenance of hydrogen-based appliances, has not yet been undertaken. Such research will be essential to inform successful change management programs within the gasfitting trade that are respectful of existing competence and seek to fill knowledge gaps in a way that receives maximum acceptance from the members of the trade itself while meeting the necessary technical requirements for a safe and effective transition in domestic energy use.

1.2 Research question

A safe and timely transition to a future fuel economy requires sufficient trades resourced with the necessary skills (AIS, 2019). Trades are also seen as a trusted source of information for consumers so transitioning trades to future fuels is critical for transition of society as a whole. The gasfitting trade will be most critical to a transition given the potential disruption of work practices that have been established for decades. A planned response to future fuel transition is needed that understands the new and evolving knowledge base, associated competencies, and resourcing level that will be required to support hydrogen in gasfitting work. This not only applies to emerging tradespeople but also registered gasfitters who are already practising and educating apprentices. It is essential to determine the capacity of the existing gasfitter workforce to meet the increased workload generated by transition to a hydrogen fuel economy. Specifically, an understanding of how to best manage the change process to support plumbers licensed as gasfitters to successfully transition to a hydrogen fuel source in the adaptation and/or installation of Type A gas appliances (including domestic and light commercial appliances such as stoves and hot water systems, among others) is required.

This research, therefore, aims to understand:

- the capacity of existing gasfitters to retrain;
- the amount of work the change will generate and the ability of the existing gasfitter (after retraining) to complete this work;
- the need to train additional plumbers as gasfitters; and,
- the support mechanisms in place to help the industry address the new work environment as the transition occurs.

To address these questions, this research will investigate the current status and structure of gasfitting trade training in Victoria and South Australia, including the current systems for recruiting and training gasfitters, and the resourcing level and evolving knowledge base required for gasfitting for future fuels. The work will commence with a desktop review of relevant literature and regulation. To complement the desktop review, interviews with key training, industry and government stakeholders, along with gasfitters are undertaken.

The following section of this report presents the research methodology that informed the desktop review, interview data collection and analysis. Section 3 of the report presents an overview of gasfitting, licensing, training and ongoing learning initiatives at a national level, then Section 4 explores the existing gasfitting capability in Victoria including the number of gasfitters in Victoria, licensing and training requirements. Section 5 moves on to the implications of hydrogen on gasfitting work, including properties of hydrogen and implications for skills needs supported by existing research, international work on hydrogen competencies and interviews with those working on hydrogen trials. Section 7 presents the findings from interviews with gasfitters, gasfitter trainers and associations to explore the needs of these key stakeholder groups in a transition to future fuels. Overall implications from this first interim report are presented in Section 8.

2 Method

The Victorian case study presented in this interim report, firstly involved a desktop review of relevant literature and regulation. To complement the desktop review, interviews with key training, industry and government stakeholders, along with gasfitters were undertaken.

2.1 Desktop review

A desktop review involves the collection and analysis of literature such as research papers, reports, websites, policy and other sources useful for developing an understanding of what research has been undertaken, key policy shifts and governance frameworks, and identified issues, enablers or gaps that need to be filled. This desktop analysis will, importantly, provide an analysis of existing frameworks and policy to provide an overview of how the training and upskilling, registration and licensing structures are placed in relation to their intended operation. This is referred to by Hollnagel (2014) as work as prescribed or work as imagined and provides a framework in which to compare and contrast the subsequently generated interview data.

2.2 Interviews

Based on a desktop review of academic and grey literature, very little research has been undertaken on gasfitter practitioners, or plumbers more broadly in Australia and internationally. Similarly, while research has been undertaken on VET sector training and employability within Australia, no research to date has focused specifically on plumbing trades and the training approaches required to transition to an alternate future fuel. In the context of ongoing training, commonly referred to by governments and industry as Continuing Professional Development (CPD), no academic research has been undertaken on post apprentice training of plumbers or gasfitters; however, a review was undertaken into professional development of plumbers in Victoria supported by data generated from surveys and focus groups. Additionally, a review is underway into professional development for building practitioners in Victoria due to problems with quality of work performed. These initiatives are further described in Section 4.4. With such limited existing research, it is important to engage those who work in the fields of gasfitting, hydrogen competencies, gasfitter training and also VET and gas industry regulators, to gain an insight into what is currently known about gasfitting skills needs for hydrogen, how this might be delivered through initial VET training and also through professional development. This includes developing an understanding of existing frameworks and their challenges as well as understanding how apprentices and licensed/registered gasfitter plumbers learn.

Semi-structured interviews were chosen as the most appropriate method to collect data, to complement a desktop analysis. Such an approach recognises and accounts for work as prescribed versus work as done in practice, a distinction defined by (Hollnagel, 2014). That is, a desktop analysis of existing frameworks provides an overview of how these frameworks are intended to operate, while engaging with stakeholders directly through interviews, provides a picture of the lived experiences of these frameworks, highlighting stakeholder perceptions of the barriers and opportunities within these frameworks based on their actual day-to-day work practices. Semi-structured interviews were chosen because of their suitability for understanding the lived experience of interviewees and explore new phenomenon as it arises during the interview (Galletta and Cross, 2013). Qualitative studies are often concerned with gaining an in-depth understanding of a phenomenon and not as concerned with making generalisations to a larger population of interest (Dworkin, 2012).

2.2.1 Participant selection

A number of stakeholder groups are of importance to generate an understanding what changes may be needed to gasfitter trades training to support the transition to hydrogen fuel in Type A appliances. Key stakeholder groups include:

- Gasfitter trainers in the VET sector or in professional development contexts
- Registered/licensed gasfitter plumbers and apprentices
- Gasfitting and appliance associations and unions
- Gasfitting licensing/gas appliance regulators
- Those with knowledge of gasfitting skills needs and timelines from their involvement in hydrogen research, standards or units of competency

The following presents the justification for the inclusion of each of these stakeholder groups.

2.2.1.1 Gasfitter trainers in the VET sector

While there is a body of research on VET sector trainers, little research has been undertaken on gasfitting training. What research has been found by the desktop review highlights a number of challenges in the VET sector for training trainers to deliver new skills. Therefore, this stakeholder group is important to interview to understand how the upskilling of training can be supported to facilitate the addition or amendments to existing units of competency and their delivery. The researchers sought the knowledge and perspectives of this stakeholder group to better understand trainers' knowledge and perception of hydrogen as well as structures in place to support them to upskill to deliver any new or updated units of competency and to understand any challenges, they perceive, in delivering new or updated training.

2.2.1.2 Registered/licensed gasfitter plumbers and apprentices

Gasfitters as an essential occupational group in the transition to a hydrogen fuel economy given their role in the installation and ongoing maintenance of hydrogen systems in homes and businesses. Both the perception of this new fuel source and required skills from a gasfitter's perspective are critical to consider, as perception and skills influence how gasfitters undertake day-to-day tasks, and also their acceptance of the need to upskill.

Based on the limited existing research on plumbing practitioners, little is known about this group of practitioners and how they learn, particularly in an Australian context. What little is known has been generated by the work of the Plumbing Industry Commission of Victoria (PIC) conducted in 2009-10. It is important to understand how they perceive learning and the best way they think it can be attained given rapid and significant changes in the contemporary world demand that practitioners continuously learn. Within this conceptual context, this project responds to the call from Webster-Wright (2009: 714) regarding the need to better understand continuing learning for the workplace. Webster-Wright (2009: 714) argue that we need to better understand how learning occurs within work practices by using 'holistic, situated research approaches' to better understand practitioners' 'experiences of learning in a way that respects and retains the complexity and diversity of these experiences' to inform the best ways to facilitate ongoing learning. Therefore, the researchers sought the knowledge, experience and perspectives of gasfitters to better understand the existing work practices, how they learn and their views on undertaking ongoing training.

2.2.1.3 Gasfitting and appliance associations and unions

Trades associations and unions have an influential role in delivering and shaping ongoing trade training. Understanding the perspectives of these stakeholders with respect to both hydrogen and its transition in the industry will add to the barriers and enablers associated with the upskilling of gasfitters.

2.2.1.4 Gasfitting licensing/appliance regulators

Regulators of both safety and trade practice associated with Type A gasfitting work are also important stakeholders. Regulators of licensing and registration have knowledge of the requirements associated with gasfitting work and can share their views and experience of barriers or enablers for adjusting such requirements with the introduction of hydrogen. These regulators are also the key precipitator of change associated with both voluntary and mandatory skills development for accredited trades people. Regulators of Type A gasfitting work which in some states differs to the regulator of gasfitting licensing, such as in Victoria and South Australia, are another key stakeholder with knowledge of potential and likely changes in standards and associated certification of appliances and installation and maintenance work.

2.2.1.5 Professionals testing hydrogen in domestic appliances and distribution networks

For initial training, there is currently a limited understanding through research or experience of the skills needs for hydrogen and associated changes in work practices that can be used to inform updates to the National Training Package and units of competency. The researchers sought the knowledge of those involved in hydrogen pilot projects, updates to appliance standards, appliance manufacturing and gasfitting work to better understand the skills needs or changes to work practice for gasfitting for hydrogen.

2.2.2 Recruitment

Participants were identified in the following ways:

- People suggested by FFCRC project partners, the project's industry advisory group and their networks.
- Researchers' professional networks

- Snowballing based on the recommendations by other participants
- Public website search
- Advertisements by organisations on behalf of the researchers via website, electronic direct mail and SMS.

Potential participants were contacted by the RMIT research team by email. A description of the research project, what participants will be asked to do if they agree to participate and any associated risks and benefits from participating were provided to potential participants in a Participant Information Sheet and Consent Form. Participants signed the consent form before participating in an interview.

Stakeholder group	Number
Training	**8**
Industry led research (working on hydrogen trials)	2
Industry association	4
Gasfitting regulator	2
Gas distribution (working on hydrogen trials)	4
Domestic gasfitter	14
Gas appliance retailer and gasfitter	1
Total	**35**

Table 2 Participant demographics

#	Sector	Qualifications	State	Gender	Experience in years
P01	Gas distribution	Associate Diploma Engineering	ACT	Male	30+
P02	Gasfitting regulator	Not disclosed	VIC	Male	30+
P03	Industry association	Licensed electrician	VIC	Male	10-19
P04	Gas distribution	Not mentioned	ACT	Male	30+
P05	Industry association	Licensed gasfitter	ACT	Male	30+
P06	Gas distribution	Bachelor of Mechanical Engineering	NSW	Male	10-19
P07	Gas distribution	Licensed gasfitter	NSW	Male	20-29
P08	Gasfitting regulator	Not disclosed	QLD	Male	30+
P09	Industry led research	Environmental Engineer	VIC	Male	20-29
P10	Industry led research	Ba. Education / Ba. Arts (Communications)	VIC	Female	10-29
P11	Training	Licensed gasfitter with Teaching Degree	ACT	Male	30+
P12	Industry association	Registered Plumber: Type A appliance servicing	VIC	Male	30+
P13	Training	Registered Plumber: Gasfitting – Type A appliances/Teaching Certificate	VIC	Male	30+
P14	Training	Licensed Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
P15	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+
P16	Training	Registered Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
P17	Domestic gasfitting	Licensed Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
P18	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+
P19	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+
P20	Domestic gasfitting	Licensed Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
P21	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+
P22	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+

P23	Domestic gasfitting	Licensed Plumber: Type A appliances	VIC	Male	10-19
P24	Training	Bachelor of Justice Studies/Masters of Human Rights	TAS	Male	10-19
P25	Training	Not disclosed	TAS	Male	30+
26	Gas appliance retailer/installer	Licensed Plumber: Type A appliances	VIC	Male	30+
27	Domestic gasfitting	Licensed Plumber: Type A appliance servicing	VIC	Male	30+
28	Domestic gasfitting	Licensed Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	20-29
29	Domestic gasfitting	Licensed Plumber: Type A appliances	VIC	Male	30+
30	Domestic gasfitting	Licensed Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
31	Domestic gasfitting	Licensed Plumber: Type A appliances	VIC	Male	0-9
32	Domestic gasfitting	Licensed Plumber: Type A appliances	VIC	Male	30+
33	Training	Registered Plumber: Type A appliance servicing and Type A appliance conversion	VIC	Male	30+
34	Training	(Formally) Licensed Plumber: Type A appliances	VIC	Male	30+
35	Industry association	(Formally) Licensed Plumber: Fire Protection	VIC	Male	30+

2.2.3 Interviews

Each participant was invited to undertake an interview and respond to questions about their views and experiences on gasfitting practices, training frameworks, and/or work practice impacts and training needs in the transition to future fuels. Interviews were recorded after receiving participant permission and transcribed for analysis.

Ethics approval for the project was obtained from the researcher's Universities ethics committee. All interview recordings and transcripts were assigned a project code and cannot be attributed to specific individuals. All interview data has been treated as confidential. This research ensures that the confidentiality of participants and their data is maintained in a number of ways:

- Interviewing participants individually
- Not using names or unique job titles in reporting research results
- Changing any other details in reported research results in a way that prevents identification of specific individuals but which maintains the context in which the research data was acquired (e.g. not using the names of the specific organisations or projects)
- Ensuring a sufficient number of participants so that individuals are not identifiable within their own organisation/group or project based on reported research results
- Using a professional transcription service
- Data management in accordance with the RMIT approved Research Data Management Plan

Interview questions differed between stakeholder groups but broadly included similar questions as shown in Appendix 10.1.

2.2.4 Data analysis

Interview transcripts were imported in NVivo 12 and thematically analysed. Given the exploratory nature of the research, thematic analysis was deemed a suitable method from which themes could emerge from the data collected (Boyatzis, 1998).

3 National context

The frameworks that govern gasfitting licensing and training exist at both national and state level, with some level of discretion involved in the delivery of initial training by vocational education providers and apprentice groups due to the privatisation of most training and some apprenticeship organisations. Therefore, to understand the frameworks governing gasfitter licensing, registration, training and upskilling in Victoria, an overview of the national context for gasfitting work and training is now provided.

3.1 Registration and licensing overview

Plumbers are amongst the 17 per cent of the Australian workforce that require registration or licensing to undertake work. While some of these occupations are registered or licensed at a national level, most professions, including plumbing, are registered or licensed on a state by state basis. As a result there are differences between the requirements for registration and licensing of certain professions between states across Australia (Department of Prime Minister and Cabinet, 2020). Plumbing is no exception.

3.1.1 Licensing harmonisation

In recognition of the inconsistency between states regarding trades licensing and qualifications including plumbing and gasfitting work, the proposal of a national occupational licensing system has been explored by the Australian government and states and territories over the past two decades. Government publications report that 'throughout 2009–2013, progress was made toward implementation of a national occupational licensing scheme (NOLS). However, in December 2013, the majority of states and territories decided not to pursue the reform, citing concerns with the proposed model and its potential costs' (Commonwealth of Australia, 2018: 2). Since this time, state and territory authorities continue to regulate the registration and licensing of occupations within their respective states.

Currently a system of mutual recognition exists between states 'to reduce barriers to occupational mobility across jurisdictions' (Department of Prime Minister and Cabinet, 2020: 1). Mutual recognition allows people:

> licensed or registered to practise an occupation in one jurisdiction to practise the equivalent occupation in another jurisdiction. A licensed person seeking to work in another state or territory can practise the equivalent occupation in the new state or territory without undergoing further testing. However, they must first apply for recognition of their existing licence and pay any relevant fee.
>
> (Department of Education, 2020: para. 4)

Mutual recognition under the Mutual Recognition Act 1992, has however received criticism due to the complexity and costs which particularly impact those practitioners that work across jurisdictions (Department of Prime Minister and Cabinet, 2020).

More recently, in 2020, Commonwealth and State and Territory governments agreed to introduce a uniform scheme for the automatic mutual recognition (AMR) of occupational registrations.

> AMR allows a person who is licensed or registered for an occupation in one jurisdiction to be considered registered to perform the same activities in another jurisdiction, without the need to go through further application processes or pay additional registration fees. The AMR scheme will apply to registrations currently covered by existing mutual recognition arrangements.
>
> (Department of Prime Minister and Cabinet, 2020: 1)

AMR will be legislated through an amendment to the Mutual Recognition Act 1992. Consultation is currently underway regarding the draft amendments. In the context of plumbers, concerns with AMR have been raised due to the inconsistency between licensing and registration requirements between states. A first concern is that the draft amendment does not distinguish between registered or licensed practitioners, which in some states, has implications for the level of responsibility that a plumber has in ensuring regulatory compliance of their work. For example in Victoria, licensed plumbers can certify work while registered plumbers cannot. The requirements for licensing in Victoria ensure that a licensed plumber has the competencies for this significant level of responsibility. Compliance systems however differ across states. Some states 'inspect all completed works, some undertake random auditing of completed works whilst others will inspect all stages of a plumbing

installation' (Master Plumbers Australia and New Zealand, 2021b: 2). According to Master Plumbers this has implications for ensuring the quality and safety of plumbing work under the proposed AMR amendments because:

> These cross jurisdictional variations in regulatory approach requires that the individuals who work within that jurisdiction have knowledge of what their responsibilities are in relation to reporting completion or in some cases commencement of that work. And, given that in some jurisdictions there is significant regulatory and legal onus on contractor level, it would therefore be impractical and unsafe to allow the relevant regulator to be effectively by-passed in the manner envisaged in the proposed changes.
>
> (Master Plumbers Australia and New Zealand, 2021b: 2)

The second concern regarding different competency requirements for licensing and registration in each state and territory from Master Plumbers is with regards to the work in which a plumber is qualified to undertake:

> In gasfitting for example, a registered person from one jurisdiction may be registered in gas but be experienced and trained only in LPG gas work. In others, a gas registration requires that a practitioner has the competency to work safely with both natural gas and LPG.
>
> (Master Plumbers Australia and New Zealand, 2021b: 3)

It is argued that these different competency requirements across jurisdictions pose health and safety risks when considering AMR and so must be considered as part of any amendment.

3.2 National standards

While licensing and registration requirements differ between states, the relevant standard for gasfitting work, AS/NZS 5601.1: 2013 General Gas Installations, is established at a national level and applied in each state. The standard sets out 'the mandatory requirements and means of compliance for the design, installation and commissioning of gas installations that are associated with the use or intended use of fuel gases such as natural gas, LP Gas, or biogas' (Standards Australia, 2013). This standard is incorporated into state based legislation, therefore, while licensing and registration requirements differ across states, requirements for gasfitting work and appliances are consistent with the AS/NZS 5601.1. This standard also informs National Units of Competency for plumbing and gasfitting qualifications.

3.2.1 Changes to existing standards

Currently hydrogen is not considered in AS/NZS 5601.1: 2013 General Gas Installations. As a result, work is underway by Standards Australia's ME-093 End Use Applications Working Group to amend this standard to include specifications for work on hydrogen installations. Standards Australia (n.d), in their ME-093 Hydrogen Technologies Strategic Work Plan, outline the following strategies in order to consider hydrogen in Australian Standards for end uses:

> 'The End Use Applications Working Group will monitor developments relating to end use applications using hydrogen or hydrogen/ natural gas blends and liaise with relevant standards committees to facilitate the development of Australian Standards for these applications. The scope boundaries are the gas equipment installed downstream of the outlet of the consumer billing meter installation including but not limited to:
>
> - Consumer piping
> - Gas components
> - Type A gas appliances
> - Type B gas appliances
>
> In addition, gas quality and HSE aspects including odorant and flame/leak detection will be addressed.'
>
> (Standards Australia, n.d: 14)

The Work Plan presents the following focus areas for three years between 2020 – 2023:

- ‘Review of current Standards Australia AG-001, Gas appliances (Type A), AG006 Gas Installation, AG-011, Industrial and Commercial Gas-Fired Appliances (Type B) and AG-013, Components used for Gas Appliances and Equipment Committees work programs through liaisons.
- Review of published international standards or guides related to appliances, components and installations for potential use in Australia.
- Monitor Australian and global research relevant to End Use Applications specifically for: — Testing of Type A appliances with natural gas/hydrogen blends and 100% hydrogen — Testing of Type B appliances used for steel, glass and cement manufacturing in the mid term
- Obtain updates of Australian based projects and review progress for input to standards work’ (Standards Australia, n.d: 14).

Given this Standard is essential to informing gasfitting work and training, any amendments to the Standard will need to be reflected in the National Training Package, licensing and registration requirements and upskilling of existing practitioners.

3.3 National training framework

In Australia, an apprentice plumber must complete a course in plumbing and also gain experience to become licensed. This is usually undertaken in a plumbing apprenticeship, however completion of units of competence and sufficient work experience can also meet licensing requirements, for example see VBA (2021a). To become qualified as a gasfitter, certain specialised course work subjects must be completed. This can be done as a specialisation after completing the required plumbing subjects or in combination with plumbing as a combined plumbing and gasfitting apprenticeship.

Plumbing (including gasfitting) training is delivered by Australia’s VET sector through Registered Training Organisations (RTOs) which include technical and further education (TAFE) institutes, adult and community education providers, agricultural colleges, private providers, community organisations, industry skill centres, and commercial and enterprise training providers (ASQA, n.d-d). The VET curriculum is designed at a national level and includes different training products developed by Skills Service Organisations and Industry Skills Committees and approved by the Australian Industry and Skills Committee (AISC) (Department of Education Skills and Employment, 2020). The training products include ‘qualifications, units of competency skill sets or accredited courses that are developed via industry training packages or VET accredited courses’ (State Government of Victoria, 2021: para. 2), that are recognised across Australia.

> The AISC draws on advice from the new Industry Reference Committees (IRCs) which are made up of people with experience, skills and knowledge of their particular industry sector. Their advice ensures training packages meet the needs of employers and the modern economy. IRCs are supported by the new Skills Service Organisations (SSOs).
>
> (Department of Education Skills and Employment, 2020: para. 6)

3.3.1 Key stakeholder roles

The path to becoming a registered or licensed plumbing/gasfitting practitioner begins with initial training, usually in the form of a plumbing apprenticeship. Initial training of gasfitters involves input from a range of stakeholders that will discussed in the following sections. Table 3 presents these key stakeholders and the following subsections explore each of these in more detail drawing on the literature from the desktop review.

Table 3 Stakeholders involved in initial gasfitter training

Stakeholder	Description
Registered training organisations (RTOs)	RTOs deliver the training to achieve the required qualifications for trade licensing in the VET sector. VET sector providers can include: technical and further education (TAFE) institutes; adult and community education providers; agricultural colleges; private providers; community organisations; industry skill centres; commercial and enterprise training providers (ASQA, n.d-d).
Australian Skills Quality Authority (ASQA)	National VET regulator (one of three VET regulators in Australia).

State VET regulators	Victorian Registration and Qualifications Authority (VRQA) and the Training Accreditation Council of Western Australia register training providers, accredit courses and register qualifications in Victoria only or Victoria and WA. The VRQA also regulate apprenticeships and traineeships in Victoria
COAG Industry and Skills Council/National Cabinet Reform Committee (Skills Committee).	Responsible for skills development and national training arrangements, with a focus on major policy reforms requiring Commonwealth-State collaboration (As of May 2020, COAG has been replaced by the National Federation Reform Council (NFRC)).
Australian Industry and Skills Committee (AISC)	Industry-led body that provides advice on the implementation of national VET policies and recommends training packages to the ASQA for endorsement.
Industry Reference Committees (IRCs)	Made up of people with links to industry, IRCs provide advice to AISC about the skills needs in their industry sector.
Skills Service Organisations (SSOs)	Independent, professional service organisations that support IRCs in their work developing and reviewing training packages.
VET trainers	Deliver training packages in RTOs, support learning and assess learning outcomes.
Group Training Organisations (GTOs)	GTOs put apprentices into short to medium term contracted work placements and into training with an RTO. Despite their name, they do not themselves provide the training but employ apprentices and place them into training and employment.

3.3.1.1 Registered Training Organisations (RTOs)

VET is delivered in Australia by RTOs who provide the training qualifications for gasfitters/plumbers in Australia. According to the Braithwaite Review, 'recent years have seen a sudden influx of RTOs into the market' (Braithwaite, 2018: 10). As of 2018, there were 4,538 RTOs delivering 1,463 qualifications to around 4.2 million students' (Braithwaite, 2018: 10). RTOs can be either private and public organisations, with private RTOs delivering more training (58.7 per cent) compared with public providers such as TAFE institutes (17.6 per cent) and community education providers (9 per cent) (Braithwaite, 2018). Organisations delivering VET qualifications in Australia include 'around 4,000 private training providers' (Smith, 2019b: 38). There is a significant variation in the size of RTOs from some having only one student enrolled to others which have over 100,000 enrolled students. 'Large providers (those with more than 1,000 students) represent approximately 18 per cent of all providers' (Braithwaite, 2018: 10) with 80 per cent of VET students enrolled with these large providers. Half of all RTOs have less than 200 enrolled students. In Australia RTOs include both private VET providers and government owned TAFE institutes. Therefore, the term RTO is used in this report to refer to both private and public VET providers.

VET emerged in Australia in response to the expansion of apprenticeship based training in a range of fields which led to the development of technical colleges and vocational institutions. Prior to the 1970s, the development of the VET sector was a state responsibility and the approaches taken varied. From the 1970s, the Commonwealth Government began to play a larger role in VET with the expansion of training and apprenticeships to a wider range of occupations. A nationalised VET system was agreed to by state governments and introduced in the 1990s. State and Commonwealth governments agreed to share responsibility for VET in 1992 with the signing of the national VET System Agreement (Joyce, 2019). 'The agreement made provisions for nationally recognised competency-based training, recognition of an individual's prior learning, a role for industry in driving the system and the development of a more open national training market. The Australian National Training Authority (ANTA) was established in 1994, the National Training Framework also in 1994 and the AQF in 1995' (Joyce, 2019: 18)

Currently, VET is funded through a range of sources including 'individual students, employers, the states and territories within their respective jurisdictions, and the Commonwealth through programs such as the National Workforce Development Specific Purpose Payment, the Australian Apprenticeship Incentive Program, the Skills

for Education Program, the Skilling Australians Fund and VET Student Loans (VSL), or a combination of these sources' (Braithwaite, 2018: 10). Both the Commonwealth and State and Territory governments share responsibility for the VET sector. The responsibilities of governments are established under the National Agreement for Skills and Workforce Development (NASWD) (Joyce, 2019). According to the Joyce Review: 'The States and Territories are largely responsible for the delivery and operation of VET in their own jurisdictions, including funding of RTOs and the matching of funded training delivery to local economic priorities' (Joyce, 2019: 16). However there has been an increasing role of the Commonwealth Government in setting qualification standards and in quality assurance (Joyce, 2019).

Smith (2019b) provides a succinct summary of the background to qualifications in the Australian VET system. According to Smith (2019b), Australia's VET system is well established with 'qualifications covering most industry areas, in occupations that are not regarded as needing university preparation' (Smith, 2019b: 38). The qualifications are delivered through 65 Training Packages, developed at a national level, and 'all of which contain large numbers of units of competency gathered into multiple qualifications, generally from Australian Qualifications Framework Level 2 (entry-level) to Level 5 (diploma level) on a scale of 1 to 10, on which a Bachelor's degree is 7 and a PhD 10' (Smith, 2019b: 38). According to the ASQA (n.d-a: para. 3), 'Industry expectations for the skills and knowledge of VET graduates are expressed in training packages and VET accredited courses'. Training packages are further described by Joyce (2019: 16):

> A training package is a set of nationally endorsed standards and qualifications for recognising and assessing people's skills in a specific industry, industry sector or enterprise. Training packages are developed by Industry Reference Committees (IRCs) working with Skill Service Organisations (SSO), to ensure that industry skill requirements are reflected in the national training system. Industry Reference Committees report to the AISC, which refers training packages to CISC [COAG Industry and Skills Council] for final approval.

According to Gekara and Snell (2018: 118):

> The system follows the notion of competency profiling whereby the competency profile provides a snapshot of the skill sets required of a competent worker to perform in a particular occupation. Skills and knowledge required to perform a job are broken down into individual tasks and their requisite knowledge and constituent skill elements, which become units of competency. This information is transformed into performance objectives, which are the basis of the training programme design. Training programmes are modularised through the provision of core and elective units of competency, thus enabling trainees and employers the flexibility to account for individual, occupational and work-related variations in skill requirements.

The current system of training packages, introduced under the Keating Government in 1997, provided formal qualifications for many occupations which previously did not have such requirements.

The critical role of vocational education in meeting rapidly changing industry and economic skills needs has been widely recognised (Tyler and Dymock, 2017). Over the last few decades, vocational education reforms have resulted in education frameworks that aim to be responsive to industry needs, with skills and competencies that are developed in consultation with and endorsed by industry bodies (Southren, 2015). Vocational education reforms created a 'system built around 'strategic training' where training was specifically developed for and delivered by the market, to fulfil enterprise skills demands' (Gekara and Snell, 2018: 111). Gekara and Snell (2018) provide a detailed historical overview of the historical shifts that transferred responsibility for vocational education from the public sector to the private sector, with private training providers offering most of the training in Australia, and the private sector also developing the training packages described above for approval by industry led committees.

Since the mid-1980s and in line with reforms in many countries, Australia's VET system shifted to a competency-based training approach delivering skills for specific roles. Under the Australian Quality Training Framework Registration, RTOs must ensure that training offered is relevant and industry engaged. According to ASQA (n.d-a: para. 4):

> To provide training relevant to employers and to maximise students' opportunities for employment, advancement or further education, your RTO must develop a range of strategies to engage with relevant industry stakeholders. You must engage with industry stakeholders to establish appropriate contexts, methods, resources and trainers and assessors to deliver training and to conduct assessment.

The current system has not gone without critique, particularly due to competency based learning approach (Smith, 2019b) and the pedagogical and learning outcome implications of the national training frameworks (Southren, 2015). It is argued that these reforms have led to prescriptive training frameworks that restrict teaching practice leaving little flexibility in curriculum design and also development of narrow skills sets amongst students (Southren, 2015). Furthermore, the privatisation of the sector has resulted in 'diminishing quality of training provided' (Gekara and Snell, 2018: 113) with the government continuing to fund the private sector training model and regulate a sector that, it has been argued, exploits loopholes. The aims of reducing both government responsibility and funding of the sector and at the same time improving the quality of training are yet to be achieved through these neoliberal reforms (Gekara and Snell, 2018). Both the Braithwaite Review (Braithwaite, 2018) and the Joyce Review (Joyce, 2019) commissioned by the Australian Government made recommendations to improve the teaching quality in RTOs, along with improving regulation and governance of the sector (Braithwaite, 2018) and quality assurance (Joyce, 2019) and improving the delivery of qualifications based on business-led models for qualification development and revamping apprenticeship incentives (Joyce, 2019).

The Joyce review, in particular, which set out to 'conduct a health check of the Australian VET sector to determine how ready it is to step up to the challenge of training more Australians, now and in the future' (Joyce, 2019: 1) recommended that the Government could improve the VET sector by:

- 'Piloting a new business-led model of Skills Organisations for qualification development, and extending work-based VET further into less traditional areas.
- Establishing a new National Skills Commission to start working with the States and Territories to develop a new nationally-consistent funding model based on a shared understanding of skills needs.
- Revamping and simplifying apprenticeship incentives to increase their attractiveness to employers and trainees' (Joyce, 2019: 2).

The relationship between RTOs and industry has changed over time. Currently, a collaborative model exists between RTOs and industry employers far beyond the provision of off-site training for apprentices and trainees Smith et al. (2017). A report into employers' training practices and partnerships with training providers found that the relationship between RTOs and employers has increased over time. The report identified that the 'nature of the partnerships between RTOs and employers has changed from a relationship based on provision of particular services to one based on long-term mutual collaboration' (Smith et al., 2017: 3) with industry providing input into training but also using 'RTOs as their main source of information about VET and increasingly use them as 'navigators' of the VET sector in collaborative partnerships (Smith et al., 2017: 3).

3.3.1.2 Australian Skills Quality Authority

One of three Australian VET regulators along with Victorian Registration and Qualifications Authority (VRQA) and the Training Accreditation Council of Western Australia, ASQA regulates RTOs using the VET quality framework. ASQA regulates around 90 per cent of Australia's RTOs which makes it Australia's largest VET regulator. The role of ASQA is further described by Joyce (2019: 16):

> The relatively new national regulator of VET, the Australian Skills Quality Authority, registers training providers, monitors compliance with national standards and investigates quality concerns, for all States and Territories that have referred their powers. In the two States that haven't referred, Victoria and Western Australia, ASQA regulates providers who enrol international students and multi-jurisdictional providers while remaining RTOs are registered with the Victorian Registration and Qualifications Authority and the Training Accreditation Council Western Australia.

ASQA was formed in 2011 when Australian Governments agreed to make changes to the VET regulatory structure. This resulted in the abolition of the majority of state based regulators which were replaced by the national regulator, ASQA. ASQA regulates over 4,000 RTOs in Australia (Braithwaite, 2018). Plans for reforms to ASQA were announced by the Australian Government in 2019 in response to two separate reviews into the VET sector the Joyce Review (Joyce, 2019) and the Braithwaite Review. The Braithwaite Review (Braithwaite, 2018: 7) noted that:

> ASQA has a challenging role in maintaining and improving quality in the VET sector. While it has a wide range of regulatory powers at its disposal, the size of the market it oversees is significant. It regulates

a continuum of organisations ranging from the highest performers to those acting on the edges of almost criminal enterprise.

3.3.1.3 State VET regulator, Victorian Registration and Qualifications Authority (VRQA)

Along with ASQA, two other bodies regulate the VET sector in Australia including the Victorian Registration and Qualifications Authority (VRQA). The VRQA are an independent statutory authority that applies standards to regulate some RTOs and accredit some courses and qualifications. VRQA do not regulate the RTOs who deliver plumbing qualifications in Victoria, these are governed by ASQA, however VRQA do govern apprenticeships in Victoria by registering apprentices and trainees, approving apprentice employers and overseeing contractual obligations between parties (VRQA, 2019).

3.3.1.4 COAG Industry and Skills Council (CISC)

The COAG[2] Industry and Skills Council 'is mandated to provide leadership and direction' (Joyce, 2019: 16) for the VET sector. CISC was established to oversee, develop and implement policies to ensure that Australian industry is competitive, and creating jobs and investment. Part of this involves skills development and national training packages and governance (Department of Industry, 2020).

3.3.1.5 Australian Industry and Skills Committee (ASIC)

The AISC is an industry-led body that 'provides advice on the implementation of national VET policies. The Committee's role is to ensure that directions taken by CISC are informed by an industry-based perspective focused on the quality and relevance of the national training system' (AISC, 2020a). Its role includes quality assurance and the approval and recommendation of national training packages to CISC for endorsement. Endorsed packages are then listed on the National Register (training.gov.au) for implementation by RTOs. AISC operates in partnership with the Australian Government, IRCs, SSOs, state and territory governments and regulators within the VET sector (AISC, 2020a).

3.3.1.6 Industry Reference Committees (IRCs)

IRCs are a forum for industry engagement and feedback on trends and skills needs, providing advice to the AISC on skills needs within the relevant industry sector. With the support of SSOs, they oversee the development of training products. IRCs 'are the formal channel for considering industry skills requirements in the development and review of training packages' (AISC, 2020b). The IRCs are made up of people from industry including representatives from business, small enterprise, peak bodies and unions. The aim of the IRCs is to 'ensure training packages meet the needs and concerns of employers, employees, training providers, and people seeking training qualifications' (AISC, 2020b).

3.3.1.7 Skills Service Organisation (SSO)

Skills Service Organisations (SSOs) are independent, private organisations who are contracted by the national government to support the IRCs in developing and reviewing training packages (AISC, 2020c; Gekara and Snell, 2018). The role of SSOs was formally undertaken by industry led, quasi-government not-for-profit organisations called Industry Skills Councils (ISCs). Individual SSOs bid to represent industries in a market based structure. There were originally eleven SSOs which has been reduced to six representing the range of industries that require training. Gekara and Snell (2018: 112) argue that 'in this new structure, there is more emphasis on industry (employer) control of the process of developing training packages and less on the tri-partite aspect; in the late 80s and early 90s'.

Artibus Innovation operates the SSO which designs the training packages for qualifications in construction and property, including plumbing/gasfitting. As an SSO, Artibus is funded by the Commonwealth Government 'to support the construction and property industries to ensure their qualifications and competency standards are up-to-date, future-focused and aligned with industry needs' (Artibus Innovation, 2021a: para. 2). Artibus works under the leadership of two IRCs: the Construction, Plumbing and Services Industry Reference Committee and the Property Services IRC. Their role is to provide 'high level secretariat services, industry engagement, research, analysis and project management to support training package development activity' (Artibus Innovation, 2021a: para. 3).

[2] COAG was superseded by the National Federation Reform Council (NFRC) in May 2020

3.3.1.8 VET trainers/teachers

Given the key role of vocational education in trades training, it has been acknowledged that teaching plays a critical role in the effectiveness of delivering national training packages (Southren, 2015) and the need for capable VET teachers has been raised over the past two decades. According to Tyler and Dymock (2017: 3):

> VET practitioners come from a range of backgrounds, are employed under various conditions (part-time, casual or on a contract basis) and have significantly diverse career paths when compared with the schooling or university sectors. This diversity means that no single approach to continuing professional development for VET practitioners can meet the needs of every industry, organisation, teacher or trainer.

A number of studies have been undertaken on the role, identity and capability of VET teachers in delivering national Training Packages. The changing contexts in vocational education from developing training *curriculum* to delivering training *packages,* has influenced the role and identity of teachers/trainers in the VET sector (Southren, 2015).

Vocational training providers in Australia must be registered under the Australian Quality Training Framework Registration. A requirement of this registration is that training providers must ensure that trainers have:

- 'vocational competencies at least to the level being delivered and assessed
- current industry skills directly relevant to the training and assessment being provided
- current knowledge and skills in vocational training and learning that informs their training and assessment' (ASQA, n.d-b: para. 1).

VET teachers are under pressure to ensure their knowledge and skills reflect fast changing industries (Tyler and Dymock, 2017). In order to meet this requirement, a diverse range of CPD activities are required of trainers by RTOs or undertaken voluntarily by trainers (Tyler and Dymock, 2017). However, it has been argued that methods to maintain trainers' 'industry currency' in the VET sector are ad-hoc, leaving trainers will little support to develop their knowledge to effectively deliver national training packages, with CPD responses failing to 'gain traction' (Tyler and Dymock, 2019: 8). As noted by Dymock and Tyler (2018), a number of publications have echoed challenges in effective CPD of VET trainers in Australia. The authors summarise that 'in Australia, CPD for VET practitioners has been criticised as being underdeveloped, with little systematic provision, lukewarm support from trainers and training organisations, and limited oversight from government agencies' (Dymock and Tyler, 2018: 198).

Drawing on the work of Billet (1999) and Smith (1999), Southren (2015) argues that the delivery of any competency-based training frameworks must be understood in context, including institutional and social infrastructures and how teachers respond to such frameworks in 'actual practice'.

3.3.1.9 Group Training Organisations (GTOs)

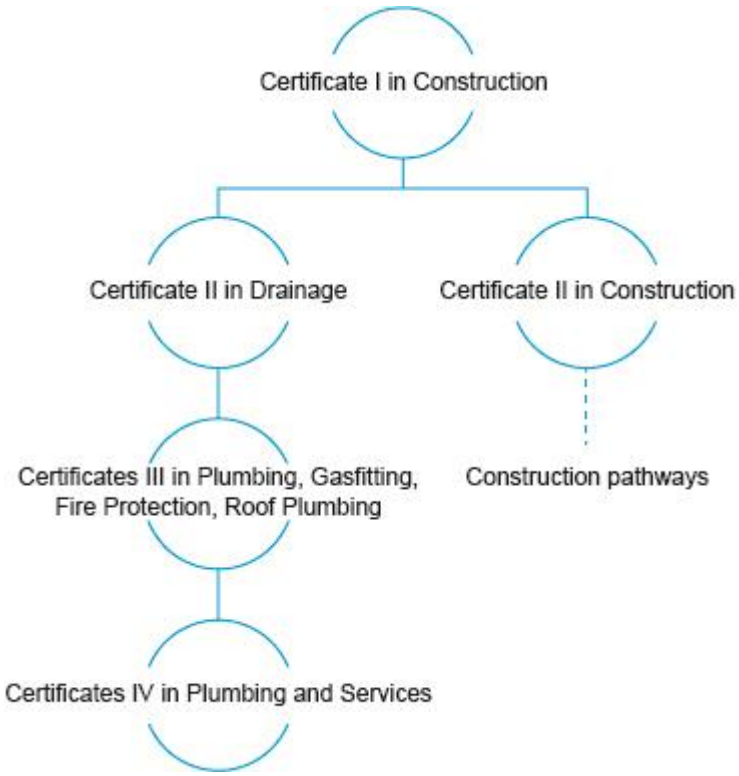
According to Smith (2010: 116), there are a 'plethora of bodies involved in apprenticeships'. While the off-the job study component of apprenticeship training is delivered by an RTO, the 'contractual arrangements between employer and apprentice/trainee and also … support services to employers and apprentices during an apprenticeship' are managed by the Australian Apprenticeship Support Network (AASN). 'In about 12 per cent of apprenticeships and traineeships, GTOs are also involved' (Smith, 2019a: 73). These GTOs 'act as employers of apprentices and trainees, 'leasing them out' to host companies and thereby relieving companies both of the risk of taking on an apprentices for a lengthy period and of the paperwork associated with employing an apprentice' (Smith, 2010: 118). GTOs were established and funded by government Joint Group Training Program (JGTP) scheme funds and other incentives to provide pathways for apprentices who would not thrive under the traditional apprenticeships, providing pastoral care, learning support including employing disadvantaged and under-represented groups. They also qualify government requirements for social procurement targets in public works.

3.3.2 Nationally recognised qualifications for gasfitting

Units of competency that make up a qualification for a trade are established at a national level as part of training packages. 'The first national Training Package for the plumbing industry was endorsed in 2004 as BCP03 Plumbing and Services Training Package' (Construction and Property Services Industry Skills Council, 2009: I). Units of competencies are grouped together under different certificate qualification levels. According to Artibus, the Construction, Plumbing and Services Training Package is structured as shown in Figure 1. Certificate I and II level courses are introductory courses and do not lead to registration or licensing in Victoria. For those beginning

an apprenticeship in plumbing, their formal training begins at the Certificate III level, and progresses from there depending on which type of licence they wish to hold.

Figure 1 Construction, Plumbing and Services Training Package certificate structure (Adapted from Artibus Innovation, 2021b)



Each unit of competency within a given Certificate generally includes:

- Unit description: Overview of what the unit aims to do including what is included, skills and knowledge covered
- Elements: Essential outcomes of a unit of competency or what someone can do if they are competent in the unit
- Performance criteria: Performance needed to demonstrate achievement of the element or how someone can show that they are competent in the element
- Key competencies: the generic skills in the unit and the level of performance (from 1 to 3) for each of the competencies. These are transferable and overlap with other units of competencies
- Range statement: Describes different work environments and situations that may affect performance.
- Evidence guide: The evidence required to show competency and can provide advice on assessment including

In other words, each unit of competency describes:

- a specific work activity
- the standards of performance required in the workplace
- assessment requirements, which specify the evidence and required conditions under which the unit is conducted
- evidence that can be gathered to assist an Assessor to determine a judgement of competency (ASQA, n.d-c).

Nationally recognised qualifications which include gasfitting units of competency required for gasfitting work are:

- CPC32420 Certificate III in Plumbing
- CPC32513 Certificate III in Plumbing (Mechanical Services)
- CPC40920- Certificate IV in Plumbing and Services
- CPC50412- Diploma of Plumbing and Services
- CPC32720- Certificate III in Gas Fitting (offered in Queensland where the qualification allows an individual to obtain an interim gas work licence while completing the requirements to progress to a full gas work licence and Tasmania, where the qualification allows an individual to obtain a practitioner's licence)

According to Artibus, the SSO that develops the National Training Package for plumbing including gasfitting, the majority of enrolments nationally are in the Certificate III in Plumbing which includes competencies for gasfitting work, followed by the Certificate III in Gas Fitting (offered in Queensland) and then CPC32513 - Certificate III in Plumbing (Mechanical Services), as shown in Table 4. From this data however, it is not possible to determine the certificate completion rate or how many of those completing these qualifications go on to be registered in gasfitting work.

Table 4 Enrolments into gasfitting qualifications

Gasfitting Qualifications	2015	2016	2017	2018
CPC32420 - Certificate III in Plumbing	11288	14373	16593	16754
CPC32513 - Certificate III in Plumbing (Mechanical Services)	56	60	66	64
CPC32720- Certificate III in Gas Fitting	192	225	305	250

(Artibus Innovation, 2020: 29)

While licensing requirements differ from state to state, course curricula including the units of competency which lead to qualification are established at a national level and delivered by RTOs to meet licensing requirements on a state by state basis. There are core units of competency that are a minimum requirement nationwide for the attainment of a qualification. RTOs however can choose from a range of additional elective units to offer as part of a qualification. The choices made are influenced by local trade needs, including the registration and licensing requirements for plumbing practitioners in each state (Construction and Property Services Industry Skills Council, 2009).

3.4 Updates to national training packages for hydrogen

Turning to hydrogen, while only initial steps have been undertaken to define competency needs for end use installations, work is underway to establish the competency needs for gas technicians working in production, transmission and distribution. In September 2020, the IRC supported by the SSO and Australian Industry Standards Limited (AIS), began a project to 'to review and develop Units of Competency and skill sets to address the skills needs of gas technicians handling hydrogen gas' (AIS, 2020a). In December 2020, on behalf of the Gas IRC, the Technical Advisory Committee (TAC) released drafts of six new Units of Competency, three new Skill Sets and 13 updated existing Units of Competency for public comment. 'The new units and Skill Sets are drafted specifically for hydrogen gas, whilst the existing units were updated to allow for hydrogen contextualisation as well as other gases' (AIS, 2020a). The Case for Endorsement has been submitted to AISC and is awaiting their approval. These units of competency and skills sets are designed for gas technicians working on transmission, distribution and hydrogen storage production facilities, not Type A gasfitting work (AISC, 2021).

Figure 2 Process for updating National Units of Competency based on a Case for Change

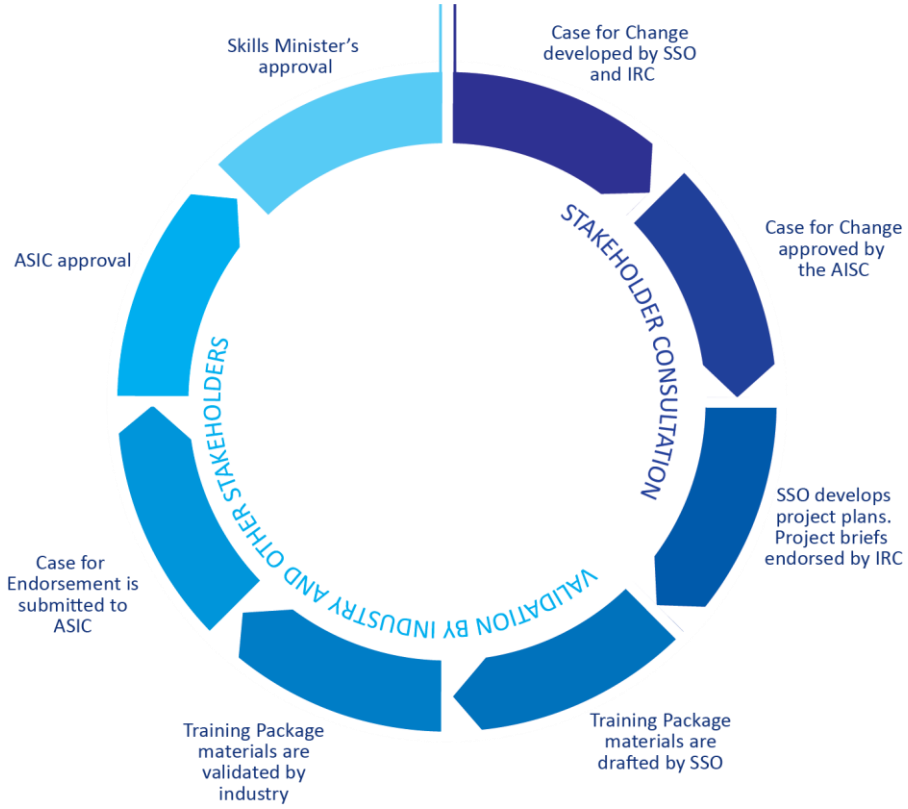


Figure adapted from AIS (2020b)

A similar project has recently begun to develop gasfitter competencies for end use appliances and installations. This is led by Artibus Innovation, the SSO which designs the training packages for qualifications in construction and property, including plumbing/gasfitting. The gasfitter competencies for end use work is completed under the leadership of the Construction, Plumbing and Services IRC, who have acknowledged the skills gaps in current plumbing and gasfitting training for working with hydrogen fuel in the domestic sector (Artibus Innovation, 2020). The SSO highlight that 'it is crucial to begin the process of reviewing and updating the training package with sufficient lead time to ensure changes reach the market when required' (Artibus Innovation, 2020: 26). Work is underway to make changes to Certificate III in Gasfitting to include hydrogen components. This process begins with the development of a Case for Change by the SSO and IRC which has been completed and, as of July 2021, is awaiting approval by the AISC. Figure 2 shows this process for updating the National Units of Competency. The timeline for the updated qualifications is as follows:

- Case for Change Drafted and submitted to AISC – Completed July 2021
- AISC project approval – 21 July 2021
- Draft 1 consultation – 1 December 2021 – 28 Feb 2022
- Stakeholder validation – May 2022
- Quality Assurance – June/July 2022
- Final consultation with states and territories – August 2022
- CFE submitted for approval – August/September 2022. (Artibus Innovation, 2021c)

As part of the project, Artibus proposes to engage with the following organisations using a range of methods:

- Technical Advisory Groups (TAGs) to be established in accordance with internal policy and procedures to guide the subject matter expertise components of the work
- direct correspondence with regulators
- direct correspondence with State Training Authorities (STA)
- direct correspondence with IRC and key stakeholders
- industry associations and other stakeholders will be invited to capital city forums in all states and territories. A copy of forums material will be published on the web and an online forum will also be facilitated

- RTOs will be engaged through online survey and trainer networks • public web project page updated fortnightly
- newsletter survey distribution to 4,200 stakeholders, including all RTOs, regulators, industry associations. Minimum of three newsletter profiles
- industry survey on early and late draft material
- distribution of survey through TAG networks and Artibus digital channels
- social media – Twitter and LinkedIn.

The Case for Change for the inclusion of hydrogen into the National Training Package has been classified as a 'complex project', 'given the complexities and time considerations arising when developing new units of competency for an emerging industry. Factors such as sustainability, workplace and community safety, regulation regimes, will all need to be considered across each unit of competency' (Artibus Innovation, 2021c: 7).

3.5 Apprenticeships

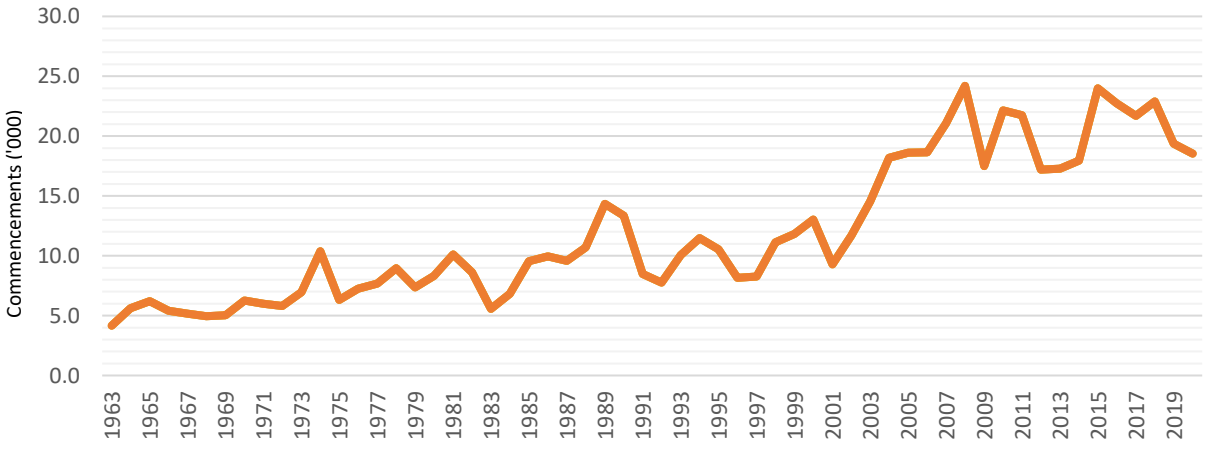
As already discussed, apprenticeships are a common way of gaining qualifications and licensing in the traditional trade occupations in Australia. 'Learning in practice-based settings remains an integral component of the vocational education and training (VET) curriculum designed to skill workers and to sustain learning across their working life' (Choy and Sappa, 2016: 88). Trade apprenticeships are usually undertaken for a period of four years and include a combination of on the job training and study at off-site training offered through a training provider. According to Smith (2019a: 70), an apprenticeship system generally has the following characteristics:

- 'training regime set up by, or with the approval of, governments;
- A combination of off and on the job training;
- The assumption of responsibility by the employer for the development of the apprentice;
- The award of a qualification and/or licence and/or some other recognition that enables an occupation to be practised independently once the apprenticeship is successfully completed; and,
- A close link to specific occupations.'

Apprenticeships result in the attainment of a Certificate III level qualification and are a widely recognised qualification for school-leavers, and to a lesser extent, mature aged students (Smith, 2019b). The formal apprenticeship system began in Australia after the Second World War. Originally a specified number of generally male occupations, including craft and manufacturing professions used the apprenticeship system of training. Since the 1980s however, apprentice training in Australia experienced a number of reforms (Smith, 2019a).

Data from the National Centre for Vocational Education Research in Figure 3 shows that apprenticeship and trainee commencements within the construction industry, which includes gasfitting, have grown over the past two decades with fluctuations in the past decade. There is however little data regarding plumbing apprenticeship commencement and completions, along with little research undertaken on plumbing apprenticeships internationally.

Figure 3 Apprenticeship and trainee commencements in the construction trades by year



Data taken from NCVER (2020)

Lensjø (2020) Norwegian case study investigated significant learning processes that occur during apprentice training on and off site to understand the value that on-site learning may bring. They found that learning the trades language and working in in the field was challenging and time consuming for apprentices however 'in return the apprentices discovered proficiency, gained confidence and were considered as participants in the community of plumbers. 'A central finding is the great value of working in a community of plumbers at the building site, combined by studying sanitary and heating technology at the training agency' (Lensjø, 2020: 148-149). This is the only relevant academic study identified that investigates the apprenticeship model for plumbing.

3.6 Ongoing learning

Ongoing learning or continuous learning can refer to a range of formal and informal learning experiences that occur over a person's career or lifetime. In the context of gasfitting practitioners, ongoing learning refers to the learning that occurs post apprenticeship, working as a qualified gasfitter. The concept of ongoing learning acknowledges that learning is a continuous process which does not, and should not, end with the completion of a qualification. A common term used in the context of ongoing learning is CPD. CPD is a broad term used commonly to refer to the 'process of undertaking and recording professional education and training after initial registration or licensing, for the purposes of maintaining and or improving professional skills and knowledge' (DELWP, 2020: 3). According to the Victorian Department of Environment Land Water and Planning (DEWLP), CPD aims to ensure 'continued competence' of practitioners while registered or licensed. This includes both maintaining a baseline competency standard for registration or licencing and maintaining industry currency by ' keeping pace with any technical and legislative changes relevant to the practitioner's scope' (DELWP, 2020: 3).

'Upskilling' is another term used that can form part of CPD depending on the context. Upskilling implies additional learning that is undertaken by a practitioner to gain additional qualifications to build on their existing registration or licensing class, for example, completing additional units of competency required to move from a registered plumber to a licensed plumber. Upskilling may also be required as part of licensing requirements in the event of a technology or fuel change where additional skills may be required to ensure 'continued competence' with new the technologies and fuels. Both CDP and upskilling are relevant to gasfitting for hydrogen fuel. As discussed later in Section 5.3, the introduction of low percentage blends of hydrogen may necessitate CPD to 'keep pace' with the changing fuel and associated technologies, despite skills remaining the same and, for 100 per cent blends of hydrogen, upskilling or the acquisition of additional competencies to safely work with hydrogen fuel will be required. Whether such upskilling is a mandatory registration or licensing requirement, will depend on the roll out of 100 per cent hydrogen. If 100 per cent hydrogen will replace natural gas across all networks, then upskilling would likely be required for all registered and licensed gasfitters, however if the transition occurs in stages or using domestic fuel cells, upskilling may only be needed for those wishing to work with hydrogen fuel or fuel cells.

In Australia there are currently no frameworks in place for mandatory CPD for registered and licenced plumbers, with the exception of Tasmania A gasfitting licence holder in Tasmania is required to complete 36 CPD points over three years as part of the licence renewal process (Tasmanian Government, 2021). In other states and territories, professional development opportunities are taken up on a voluntary basis and include information sessions and materials provided by state gas regulators, voluntary courses offered by appliance manufacturers and plumbing associations. For example, Master Plumbers has more than 2,600 active participants in its voluntary industry scheme for CPD. Introducing mandatory CPD requirements to ensure plumbing practitioners, amongst other building trades, maintain industry currency remains contentious and proposals to introduce CPD have been contested in a number of states, including Victoria.

3.7 Implications for Future Fuels

Based on the desktop review, the existing system for training, registration and licensing of gasfitters will support the transition to hydrogen in many ways. Firstly, units of competency are developed at a national level and delivered locally by RTOs. This means that hydrogen could be included in the National Training Package which then translates into training across Australia using uniform competencies. Work is currently beginning to update the units of competency for gasfitting work in light of working with hydrogen fuel.

While there are some advantages for the transition to hydrogen in the way VET sector training is structured, there are also many challenges. Understanding of the skills needs for hydrogen and associated changes in work practices to inform updates to the National Training Package and units of competency is currently limited. The VET sector has been reformed over the past decades to respond to market need and while the sector is ready to

respond, a new market such as hydrogen with little clarity on what end use applications will entail presents a challenge. This applies not just to the content of training packages but also questions of trainer 'industry currency' within RTOs. Therefore, after the update and sign off of plumbing training packages, a significant consideration will be upskilling the trainers delivering the new competency units. As well documented in the literature, upskilling VET sector trainers is ad-hoc and administered by each RTO rather than a centralised unit. Given the well documented issues with regulation of RTOs, the ability of the sector to deliver uniform quality is questionable. If VET trainers do not have the skills to deliver updated training packages, this will delay the development of gasfitting practitioners and the transition toward the uptake of future fuels. Further, without effective training, the VBA cannot also assume that the skills associated with hydrogen will translate into practice for newly registered or licensed plumber gasfitters.

Despite common training units, licensing requirements and categories for gasfitting work vary across states. Licensing and registration for hydrogen gasfitting work will therefore likely be implemented on a state by state basis and training packages will have to be tailored to meet potentially differing requirements. It will be the responsibility of state regulators to decide what the requirements are. It will be difficult for gasfitters trained in hydrogen to move around the country to undertake such work as the need arises due to potentially different licencing and associated competency requirements and any future changes to the system for mutual recognition of gasfitting work will need to take into consideration the gasfitters competency in hydrogen work.

Work is underway to update AS/NZS 5601.1: 2013 General Gas Installations to give consideration to hydrogen. This work will then inform the work practices of existing gasfitters and also competencies, compliance and licensing requirements. These changes will need to be communicated to stakeholder groups including Artibus, the industry reference committee, the RTOs and trainers. New or changed requirements will need to be reflected in the national training framework. With reforms to both the national units of competency and also to AS/NZS 5601 being undertaken concurrently, there is an opportunity to ensure reforms are complementary.

The discussion above relates to newly qualified gasfitters. Training and upskilling of existing licence holders is another significant consideration. Amendments to the standard would also need to be communicated to this group via other mechanisms. This is already done, through for example, Energy Safe Victoria (ESV) who provide information sessions when standards are updated. A transition to 100 per cent hydrogen would require that gasfitters involved in hydrogen work have the required competencies to work safely with hydrogen and associated appliances through upskilling and verification of competency as part of licensing and registration requirements. This is also critical when supervising apprentices who may be working with hydrogen. Currently, CPD is not a mandatory requirement in any state or territory in Australia, with the exception of Tasmania. There is a range of approaches to upskilling that could be used but this needs to be grounded in how plumbing practitioners learn best and the type of learning required to ensure the required competency for work undertaken.

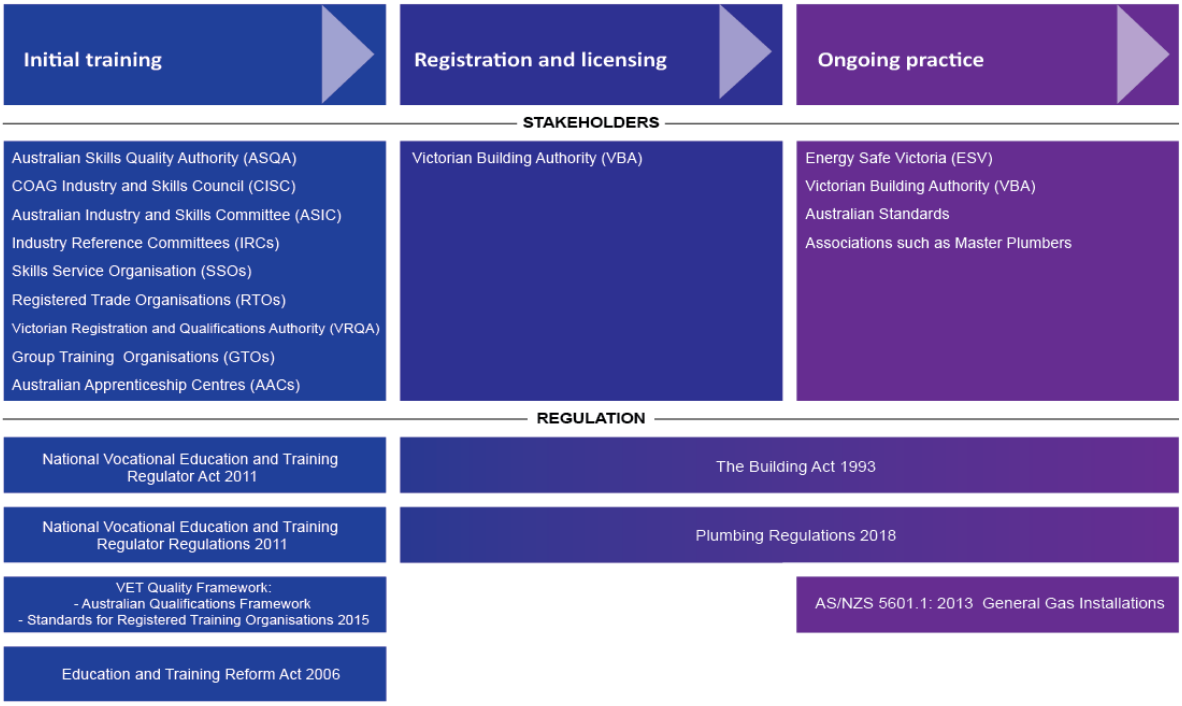
4 Existing gasfitter capability in Victoria

To identify what training needs are required for gasfitters in Victoria to support the transition to hydrogen, an understanding of the existing gasfitter capability including the numbers of gasfitters, the qualification requirements and processes and the competencies required as part of these qualifications must first be established. This section presents an overview of this existing gasfitter capability and frameworks for the State of Victoria.

4.1 Stakeholders and regulation in Victoria

There is a range of stakeholders involved with regulating initial training and apprenticeships in gasfitting, registration/licensing of gasfitting, gas work and informing ongoing learning and compliance. These stakeholders across three phases of gasfitting work from initial training, through to registration/licensing and then ongoing practice are shown in Figure 4, along with the regulation that applies to the difference phases of gasfitting training and practice. The following sections of the report provide more detail about each of these phases and the relationships between them and the stakeholders involved.

Figure 4 Stakeholders and regulation for each phase of gasfitting practice



4.2 Licensing and registration

In Victoria, gasfitting is a class of plumbing work that is part of a plumber's registration or licensing. Therefore, not all plumbers are able to perform gasfitting work, only those that have undertaken the required training to being either registered or licensed in gasfitting work. Registration is the first step to becoming licensed, then a plumber can become licensed provided they complete additional requirements further described below.

In Victoria, the authority that deals with licensing and registration of plumbers is the Victorian Building Authority (VBA). The Building Act 1993 and subordinate Plumbing Regulations 2018 regulate the registration and licensing of plumbers in Victoria while the Gas Safety Act 1997 regulates the technical and safety requirements for the installation, operation, maintenance of gas appliances.

The VBA regulates plumbing practitioners including registering, licensing, auditing, and disciplining plumbers in Victoria. The VBA also 'administers the self-certification and compliance certificate scheme for plumbing, including standard gas fitting work' (Weber, 2016: 26). Following completion of work, plumbers have five days to

lodge a compliance certificate with the VBA stating that their work complies will all applicable codes, regulations and standards. Compliance certificates for general plumbing work are only required if the work exceeds $750, whereas any standard gasfitting work that involves 'the installation, relocation or replacement of any Type A gas-using appliances, regardless of the cost' (VBA, 2021c) requires the gasfitter to complete a compliance certificate. Standard gasfitting work is generally undertaken in domestic or light commercial premises. All other gasfitting work in public and high rise premises is considered complex and regulated by ESV. Type A Servicing which is defined by the Victorian Plumbing Regulations 2018, as the 'internal cleaning, maintenance and adjusting of a Type A appliance and includes the adjustment, repair or replacement of a component of the Type A appliance', does not currently require a compliance certificate.

In the context of gas safety, VBA and ESV 'share dual regulatory responsibility for gas safety within Victoria' (Weber, 2016: 24). In 2019 to 2020, the VBA undertook 1,095 inspections for their auditing process on active construction sites with regards to plumbing work. The VBA states that this is a 50 per cent increase in inspections from 2018-19 (VBA, 2020). The proportion of such inspections that focussed on gasfitting is not reported.

All plumbers must be registered in Victoria; however, to sign off on compliance certificates a plumber must also be licensed. 'A licensed plumber is expected to have additional knowledge and experience compared to a plumber who holds registration' (VBA, 2021d). Gasfitting is one of the main classes of plumbing which can apply to both registered or licensed plumbing registrations. Being registered or licensed in the gasfitting class of plumbing allows a practitioner to install, commission and test Type A gas appliances including associated pipework and flues. In addition to this, specialised or restricted class registrations or licenses are required for any Type A appliance servicing work, Type A appliance conversion work or Type B gasfitting work. The classes of plumbing work are shown in Table 5 and the type of work permitted and requirements for the three classes of plumbing that involve gasfitting work with Type A appliances are shown in Table 6.

Table 5 Classes of plumbing work in Victoria

Main classes	Drainage
	Fire Protection
	Gasfitting
	Irrigation (non-agricultural)
	Mechanical Services
	Refrigerated Air-conditioning
	Roofing (stormwater)
	Sanitary
	Type B Gasfitting
	Water Supply
Specialised classes of plumbing work	**Type A Appliance Servicing**
	Type A Appliance Conversion
	Type B Gasfitting Advanced
	Backflow Prevention
	Thermostatic Mixing Valve

Table 6 Classes of gasfitting work and requirements

Registration			Licensing		
Class	**Type of work permitted**	**Requirements**	**Class**	**Type of work permitted**	**Requirements**
Gasfitting	Installation, commissioning and testing.	• *Successful completion of 8 general plumbing units.* • *Successful completion of 23 class specific units* • *Relevant experience in related work*	**Gasfitting**	Installation, commissioning and testing. Issue certificate of compliance	• *Successful completion of 8 general plumbing units.* • *Successful completion of 23 class specific units plus 1 additional unit of competency for licensing* • *Relevant experience in related work*

		• *Successful completion of Journeyman exam*			• *Successful completion of Journeyman exam*
Type A Servicing	Service Type A appliances.	• *Registration in gasfitting class of plumbing* • *Successful completion of 1 additional specialised class unit of competency*	**Type A Servicing**	Service Type A appliances. Issue certificate of compliance	• *Licensing in gasfitting class of plumbing* • *Successful completion of 1 additional specialised class unit of competency*
Type A Conversion	Convert Type A appliances.	• *Registration in gasfitting class of plumbing* • *Successful completion of VBA's examination of registration competencies for Type A appliance conversion work*	**Type A Conversion**	Convert Type A appliances. Issue certificate of compliance	• *Licensing in gasfitting class of plumbing* • *Successful completion of VBA's examination of registration competencies for Type A appliance conversion work*

Registered plumbers must re-register every three years and licensed plumbers every year in Victoria; however, currently only evidence of sufficient insurance is needed to re-register or renew a licence (VBA, 2021e).

The system of licensing and registration in Victoria described above has been in place since the introduction of the Plumbing Regulations 2008 that separated out gas servicing work from the main class of gasfitting work, creating the special class of plumbing, Type A Appliance Servicing. When the new system was introduced, working plumbers were 'grandfathered' into the new system and all given the Type A Appliance Servicing endorsement as part of their licence. As a result, these grandfathered gasfitters were licensed in gas servicing work without needing to meet the new training requirements.

According to the VBA, as of June 2021, there were 8,676 plumbers licensed and 11,586 plumbers registered in gasfitting work and 5,687 licensed and 4,750 registered in Type A appliance servicing work in Victoria3 (see Table 7). Table 8 shows the numbers of gasfitters by age group and gasfitting class.

The numbers of registered and licensed Type A Servicing gasfitters are a subset of the corresponding class in Gasfitting Type A endorsement. That is, those that are registered in Type A Servicing first need to be registered in Gasfitting Type A and those licensed in Type A Servicing first must be licensed in Gasfitting Type A. Therefore, approximately 65 per cent of licensed Gasfitting Type A practitioners are also endorsed in Type A appliance servicing work and 40 per cent of registered Type A gasfitters are also registered in Type A Gas servicing. It is important to note these figures to not identify the number of gasfitters who were grandfathered into the Type A Appliance Servicing class or the number of gasfitters who are practicing in gasfitting work. Based on anecdotal evidence, there is also a potentially significant number of plumbers who undertake gas appliance serving work that are not registered or licensed in Type A appliance servicing work.

Table 7 Gasfitting practitioners by Class June 2021

Gasfitting Class	Licensed	Registered	Total
Gasfitting Type A	8,676	11,586	20,262
Type A appliance servicing work	5,687	4,750	10,437

[3] Figures provided by the VBA

Table 8 Practitioners by Class and Age as of April 2021

Gasfitting Type A	Total	under 30	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	over 80	% over 60
Licensed	8661	536	2174	2070	2192	1425	248	15	19%
Registered	11576	3605	3658	1841	1331	836	253	52	10%
Type A appliance servicing work	**Total**	under 30	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	over 80	% over 60
Licensed	5722	32	591	1522	1952	1364	246	15	28%
Registered	4823	34	1042	1443	1222	786	245	51	22%

As shown in Table 8, the number of licensed Type A appliance servicing gasfitters under 39 is relatively low compared with the 40-49 and 50-59 age brackets. This could be due to the time it takes to become licensed in Type A appliance servicing including initial apprenticeship training and work experience required to become licensed in Gasfitting Type A, then to complete the additional training and work experience requirements for licensing in Type A Servicing.

To become registered in the gasfitting class of plumbing, certain specialised units of competency must be successfully completed. This can be done as a specialisation after completing the required plumbing subjects or in a combined plumbing/gasfitting apprenticeship. Please refer to Appendix 10.2 for details about competency requirements for the different classes of plumbing work.

4.3 Initial training providers in Victoria

There are 16 RTOs of three different RTO types including TAFE, skills or polytechnic institutes, government universities and industry associations that offer Certificate III in Plumbing including the units of competency for gasfitting registration in Victoria. These RTOs include:

- Holmesglen Institute
- GOTAFE
- Chisholm Institute
- Bendigo Kangan Institute
- Box Hill Institute
- Gordon Institute of TAFE
- Melbourne Polytechnic
- South West TAFE
- Sunraysia Institute of TAFE
- Gippsland Institute of Technical and Further Education (TAFE Gippsland)
- Victoria University
- Federation University Australia
- RMIT University
- Swinburne University of Technology
- Gippsland Group Training Ltd (Apprenticeships Group Australia)
- Master Plumbers & Mechanical Services Association of Australia

Master Plumbers and CEPUTEC offer their training out of the Plumbing Industry Climate Action Centre (PICAC) campuses in Brunswick, Geelong and Narre Warren. With regards to hydrogen, PICAC are building a Centre for Excellence in Hydrogen in Queensland to support training and upskilling of gasfitters for hydrogen (PICAC, 2020b) and are exploring the potential to establish a similar centre in Victoria (PICAC, 2020a). Deakin University are also hosting a Hycel Technology Hub at Deakin's Warrnambool campus with plans to deliver hydrogen training in partnership with South West TAFE, however details of the type of training that will be delivered are yet to be provided.

Each RTO type was formed at different stages in the evolution of the VET sector and with different organisational motivations and contexts. The RTOs that deliver plumbing qualifications in Victoria are all regulated by the Federal regulator, ASQA. Funding arrangements for RTOs vary with some operating an a strictly commercial basis with fees for trainees and others subsidised by government to varying extents. One example is the free

TAFE initiative in which the State Government subsidises TAFE courses in areas of critical skills needs. Free TAFE for priority courses covers tuition fees for students who are eligible for government-subsidised training.

The relationship between national and state bodies and the RTOs operating in Victoria, is shown in Figure 5.

Figure 5 Relationship between National and State governing bodies and RTOs

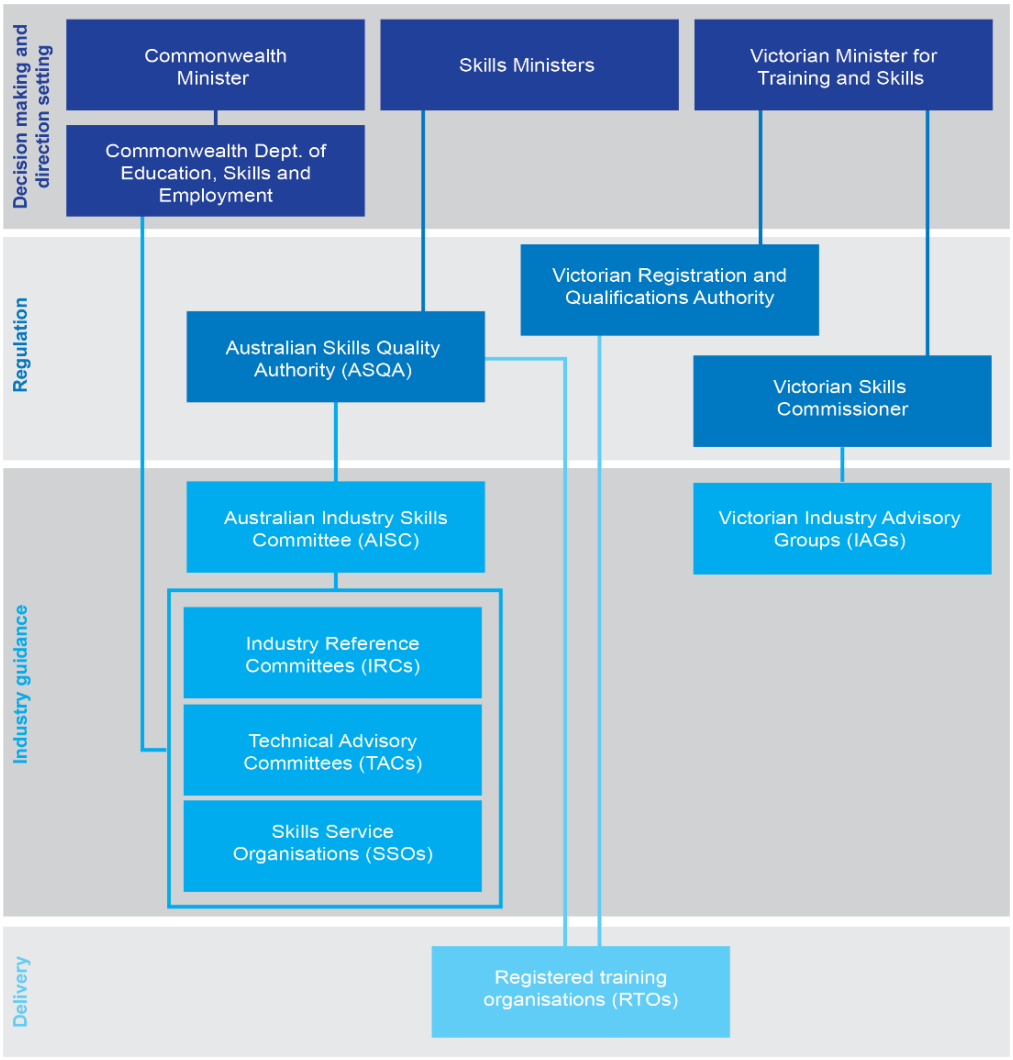


Figure adapted from (AIS, 2020b)

The frameworks governing the VET sector in Victoria have been criticised for being overly complex and fragmented with limitations in accountability and funding systems. As a result, in 2020 the Victorian Government commissioned an independent review into Victoria's post-secondary education and training system. The review argued that:

> A history of public policy failures, in which market-driven ideology has been taken to damaging extremes, has resulted in a VET system that is not meeting the needs of the economy, students, governments or the community. More needs to be done to ensure a VET system that will meet the needs of Victorians into the future. (Victorian Department of Education and Training, 2020: 5)

While competencies are established at a national level, considerable consultation is undertaken with the states that still have a role to play in setting their own policy agendas in regards to skills needs and how these can be supported at a state level. Particularly relevant for hydrogen is the Clean Economy Workforce Skills Initiative developed as part of the Victorian Government's Climate Change Strategy. The initiative has recently been launched and it includes a Clean Economy Skills and Jobs Taskforce. The role of the taskforce is:

> to provide independent expert advice to Government on the sector's skills needs and oversee the development of a Clean Energy Workforce Development Strategy – so that government investment in skills and training is targeted in the right areas. This will be supported by a $6 million Clean Economy Workforce Capacity Building Fund, which will provide grants to build teaching capability, curriculum, learning resources and collaborative learning platforms' (Andrews, 2020).

Funding such as this could be important for assisting to upskill trainers in hydrogen and support additional learning resources needed to train gasfitters in hydrogen.

4.4 CPD and upskilling in Victoria

Currently, regulation within Victoria does not require gasfitting practitioners, amongst other building trades, to 'undertake activities aimed at reinforcing and developing their knowledge and skill' (DELWP, 2020: 4) beyond qualification and competency requirements for initial registration. As explained previously, CPD of plumbers is not a requirement for licence renewal in Victoria, however amendments have been made to the Building Act 1993 that allow the VBA to:

> consider whether a building or plumbing practitioner has complied with any prescribed CPD requirements before renewing a registration or licence. The amendments enable the VBA to refuse to renew a registration or licence if a person has not complied with any prescribed CPD requirements and to take disciplinary action for non-compliance (DELWP, 2020: 3).

As such, the framework is in place to enforce CPD requirements without any such requirements yet being defined. A government review is currently underway into options for CPD for building and plumbing practitioners in Victoria (DELWP, 2020) and policy recommendations are set to be delivered at the end of 2021. The Victorian government acknowledges that ongoing education for practitioners is important for two reasons:

- 'the knowledge and skill held by a practitioner at initial registration or licensing (i.e. the baseline level of competence) can deteriorate over time. Deterioration may occur if the practitioner specialises in a narrow sector of the plumbing or building industry. As a result of specialisation, the knowledge and skills once held in other areas of work may diminish over time due to infrequent use…
- significant changes affecting the building and plumbing industry, including updates to legislation, professional standards, or the introduction of new products and technologies, may alter the nature of best practice' (DELWP, 2020: 4).

The consequence of not undertaking ongoing education is competency gaps which will result in sub-standard work and 'may result in a multitude of harms, including damage to property and financial loss, reputational loss to the practitioner, and negative health and safety outcomes both for practitioners, building occupants and other members of the public' (DELWP, 2020: 4). In the context of this research, CPD programs that aim to train existing gasfitting practitioners with any additional competency needs/awareness for gasfitting for hydrogen will likely be an enabler to ensure gasfitters are appropriately trained and informed of such changes.

Any updates to Standards and the National Construction Code (which does not cover gasfitting) regarding hydrogen need to be understood and applied by plumbing practitioners. However, a stakeholder engagement study into CPD by the Victorian Government found that 'there is a consensus amongst stakeholders that there are problems with practitioner understanding of technical requirements under the National Construction Code (NCC), Australian Standards and work requirements prescribed by regulations' (DELWP, 2020: 5). Currently, if a plumber wishes to undertake CPD there are options available. Master Plumbers Australia offers a voluntary CPD program to members. The Australian Building Codes Board also offers CPD for plumbers, amongst other building practitioners in regard to the National Construction Code (NCC), to 'maintain, improve and broaden… knowledge and competence in the NCC' (ABCB, n.d), however this does not apply to gasfitting work. ESV and VBA offer information phone lines for gasfitters seeking further information on practice in line with standards and regulations or licensing and registration requirements. The VBA can also take disciplinary action against practitioners whose work does not comply with regulations, if they become aware of such work. Appliance manufacturers also offer training in various formats for the installation and maintenance of their respective appliances.

In 2010, a report on CPD options for plumbing practitioners based on industry needs and perspectives was commissioned by the Plumbing Industry Commission of Victoria (PIC), VBA's predecessor that regulated the

registration, licensing and performance of plumbing practitioners. Research undertaken for the report collected data via three forums in regional Victoria, 1,322 surveys – with Registered or Licensed plumbers across Victoria, and 42 in-depth interviews – with Victorian and interstate stakeholders. The report found that:

> Overwhelmingly, plumbers in Victoria support the concept of a professional development program. 48% of plumbers 'strongly support' the idea of a CPD program, and overall, 74% support it to some degree (Walker and Powers, 2010: ii).

The research also found that at the time, '41% of plumbers experience difficulty in finding technical learning opportunities. The lack of information is the most critical challenge in finding technical professional development– larger than finding time, access or cost' (Walker and Powers, 2010: iii). The report outlined a number of principles and goals that could be used to inform government policy on CPD for plumbing practitioners. These are outlined in Appendix 10.3 .

The current Victorian Government review into CPD looks likely to recommend that the government introduce mandatory CPD, with a regulatory impact statement (RIS) due mid-2021. Table 9 presents the high level CPD options outlined in the DELWP consultation paper.

Table 9 High-level CPD options considered in the DELWP Consultation Paper

Option	Description
1. Maintain the status quo	This option would not introduce any mandatory CPD requirements. Practitioners may continue to voluntarily participate in CPD programs provided through industry associations or other means.
2. Introduce mandatory CPD with no compulsory subjects	This option would introduce mandatory CPD for building and plumbing practitioners but would allow subjects to be selected based on self-identified learning needs.
3. Introduce mandatory CPD with a mixture of compulsory and non-compulsory subjects	This option would introduce mandatory CPD for building and plumbing practitioners and prescribe some compulsory subjects. A potential compulsory subject is compliance with the National Construction Code.

(DELWP, 2020: 6-7)

Another potentially relevant review currently underway is the Building System Review being undertaken by an expert group for the Victorian government. This review aims to support 'skilled and experienced practitioners to carry out compliant and safe practices' and also support 'regulators to effectively and efficiently enforce compliance' (Victorian Government, 2021a). The review notes current issues in these areas for ensuring consumer protection, and quality and safety outcomes in the building sector including gasfitting work (Victorian Government, n.d). The review will make recommendations for changes to be implemented from 2021 and 2023.

4.5 Implications for future fuels

Based on the desktop review, Victoria has a governance and licensing system in place that can accommodate a transition to future fuels through licensing requirements and auditing of work; however, there are a number of potential challenges that arise with implications for hydrogen.

Firstly, Victoria's self-certification system combined with inspections or audits undertaken on a small percentage of gasfitting work, present potential regulatory gaps in light of the potential challenges of transitioning to hydrogen fuel and the potential need to closely monitor the skills and workmanship of hydrogen based gasfitting work. Furthermore, a compliance certificate is not required for gas servicing work. Based on anecdotal evidence there are also those undertaking gasfitting work without the licencing or registration endorsement to do so.

Combined, this has implications for understanding what the existing qualifications of practitioners are and how many are practicing. Such data is important for establishing a clear understanding of any potential skills gaps for hydrogen and what the existing knowledge and experience base of gasfitters in Victoria is.

Furthermore, the Victorian licensing system is largely dependent on completion of units of competency that are designed as part of the National Training Package. This means that registration and licensing with regards to

hydrogen will need to consider the competencies for hydrogen developed at a national level and ensure these are adequate to achieve the safety outcomes required for hydrogen.

Another main interest at a state level is how to reach existing gasfitters and ensure they are skilled for hydrogen appliances. There is currently no requirement for CPD for gasfitting but the issue of CPD requirements for all building trades in particular is under the spotlight. Building sector regulatory reform means that there is currently a strong focus on CPD for building practitioners including gasfitters in Victoria. Depending on the timing, this is useful for the hydrogen sector as a CPD framework would provide the necessary vehicle for training on hydrogen to be rolled out to the gasfitting trade.

Given the currently voluntary nature of the various professional development options, there may be gaps in gasfitter knowledge and skills as standards and technology evolve. Non-compliant work may go unnoticed unless there is an audit of the work by the VBA, an accident case or an issue is reported to ESV or the VBA. While a review into CDP for building professionals and plumbers is underway in Victoria, previous attempts to introduce CPD in Victoria have not been successful. Furthermore, there is limited research on plumbing practice and professional learning to ground policy reform for CPD to best suit the needs of practitioners and how they learn.

Regardless of the outcomes of implementing mandatory CPD in Victoria to maintain gasfitters' industry currency, gasfitters working with 100 per cent hydrogen will need to attain the requisite competencies to work with hydrogen, as explored in Section 6.

Overall, these challenges will all need to be considered in any changes to units of competency at a national level and upskilling existing practitioners. Industry and governments working to advance hydrogen should be mindful of these challenges and find ways in which to address each of these in the transition to hydrogen fuel in the domestic sector.

5 Impact of transition to hydrogen on gasfitting work

With an understanding of the existing capability of gasfitters in Victoria, this section will now explore how the transition from gas to hydrogen would take place in the context of appliances and associated gasfitting work in Australia, including the technical skills required by registered or licensed gasfitters, perceptions of practice associated with such skills and tasks, the number of trained gasfitters required to support the transition and the likely timeline for such transition.

5.1 Hydrogen properties and domestic uses

5.1.1 Literature review

While much research attention has been paid to understanding the impact of hydrogen for use in vehicles, less research has been undertaken on hydrogen performance in domestic appliances *(de Vries et al., 2017)*. Furthermore:

> The studies reported to date have been limited to fundamental combustion studies of phenomena related to the performance of domestic appliances or to the laboratory investigation of some practical appliances. Since domestic appliances are connected to the natural gas grid in very large numbers, and that the admixture of hydrogen can change the combustion properties of natural gas substantially, the lack of information on their performance when fuelled with hydrogen/natural gas mixtures forms an essential uncertainty for grid management analyses (de Vries et al., 2017: 1008).

A critical difference between natural gas and hydrogen relates to the Wobbe Index, 'the most important parameter characterizing a (natural) gas' (de Vries and Levinsky, 2020: 114116). The Wobbe Index is 'defined as the ratio of the calorific value of a gas per unit volume and the square root of its relative density. In many jurisdictions, such as in the USA, European countries, Australia and New Zealand, ranges of natural gas quality are given in terms of Wobbe Index (Wobbe bands)' (de Vries and Levinsky, 2020: 114116). Appliances are designed to be fuelled with gases according to Wobbe band. 'When a new type of appliance has been tested successfully and obtained its certificate, it is regarded to operate safely and deliver the comfort intended during its lifetime when fuelled with gases from the Wobbe band for which this appliance type was designed' (de Vries and Levinsky, 2020: 114116). Because natural gas naturally varies in composition around the world, 'the Wobbe band adopted by specific countries largely depended on the quality of natural gas available to them' (Zachariahwolff et al., 2007: 1241). Appliance flexibility for different gas properties differs between countries, for example, in the Netherlands appliances are designed with a very limited range, compared with Belgium or France, where appliances are designed to be flexible to different Wobbe bands.

A key safety issue for hydrogen use in domestic natural gas atmospheric appliances is flashback, 'in which the flame physically enters the burner, usually prior to extinguishing; this results in spillage of combustible mixture into the living space creating an explosion hazard' (de Vries and Levinsky, 2020: 114116). The high burning rate of hydrogen can move 'the flame front from the burner heat upstream into the burner body' (American Gas Association, 2006: 21).

Another noted difference is with regards to hydrogen's small molecule size, low molecular weight, high diffusivity and low viscosity which may lead to leakage when injected into existing distribution systems (Hormaza Mejia et al., 2020).

Broader safety issues associated with domestic use of hydrogen appliances has also been raised:

> ….in industries, hydrogen is handled by people who received specific training at a professional level, and, installations involving hydrogen are subject to professional safety management and inspection. The hydrogen economy, on the other hand, involves the use of hydrogen technologies by general consumers and a similar dedication to safety, e.g. training general consumers to a professional level, would become impractical. The safety of hydrogen technologies and applications must therefore be ensured before entering the consumer market (Dahoe and Molkov, 2007: 1114).

Dahoe and Molkov (2007) note that the different properties of hydrogen compared with other fuels mean that even housing design standards as set out in building codes may need to be updated to accommodate hydrogen for domestic uses, for example:

> Many countries' building codes, for example, require garages to have ventilation openings near the ground to remove gasoline vapour, but high-level ventilation is not always addressed. As a result, even very slow releases of hydrogen in such buildings will inevitably lead to the formation of an explosive mixture, initially at the ceiling-level (Dahoe and Molkov, 2007: 1113).

These differences in gas qualities can all be managed safely but have implications for gasfitting work, amongst other residential build and broader gas supply chain considerations.

5.1.2 Interviewee perspectives on hydrogen properties

Due to limited understanding through research or experience of the skills needs for hydrogen, the researchers sought the knowledge of those involved in hydrogen pilot projects, updates to standards, appliance manufacturing and regulation to better understand the different properties of hydrogen compared to natural gas and the implications for gasfitting practice. The data presented here was collected during interviews with 9 participants from the following participant groups:

- Industry led research (working on hydrogen trials) (2)
- Industry association (1)
- Gasfitting regulator (2)
- Gas distribution (working on hydrogen trials) (4)

In response to the question of how hydrogen properties differ from natural gas and whether these differences are important in training of gasfitters, a range of properties were noted by participants, however, the implications of these properties for gasfitting work differed considerably in some cases. Therefore, the following data requires triangulation with existing research. Table 10 presents the hydrogen properties mentioned by the participants and the number of participants who mentioned each property.

Table 10 Hydrogen properties mentioned by interview participants

Hydrogen properties	Difference to Natural Gas	Potential implications	Number of participants that noted this property
Colour	The flame is not easily visible	Gasfitters or appliance users cannot see the flame or leaks	4
Corrosion	Can be corrosive for some materials that normally accommodate NG	Can lead to hydrogen embrittlement of certain materials	3
Flammability	Much wider flammability range than NG (H2: 4-74%, NG: 5-16%)	Leaks can ignite more easily.	7
Flame speed	Has a high flame speed	Will create lightback, if appliance is not designed to prevent this	3
Heating value / Wobbe Index	Lower Wobbe Index than natural gas	May require changes to burner design at higher levels of blending	1
Molecule size	Smaller molecule size	Leakage with some joints and sealants	6
Oxygen (as a by product of manufacturing)	Using electrolysis to produce hydrogen also produces oxygen.	Pure oxygen is a strong oxidising agent and so is hazardous.	1
Radiated heat	Flame temperature is similar to NG	No major impact	1
Odour	Odourless	As for natural gas, odorant would need to be added to ensure that leaks or open burners can be easily detected by gasfitters/technicians	5

Condensation	Produces water vapor when burned instead of carbon dioxide	This means that burning hydrogen will cause condensation which will need to be removed from the appliances through ventilation or drainage pipes	2
Weight	Lighter than natural gas	Hydrogen rises/disperses faster than NG which is useful outdoors but can create a hazard in enclosed areas.	5

While these properties were mentioned by participants, participant views of the implications of hydrogen properties on gasfitting work differed for some of these properties, including colour, flammability, molecule size, odour and weight. The different views on implications are important to highlight, as while many of the participants have had extensive experience in the industry, there are still mixed views about the implications of the differences in hydrogen for gasfitting practices. Examples of these different views are shown in Table 11.

Table 11 Interview participants perspectives on the properties of hydrogen and implications for gasfitting

Hydrogen Properties	Example of how it matters	Example of how it does not matter
Colour	'[I]f there is a leak it's not visible sometimes. Even flames are not visible with naked eye. So the risk is more, even there is a small leak, and it's hard to identify.' P06 'Well, 100 per cent hydrogen, that clear burning flame will definitely be a big problem, because if you do have a distributed system and you have a leak in the street, potentially people aren't going to know about it until something else catches on fire nearby if it's ignited, which will be a big concern.' P07 'Visibility is another thing that you would want to make as part of any training package that's developed.' P02	'The scientists will tell you that a hydrogen flame is completely see-through. You can't see a flame… it just distorts the light. In practical senses, you can see the flame, because pipes are never clean, so the dust and the dirt from the inside of the pipe burns through the flame and you can see it glows orange…' P08
Flammability	'The fact that we've got this explosive gas that if we get the wrong quantity of it in an area before it's ignited, it could be potentially explosive. My brain, from a design point of view, is thinking we need to remove this risk from the appliance altogether. ' P03 '[T]he flammability ranges from 4 per cent to 75 per cent in air, whereas a natural gas is between 5 per cent and 15 per cent . So you can see that you can get a flammable mixture at much greater ranges. And you can apply all your hazardous area calculations and those sorts of things that we've got in place at the moment, but you also need to understand that the composition of the gas is quite different. And therefore the hazardous areas become quite different and the way you actually manage that product is different.' P04 'There's a greater range over which hydrogen will ignite compared to natural gas or LPG, which obviously means that there's a greater chance of it igniting, so there's a greater risk. The other thing to consider is that the amount of energy that's required to make the gas ignite, is considerably less than what is required for natural gas'. P02	'You know you mentioned about the flammability limits and combustibility. We already deal with things like that in gas trade, because we have to know various gases like LPG, and butane, and acetylene. So, it's only a small step to add that little bit in for hydrogen, it's really not big.' P05 '[I]t doesn't matter if it's above the lower explosive limit for natural gas, it's considered as flammable. So you're actually not operating any differently if you're in that entire hydrogen range. It's hazardous for its whole range.' P01 'But the offset with hydrogen – do you remember I was talking about that large ignition range, flammability range. The offset with hydrogen is that the dissipation rate is 10 times greater than natural gas. So if you divide the dissipation rate by the flammability, you get a much smaller – well, it's sort of a gross measure of the ability to formulate a gas.' P04 'In terms of pros, I would say, the fact that hydrogen is so less denser than natural gas. I think it's a third the density of natural gas, if my memory serves me correctly. What that means is, that even if you were to get a situation where you've got a leak and then that leak ignites. As long as that leak isn't in a confined space, then there's less risk associated with leaking hydrogen, as there is with leaking natural gas or even worse still, leaking LPG.' P08

Molecule size	'I don't know whether these types of compression fittings are going to be suitable with hydrogen because hydrogen obviously is a finer molecule, and it might get through.' P03 'A lot of the procedures we have are the same, but you need to take them to a higher degree... we've actually had technicians come in and gasfitters come in and actually fit components exactly the way they would on a natural gas network. And then we test it on 100 per cent hydrogen. And some of those installations leak... if you don't follow the procedures to the nth degree with hydrogen... you've got a much greater chance of it leaking on hydrogen than you have on natural gas... you're just going to have to make sure that both your inspection procedures, test procedures and your installation processes are followed to the letter.' P04	'I think materials-wise, probably won't affect the industry too much. My understanding is much of what we use currently will be applicable to hydrogen.' P07 '[W]e thought it likely that the plastic materials, in particular, would be harder to retain the hydrogen. That's not proven to be the case so far. Luckily, our test… has shown no leakage of any significance. So we're pretty happy with that result... all those things that we suspected might be an issue have not proven to be an issue. The one that we didn't expect – which was interesting – was threaded joints.' P01
Odour	'[H]ydrogen won't smell the same as natural gas because they don't want the odorant to smell the same. That was another discussion that we've had as an industry. So they want the hydrogen to smell different to natural gas or LPG. And that might pose some confusion too because if it smells like turpentine, people are going to say, "Well, that's not gas"'. P03 Several people also asked questions about plans to odourise hydrogen. Some understand that a different odorant is to be used. Others assumed that methyl mercaptan will be used as for natural gas.	I believe it's odourless, which shouldn't really be a major factor because natural gas comes out of the ground as odourless, so we inject an odour into it. But obviously if hydrogen leaks before it's odourised, that's an issue…' P07
Weight	'I guess you're going to have to really worry about is the different weights in gases. Like you compare LPG which is heavier than air, and natural gas which is lighter than air. But hydrogen is significantly lighter than natural gas, so that's one thing that people really need to be aware of'. P05 'So hydrogen is going to be a lot lighter and it is going to lift and accumulate in – for example, if we're in an enclosed environment, in a house or in a kitchen, if there was no ventilation in place, it is going to accumulate on the ceiling.' P03	'[I]t's not so hard to work with; it's even lighter than air than hydrogen is. So therefore, the accumulation risk is lower.' P01 'Hydrogen is similar to natural gas in it's lighter than air, but it also dissipates as a much great rate if you do get a leak. Hydrogen obviously bonds back with the air very, very quickly and dissipates much easier than natural gas'. P08

Note that the data presented in Table 11 is shown not as a source of definitive information on the properties of hydrogen but to illustrate the range of responses, even from people within the gas industry, on the impact of hydrogen on gasfitting practices. Until this uncertainty is resolved, the basis of any required training cannot be determined.

5.2 Gasfitting skills and knowledge for hydrogen

The need to upskill Australian trades, including gasfitters, to support the transition to hydrogen fuel has been noted in a number of recent reports (Meagher and Dyrenfurth, 2020; PICAC, 2020a; Government of South Australia, 2019; Kosturjak et al., 2019; AIS, 2019). Work is underway to better understand the competency needs for gasfitters of hydrogen based appliances and associated installation, as shown in the following sections.

5.2.1 Hy4Heat Competency framework

Internationally, the most recent and advanced work on hydrogen competencies has been undertaken in the UK by the Hy4Heat project, commissioned by the UK Department for Business, Energy & Industrial Strategy. As part of the project, the Institution of Gas Engineers and Managers (IGEM) have developed an interim standard for hydrogen for gasfitting work and Energy and Utility Skills have developed a training specification to inform the development and delivery of a hydrogen course/module for the upskilling of existing gasfitters and an assessment module to be used by the relevant certification body to assess the competence of gasfitters who

have completed the training module to grant them certification in gasfitting for hydrogen[4]. In summary, the work includes:

- A Training Specification aligned to IGEM/IG/1 (the existing standards for training in gas work in the UK)
- An Approved Code of Practice (ACoP) Assessment Module
- Development of an Interim Technical Standard

The training specification includes 16 units of competency (referred to as core competencies in the UK) with specified hours of training required for each competency. These units of competency and the performance and knowledge criteria for each unit are shown in Appendix 10.4. The training specification states learners must be able to demonstrate their ability to perform the actions listed in the performance criteria and demonstrate knowledge and understanding via tests or oral questioning for the items listed in knowledge and understanding criteria.

> Where Performance criteria are shown, learners must demonstrate their ability to carry out the actions described. Learners must also demonstrate knowledge and understanding, through oral questioning or written testing of aspects shown as knowledge criteria. As appropriate, specific reference to relevant information in the Hydrogen Interim Standard, relating to each criterion, is shown in brackets as follows (H/2 Section/Clauses). (Energy and Utility Skills Group, 2021: 7)

It is important to emphasise that the units of competency are designed for upskilling gasfitters in the type of plumbing they are already licensed in. The following guidance is provided in the training module:

> This Specification is designed to enable existing engineers to extend their competence to include hydrogen fuelled appliances only in the categories they currently hold for natural gas or LPG. This Specification (and any training courses developed to meet it) does not facilitate or enable an engineer's changeover or conversion from domestic to non-domestic or any other category. (Energy and Utility Skills Group, 2021: 1).

After successfully completing the hydrogen Assessment Module, after the completion of the above units of competency, a gasfitter will be certified and endorsed on their gas safety registration to work with hydrogen. 'A five-year renewal of competence in hydrogen will be required as with existing categories of work and a process to facilitate this will be developed as required' (Energy and Utility Skills Group, 2021: 1).

5.2.2 Hydrogen competencies upstream of the meter

Australian Industry Standards on behalf of the Gas Industry Reference Committee has facilitated the review of National Units of Competency for Certificate III and IV in Gas Supply Operations and additional units of competency in two other certificates. These include UEGNSG982Y *Apply safety practices, procedures, and compliance standards for handling hydrogen gas* to be added to Certificate II and III in Gas Supply Operations, and UEGNSG978Y *Monitor and control hydrogen in gas distribution networks* and UEGNSG983Y *Undertake routine hydrogen storage operations* to be added to Certificate III in Gas Supply Operations.

These competencies have been designed for work undertaken upstream of the meter; however, given the limited research on skills for hydrogen, an overview of these units of competency are included here. These Units of Competency, which are currently in the validation stage, are shown in Table 12.

Table 12 New Units of Competency and Skill Sets under review

Product type	Code	Title	Usage
Unit	UEGNSG969Y	Commission, operate and maintain electrolysers	Draft
Unit	UEGNSG970Y	Fault find and repair hydrogen storage equipment	Draft
Unit	UEGNSG978Y	Monitor and control hydrogen in gas distribution networks	Draft
Unit	UEGNSG979Y	Handle hydrogen gas	Withdrawn from project
Unit	UEGNSG980Y	Inject hydrogen gas into distribution networks	Draft

[4] Note that the Hy4Heat materials refer to gas engineers. This is UK terminology for what is called in Australia the trade of gasfitting.

Unit	UEGNSG981Y	Injection of hydrogen gas into transmission pipelines	Withdrawn from project
Unit	UEGNSG982Y	Apply safety practices, procedures, and compliance standards for handling hydrogen gas	Draft
Unit	UEGNSG983Y	Undertake routine hydrogen storage operations	Draft

(AIS, 2020b)

5.2.3 Interviewee perspectives on gasfitting skills and knowledge for hydrogen

Interviewees noted a range of skills which they viewed as needed for gasfitting for hydrogen. These included:

- Understanding hydrogen properties
- Commissioning
- Pressure checking
- Leak detection
- Installation (fittings and choice of materials)
- Managing condensation
- Appliance conversion
- Working with oxygen
- Undertaking hydrogen safety procedures
- Skills associated with fuel cells

The most noted requirement for gasfitters with a transition to hydrogen was knowledge of hydrogen properties. According to one participant:

> A lot of gasfitters… know the difference between LPG, propane, butane, and natural gas… but when it comes to the properties of hydrogen, they don't have a clue. It's not part of their actual curriculum at the moment… [P04].

Understanding hydrogen included characteristics such as explosive limits, gas to air ratios for combustion, weight, odour, lightback, appropriate materials and operating pressures were noted by participants as important parts of having an awareness of hydrogen properties.

Regarding skills, participants noted the need to understand how to commission, pressure check and detect leaks when working with hydrogen. They also noted the need for skills in material selection for hydrogen pipes and fittings and how to suitably install pipes and fittings for hydrogen to prevent leakage. Gasfitters would also need skills in managing condensation produced by hydrogen appliances and also how to convert appliances, in the case of 100 per cent hydrogen. Working with oxygen was also noted by two participants and being skilled in safety processes for handling hydrogen emergencies was noted by two participants.

Underpinning such skills, and in particular installing fittings, two participants raised the issue of 'quality of workmanship'. One participant noted that they had observed that how well a pipe or fitting is installed influenced leaks. Another participant noted that average or poor-quality workmanship that may be tolerable in installation of natural gas appliances could pose a problem for hydrogen appliances and installations and this was something that gasfitters would need to be aware of:

> I know there's some little tricks of the trade that you could get away with when you've got corroded pipe or damaged pipe to make it work. Whereas if you're dealing with a smaller atom such as hydrogen, you could come across some real problems, for sure. [P07].

Other participants noted that there was no significant change to gasfitting skills needed in the transition to hydrogen in the domestic sector but that an awareness of the differences between hydrogen and natural gas was needed.

> …so the way the way you would go about it wouldn't change. In terms of commissioning, checking pressures, checking for leaks. But just being aware that the pressures are different or may be different. The smell of the gas might be different. We don't know yet but it might be [P02].

And:

> if you're using hydrogen through combustion, I'm not sure there's a great deal to be learnt by someone who is competent. The principles are still all the same. There are different parameters, but the

> principles of combustion remain. You need an amount of gas, an amount of air, and some heat, and then it'll burn [P08].

Interestingly, a number of participants noted the role of fuel cells in the transition to hydrogen. Participants all noted that fuel cells would have implications for gasfitting and other trades professionals such as electricians and automobile mechanics. Some participants also noted that there may be the need for cross disciplinary skills and this could result in a new 'Type C' class of gasfitting.

> you're going to need some skills to understand hydrogen combustion, but the other skills are more going to be chemistry and electrolysis skills to understand how electrolysers work, and how fuel cells work… gas fitting is going to transition from combustion to electrolysis and fuel cells. I see that as just being part of gas fitting [P05].

The implications for training of gasfitters for fuel cells was described by one participant:

> Once we have Australian standards in place and materials that are compatible with the gas, I think it's just a matter of working through the installation requirements as required by the standard and that'll be built into the training. But I don't think there'll be a lot of change or difference, personally. I think where the real difference will be is around the fuel cell technology because is it an electrician's job? Is it a gasfitters job? [P11].

> for combustion… you could probably pick up five or six units of competency that could be developed that could be plugged onto an existing certificate III in plumbing/gasfitting… But then we've got the fuel cell technology and that side of it where I'm not convinced that it's as simple as bolting on those four, five, six, seven units onto a certificate III in gasfitting or plumbing, and then them having enough knowledge to actually be able to work on a fuel cell [P08]

5.2.3.1 Key challenges in determining gasfitting skills needs for hydrogen

There were four key challenges in estimating the skills requirements for gasfitting and the timeline for these skills noted by participants interviewed regarding skills needs and timeframes for hydrogen in gasfitting work.

The first challenge identified by participants when articulating the skills needs for hydrogen was the absence of a clear and consistent national plan for the hydrogen roll out with target blends and end uses defined based on an established timeline. Currently there exists no consistent plan to guide appliance manufacturers and trainers to test and develop appliances and identify skills and training needs in line with a national plan.

> So if there's a pathway to hydrogen and it has a couple of steps along the way, are those sorts of percentages going to be uniform across the eight [state] jurisdictions, or are they going to be South Australia wants 15 per cent ; Queensland wants 30 per cent and New South Wales wants 5 per cent ? [The appliance manufacturing industry] finds that really challenging because that means they're designing eight different appliances for Australia, rather than one for what is already a relatively small market. So I think that needs to be addressed on a national framework basis. We seem to have a consensus about 10 per cent [hydrogen blend] by 2030 because that's what current appliances will do [P01].

> [We] are being left a little bit in the dark. And I think the public are kind of the same. They're hearing this, "Oh, hydrogen is the future of Australia." But nobody's really promoting what that looks like' [P08].

> I think somebody at a national level probably needs to decide on a few things [P02].

A second challenge identified was the absence of an Australian hydrogen standard which, according to the interviewees would provide a foundation on which decisions about training and skills needs can be founded.

> At the moment, gasfitters are trained on 5601, the Australian standard for gas installations. If we develop a new standard or adopt an overseas standard, like the interim standard that the UK is working on at the moment, there'll be further training required in with respect to that standard [P02].

Part of the issue with updating or introducing new standards is the lack of evidence available in which to base such standards on. While there is a lack of evidence for hydrogen gasfitting and appliances, some participants felt that the technology for hydrogen is advancing quickly which may leave a gap between technology available, standards and the skills required to undertake the installation, maintenance and repairs of hydrogen technology.

> unfortunately I think there's going to be products that are going to be launched in Australia before there's going to be any skills that are available to work with them. So, there's a product that University of New South Wales is releasing, it's called a LAVO, and it's a domestic fuel cell and electrolyser, but there isn't anybody with any training to work on it. If it breaks down, who does anything with it? Who knows if it's broken down? Who services it? [P05].

Similarly, a participant from the VET sector said:

> I think it's going to come quicker than we probably would have expected a year or two years ago, but knowing what the skills are and what the needs are, I think there's a little bit of a lag at the moment and so we may actually have product available with nobody trained for it. But the problem is: what are we training for? I think there's a bit of a lag happening at the moment [P11]

5.3 Implications for future fuels

The literature and interviews have identified that while gasfitting skills for hydrogen would be similar to those required for working with natural gas, there is a range of properties of hydrogen which differ to natural gas and therefore have implications for gasfitting work. Safety, and the perception of safety, will be key to the success of hydrogen. For hydrogen, where it would be reasonable to anticipate some public concerns over safety, ensuring that the fuel, appliances and associated gasfitting work is safe is critically important. Working safely with the different properties of hydrogen noted in this section can be adequality addressed, as is being done in the UK, with appropriate training and licensing frameworks in place to ensure gasfitters are competent to work with hydrogen and that safety is attained and maintained. The skills and knowledge requirements for hydrogen work will likely differ however depending on the percentage blend and end use of hydrogen. The following section describes three end use scenarios for hydrogen that have been proposed and the implications for gasfitting work from these.

6 Hydrogen scenarios and gasfitting work

Drawing on the data presented in Chapter 5, this chapter presents three residential end use scenarios for hydrogen and their likely implications for gasfitting work. To begin, it is important to highlight that there are currently no consistent targets for the rollout of hydrogen at a national or state level, including specific target percentage blends of hydrogen for injection into reticulated gas systems, in Australia. According to Australia's National Hydrogen Strategy:

> It is too early to say whether setting targets for hydrogen use in any sector would be warranted in Australia. Governments have agreed that mandatory national targets would not be appropriate at this time, but will revisit this question periodically as the market develops.(COAG Energy Council, 2019: 33).

According to AMEO, 'Australia's share of global hydrogen demand, early target market(s), early production technology, level of grid connection for electrolysers, role of residential sector as early adopters, and scale of hydrogen production in each state' (AMEO, 2021: 65-66) are current areas of uncertainty for hydrogen.

The Victorian Renewable Hydrogen Industry Development Plan was released in March 2021 (Victorian Government, 2021c). Outcome 7 of the plan is 'gas networks have a pathway to renewable hydrogen'. Discussion about this outcome emphasises repurposing of the existing gas network to deliver hydrogen to domestic users (along with commercial and industrial premises). It also points out that the Victoria government is already supporting research to promote the safe blending of hydrogen between 10 and 100 per cent into the natural gas system. Victoria is also currently producing a Gas Substitution Roadmap. The consultation paper supporting the roadmap development describes the substantial use of gas in homes and notes that substituting natural gas with hydrogen or biogas as two of six decarbonisation pathways. The paper also notes that the best solution is likely to be a mixture of pathways, rather than there being a single 'winner' (Victorian Government, 2021b).

Based on these plans, three scenarios have been developed for use of hydrogen for the domestic sector that may have implications for gasfitting practices and skills needs. These were selected because each utilisation has different implications for gasfitting work. An exploration of the skills, knowledge and practice needs for these three scenarios then follows.

The three scenarios include a methane enrichment scenario, a 100 per cent hydrogen scenario and the use of residential fuel cells. These scenarios are not mutually exclusive, and it may be that all three applications are used in some parts of Australia depending on local markets, policy incentives and availability of technology. The first two involve 'power to gas' whereby hydrogen is produced from electrolysis or steam methane reforming and injected into the gas network (Quarton and Samsatli, 2018) for residential combustion uses such as cooking (stoves and ovens), gas heating and gas water heaters (Bruce et al., 2018). Residential fuel cells involve a range of technologies at different stages of development (Bruce et al., 2018) and can involve the onsite production of electricity from hydrogen, or hydrogen from electricity to be used in the home. In both cases, hydrogen can be locally stored and used as needed. These residential applications of hydrogen are described in the CSIRO's National Hydrogen Roadmap (Bruce et al., 2018) with different estimations for timelines for their feasible rollout in Australia. The ME-093 Hydrogen Technologies Strategic Work Plan by Standards Australia also focuses on reviewing existing standards with these different applications in mind. Figure 6 shows Standards Australia's conceptualisation of the hydrogen value chain.

Figure 6 Standards Australia hydrogen value chain

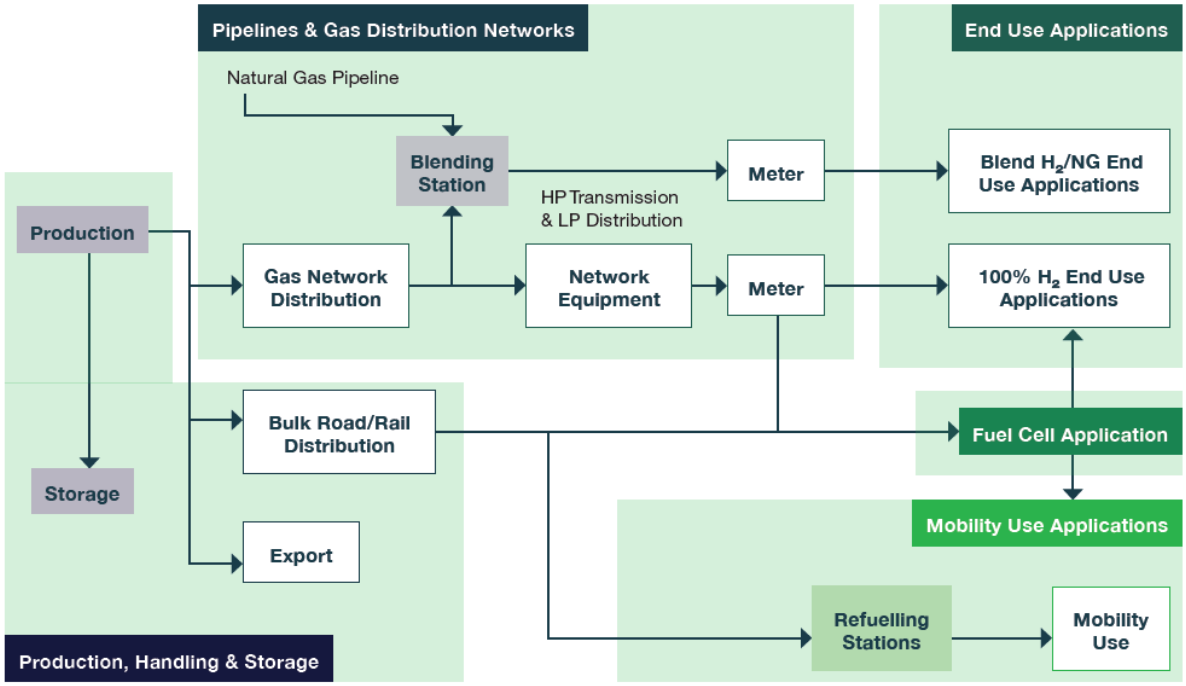
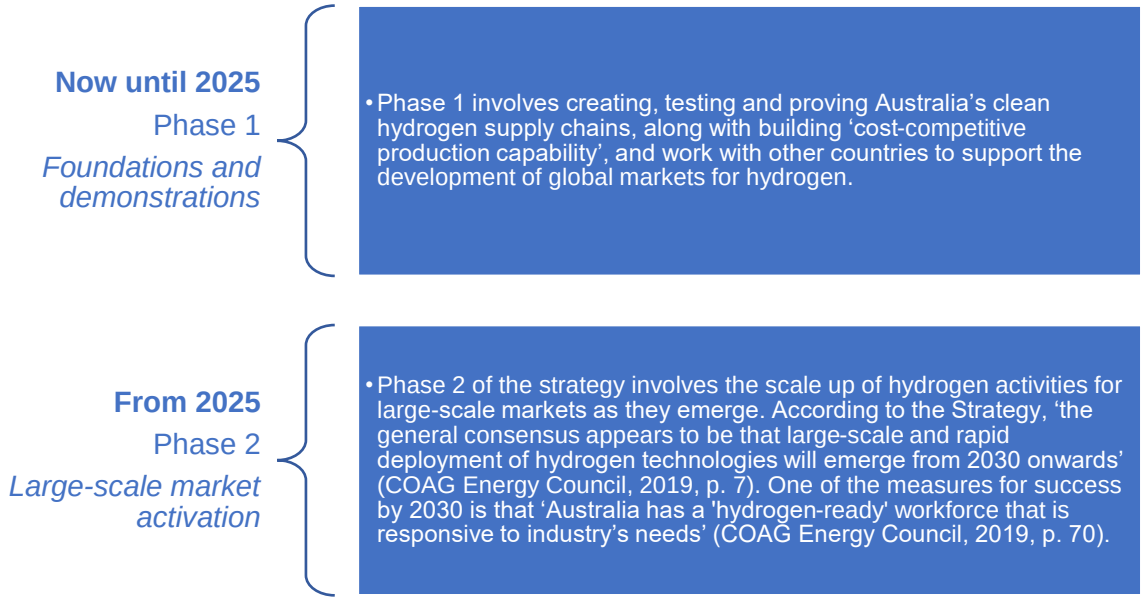


Figure taken from (Standards Australia, n.d: 7)

Another factor to consider in the supply of hydrogen for domestic use are timelines. This report draws on timelines established by the National Hydrogen Strategy. The COAG National Hydrogen Strategy establishes two phases for the rollout of hydrogen over a decade. These are described in Figure 7.

Figure 7 COAG National Hydrogen Strategy Phases



6.1 Low percentage hydrogen blend in existing reticulated gas networks

Internationally, there is broad agreement within existing studies that the injection of hydrogen into the existing gas network to achieve up to a 20 per cent blend of hydrogen can be accommodated by existing household

appliances (Bruce et al., 2018: 46; PWC, 2020; Quarton and Samsatli, 2018) and even up to 30 per cent 'appear to be a viable' and 'may not significantly increase the risk of introducing such a blend to the overall public safety or the durability and integrity of the existing NG infrastructure' (Hormaza Mejia et al., 2020: 8812). According to Quarton and Samsatli (2018: 303). 'It is broadly agreed that hydrogen can be injected into the distribution network at a low concentration with no serious safety issues. Although the exact level is disputed, several studies suggest that up to 15–20% hydrogen blend by volume (vol%) should be allowable'.

However, appliance tolerances in Australia are indicated to be lower than what is reported on in the international literature. Currently, according to AS4645 *Gas Distribution Networks (Part 1 – Network Management)*, a blend of 15 per cent hydrogen in the gas distribution network is allowed under this standard. However, it was noted by an expert participant [P02] in this study that, within current Australian domestic appliances, a lesser blend of 12-13 per cent could be tolerated. Furthermore, appliance testing of 10 vol% hydrogen and 90 vol% natural gas in a selection of Australian appliances was undertaken as part of Future Fuels CRC research project *RP1.4-01 Future Fuels End-use – Type A appliances Test.* The study concluded that 'There were no, or only minor, notable observations across the majority of appliances tested with a blend of 10 vol% hydrogen and 90 vol% natural gas' (Smith et al., 2020: 11). 'The appliances tested that had no observations beyond these minor gas leakage and gas consumption observations were:

- Commercial Fryer
- Overhead radiant tube heater
- Commercial pasta cooker
- Decorative log effect space heater
- Space heater, power flued and room sealed
- Water heater external, Instantaneous, fan forced
- Water heater external, Instantaneous – natural draught
- Overhead radiant tube heater
- Commercial boiling table
- Domestic cooktop with venturi tube injectors (A)
- Domestic cooktop with venturi tube injectors (C)
- Radiant heater, wall mounted.

> There were some notable observations for domestic flueless space heaters, cookers and cooktops… In the tests conducted using natural gas with 10% hydrogen, oxygen depletion systems (ODS) for flueless space heaters operated at between 17 and 18%, which is below the minimum 18% oxygen level specified in the Standard for operation on Natural Gas. During delayed ignition testing by both laboratories, there were instances of light-back with blends of natural gas with 10% and 21.7% Hydrogen on domestic freestanding cooker hob burners with upward facing injectors.' (Smith et al., 2020: 8).

As a result of this context, the low level percentage blend of hydrogen in existing gas networks includes 10 per cent hydrogen with natural gas, rather than the 20 per cent blend advocated in the National Hydrogen Strategy which was based on research done in the UK. The differences between Australia and the UK in regards to the percentages of hydrogen are directly attributable to natural gas supply quality where Australia has always had very good quality natural gas within tight tolerances.

6.1.1 Implications for gasfitting work in this scenario

With a blend of 10 per cent hydrogen in existing gas networks the impact on gasfitting work will likely be minimal. In this scenario with low level blends of hydrogen, there is likely to be little change to appliances and fittings and gasfitting practices or skills requirements. Based on the desktop review and consultation and interviews with stakeholders who are involved with the development of hydrogen standards, low blends of hydrogen in natural gas will not affect the performance of appliances or their installation, repair or maintenance. Past use of Towns Gas, that contained a minimum of 55 per cent hydrogen, is often cited as evidence that the existing gas network can tolerate blends of hydrogen. Despite this, with a wide scale injection of hydrogen into existing gas networks, knowledge about hydrogen may be required to promote the professional and social acceptance of hydrogen in domestic settings and for gasfitters to communicate the differences and risks of hydrogen to households. Achieving such an awareness of hydrogen properties including the impact (or lack of) low level blends of hydrogen in domestic appliances and potentially skills in communicating this knowledge with peers and clients has implications for training and upskilling. This was summarised by one participant involved in appliance testing and the review of gas installation standards:

> anytime someone's only injecting 10 per cent into the network, well it's still only natural gas. So there's no reason really to change anything apart from potentially a couple of minor units of training about what is hydrogen, why is it different.... [F]or me, anything less than 10 per cent or 13 per cent injection into the network is still natural gas. Because you haven't changed the characteristics of the gas at all. It's still natural gas. In some ways it's probably a little bit of a public awareness comfort process, rather than an actual change to the gas [P02].

CPD could be an enabler to ensure gasfitters are appropriately aware and informed of such changes in the gas mix with the inclusion of a 10 per cent blend of hydrogen.

6.2 100 per cent hydrogen in reticulated networks

The second scenario is the supply of 100 per cent hydrogen which is being trialled in a number of pilot projects around Australia. While there is broad agreement that 'In order to accommodate 100 per cent hydrogen, existing appliances need to be upgraded or replaced due to the difference in the properties of hydrogen as compared with natural gas' along with upgrades to existing infrastructure (Bruce et al., 2018: 46), there are few detailed and completed studies on using 100 per cent hydrogen as a primary fuel (Özdemir et al., 2021: 3). Based on a review of existing literature, no research has been undertaken on the implications of such a change to domestic gasfitting work. Therefore, this research draws on the knowledge and experience of those working on hydrogen projects underway to better understand the skills, knowledge and practices needs for 100 per cent hydrogen.

6.2.1 Implications for gasfitting work in this scenario

With the introduction of 100 per cent hydrogen into the gas networks for domestic end uses, gasfitting skills will broadly remain the same, however, knowledge of hydrogen properties and how to work with hydrogen safely will be required including what materials and fittings are suitable to accommodate 100 per cent hydrogen. The desktop review and interviews with stakeholders working on hydrogen projects, along with consultation with IGEM and the Energy and Utility Skills Group in the UK confirm the likelihood of these implications for gasfitting work.

While there are still many unknowns in regard to domestic appliance types and combustion fuel uses in the residential sector and the geographic influence on the use of hydrogen as a combustion fuel in Australian homes, appliance and fitting conversion work is likely, along with the replacement for, or installation of, hydrogen ready appliances.

It is appropriate therefore to consider the scale of this task and the resources required to visit every gas customer in Victoria. Based on data collected for another FFCRC research project (RP2.4-02), APA, AGIG and Ausnet currently have collectively 2,189,487 gas customers in Victoria including both residential and business. This is a similar figure to estimates produced by combining ABS data. As shown in Table 13 and Table 14, the ABS 2016 Census shows there were approximately 2,113,699 occupied dwellings in Victoria including a range of dwelling types. The 2014 ABS Energy Use and Conservation Survey estimated that approximately 83 per cent of dwellings are connected to mains gas across the state. Therefore, approximately 1,754,370 occupied dwellings in Victoria are connected to gas based on 2014 energy consumption data and 2016 census data. The number of dwellings in Victoria however is projected to increase. According to the Victorian Department of Environment, Land, Water and Planning, 'From 2016 to 2056 Victoria will require an additional 2.3 million dwellings to house the extra population: almost 1.9 million in Greater Melbourne and over 400,000 in Victoria's regions' (DELWP, 2019: 8). Based on the percentage of current gas connections in Victoria, by 2030, when the National Hydrogen Strategy plans for 'large-scale and rapid deployment of hydrogen technologies', there will likely be an additional 805,000 dwellings in Victoria, with a total 668,150 new households connected to gas in addition to the approximately 1,754,370 households connected to gas based on the 2014 and 2016 ABS data. With these estimates, there will be between 2 and 2.5 million households connected to mains gas in Victoria (assuming the number of gas connections will remain consistent over time) all of which may require appliance conversion or the installation of hydrogen ready appliances and associated fittings to support 100 per cent hydrogen in the home.

Table 13 Number of Victorian Dwellings according to ABS Census data 2016

Dwelling structure	Number
Occupied private dwellings	2,112,699
Unoccupied private dwellings	278,629
Total	**2,391,328**

(ABS, 2016)

Table 14 Dwelling types in Victoria according to ABS Census data 2016

Dwelling structure: Occupied private dwellings	Number
Separate house	1,546,945
Semi-detached, row or terrace house, townhouse etc	300,918
Flat or apartment	246,040
Other dwelling	11,093
Total	**2,104,996**

(ABS, 2016)

Assuming conversion work takes on average 4 hours per household and an average work time of 1750 hrs per year, conversion of 2.5 million households would require approximately 5700 gasfitters working full time for a year. As of June 2021, in Victoria there are a total of 20,262 plumbers, of which 8,676 are licensed. A transition to 100 per cent hydrogen across the Victorian gas network would require that around two thirds of these licensed gasfitters receive upskilling in order to undertake appliance conversion over a one year period. In addition, if 100 per cent hydrogen was supplied across the gas network, all practitioners undertaking gasfitting work would require upskilling to install and maintain hydrogen appliances and work with hydrogen.It may likely not be the case, however, that all networks immediately switch to 100 per cent hydrogen, and if a staged roll out where to occur, a similar approach to training and development could be implemented as is being done in the UK, with existing gasfitters who wish to be licensed in hydrogen gasfitting work, able to choose to undertake additional units of competency and assessment to gain this licensing.

6.3 Home electrolysers and fuel cells

Initially, this research set out to investigate gasfitting for combustion-based home use, however, during interviews with key stakeholders it became apparent that another hydrogen technology, the fuel cell, also has potential implications for domestic gasfitting work. The view from participants was that the roll out of domestic fuel cell technology is 'moving faster than the combustion stuff' [P08], and as a result of the speed of development 'there's going to be [fuel cell] products that are going to be launched in Australia before there's going to be any skills that are available to work with them' [P05]. As another participant summarised:

> I think the hydrogen industry's working out what it looks like and I can see that there's going to be a need for combusting hydrogen gasses, appliances, but also there'll be fuel cells and the like that potentially will also contribute to the energy requirements [P11].

There are many types of fuel cell designed for different applications and all at various stages of development (Bruce et al., 2018). Technology that utilises hydrogen for energy at a residential or small distributed scale include electrolysers that convert water into hydrogen using electricity and fuel cells which convert hydrogen to electricity. In demonstration projects such as the Phi Suea House in Thailand, these two components are connected with the addition of hydrogen storage tanks and electricity generated from solar power to power a home day and night[5]. The Picea Home Power System developed by German Company Home Power[6] and the Australian Lavo Hybrid Hydrogen Energy Storage System[7] are combined units which are powered from solar and

[5] https://www.phisueahouse.com/
[6] https://www.homepowersolutions.de/en/product
[7] https://lavo.com.au/lavo-hydrogen-battery/

grid electricity, converting water and oxygen to hydrogen that can be stored like a battery, and then converted as needed into electricity via the fuel cell to power the home.

6.3.1 Implications for gasfitting work in this scenario

According to the interviewees, working with fuel cell appliances would likely require multidisciplinary knowledge of hydrogen, chemistry and electrolysis and electrical, water plumbing and gasfitting skills. While electrical skills are sometimes required as part of certification for plumbing professionals, knowledge of how electrolysers and fuel cells work along with skills in installation and maintenance of these appliances would be required for gasfitters undertaking work on such appliances.

7 Perspectives on training and upskilling for hydrogen

This section presents the findings from interviews undertaken with 15 gasfitters, 8 trainers and those involved in training package development and four industry associations.

7.1 Victorian gasfitter perspectives

7.1.1 Views on hydrogen

The interview data provided insight into the perception of hydrogen held by practicing gasfitters in relation to its adoption as a fuel source, their attitude towards working with hydrogen and the type and source of information that contributed to shaping their perspectives on these topics. The following sections will explore each of these aspects in relation to the emergent themes identified from the interview data.

7.1.1.1 Perceptions of hydrogen

Most gasfitters interviewed were aware of the potential blending or replacement of natural gas with hydrogen in existing gas networks for domestic use. Just over quarter (27%, n=4/15) of the gasfitters interviewed were completely unaware of the protentional blending or substitution of natural gas with hydrogen. Despite this lack of awareness, all participants believed the partial or total adoption of hydrogen gas as a future fuel would be a positive transition for the gasfitting trade and plumbing industry as a whole. Several reasons were cited by gasfitters for their support of a transition to hydrogen including: the recognised environmental benefits, securing the longevity of gasfitting as a trade and the self-imposed transition (natural attrition) out of the industry by those non-compliant or no longer committed gasfitters from industry due to the required commitment and effort to upskill.

Forty-seven per cent (n=7/15) of gasfitters interviewed recognised that hydrogen was a cleaner or greener fuel source than natural gas. Participant 18 commented, 'I think the hydrogen will be great, because obviously it's a cleaner burning fuel. A lot better than basically what we've got'. Participant 23 identified that not only was the combustion of hydrogen cleaner but so was its production when compared to the fracking of natural gas once gas reserves are depleted: 'I'm all for it… it seems like possibly a more sustainable method than fracking for gas throughout the country'. The environmental benefits associated with hydrogen were recognised by Participant 26 as important not just in the short-term but also for future generation:

> I'm excited. Anything new excites me… anything that's better for the environment, the planet, the future. I've got four kids, so I've got to make sure I leave something healthy for them behind. So, you know, you've got to think of life that way. You've always got to be bettering or improving something [P26].

Use of hydrogen was also viewed as an opportunity to retain use of existing infrastructure further validating its environmental importance rather than resulting in the abandonment of the existing gas network. Participant 22 reflected on how this use of the existing network made sense: 'Why wouldn't we just choose a product which is less harmful to the atmosphere than natural gas using that same reticulated system, which is hydrogen?' This comment reflects the innovative nature of the adoption of hydrogen as viewed by gasfitters and the identified cumulative benefits that would result if the transition became a reality. Not only was hydrogen viewed as a green gas, but it would enable the continued use of the existing gas network while also evolving the trade itself. Participant 19 simply stated that hydrogen was 'a way of keeping the gas industry instead of losing it.' The use of hydrogen was identified as a way of continuing the viability of the industry as natural gas reserves are depleted which Participants 28 stated 'I knew it was coming [the end of natural gas reserves]. It was just a matter of when.' Participant 29 stated that the adoption of hydrogen would "make sure that we're [gasfitters are] at the forefront." As such, fifty-three per cent (n=8/15) of gasfitters spoken to believed that hydrogen played a positive future role in the gas-sector and their professional practice, for example: 'I believe hydrogen's the future for gas, and hopefully one day we'd like to see it 100 per cent' [P20]. Gasfitters recognised hydrogen would ensure their relevance as part of the energy sector in Victoria.

Hydrogen was also seen as having potential to improve the practice of gasfitters working the industry if there was a necessity to upskill for hydrogen or leave the industry. As discussed later in Section 7.1.3.1, issues with quality of work were noted by many interviewees and Participant 20 felt that the adoption of hydrogen 'could do a lot of plumbers out of work, but then it could also make the future so much better.'

7.1.1.2 Perceptions of working with hydrogen

Gasfitters were asked if they had any concern about working with hydrogen as a gas in their day-to-day practice. No gasfitters, even those who has not heard of or considered hydrogen as a domestic fuel, interviewed expressed any hesitation about working with hydrogen as fuel itself. Initial or broad comments made about the prospect of working with hydrogen referenced that a change in fuel was simply part of learning on the job. Participant 21 stated he/she would '…just go with the flow' as 'if it's the way of the future you learn, so you keep going' [P21]. Other gasfitters interviewed recognised the need for such a transition suggesting that it should already be part of the industry 'and the sooner the better' [P19] and 'we've known about it for a couple of months now and we've already said to the guys that the future is coming, to be prepared and be open eyed and ready to go' [P29]. These comments recognised the preparedness of the sector for such a transition and that it simply makes sense to move forward. Further, the level of professionalism of plumbers and concern for safety regardless of the gas indicates that a change in combustion fuel is not something gasfitters will shy away from.

The overall view from interviewees was that gasfitters are trained to work with flammable gas and that hydrogen is another form of gas and therefore any transition would be simple in work practice. As stated by Participant 28, "I think it's a great thing. I can't really see how it's going to be any great change, to be perfectly honest." Simple in this context refers to the assumptions held by gasfitters that before hydrogen was introduced into the system there would be sufficient regulation, standards, guidance, manufacturer support and training with respect to hydrogen and its associated gaseous properties, for example:

> The product will come out. All the development will be done on the product. The hydrogen will be in the lines. They'll just screw it on the wall there and do the connection up and turn it on. And if it runs, goodo, if it doesn't, ring the manufacturer [P18].

In fact, some gasfitters interviewed anticipated that the transition would be led by manufacturers and service technicians employed by manufacturers, rather than self-employed gasfitters. 'So that initial changeover period… I'm sure there will be companies that will just go out and employ people and just get heaps of techs or plumbers out there and just offer that one-stop kind of shop' [P32].

Important to note, however, comments about working with hydrogen made by gasfitters were speculative, given the lack of specific plans for change available to them. Many interviewees responded to questions about working with hydrogen with further questions about the properties of hydrogen, for example '…[are] the products of combustion from burning hydrogen going to be no different? [P30] or the change in infrastructure requirements, 'Does that mean you don't have to have a greater sized pipe? Or does it mean you'd have a smaller pipe? Or would it mean you'd have a different regulator at the meters? Or…?' [P31]. While there is confidence in working with hydrogen amongst gasfitters interviewed, there still exists uncertainty that cannot be validated or resolved in terms of practice until the transition has been better defined. Further, and as discussed in the next section regarding training, this is dependent on standards and regulation which can only be determined once relevant practice has been established.

7.1.1.3 Sources of knowledge of hydrogen

Gasfitters gained their knowledge about hydrogen from a number of sources. These sources indicate where gasfitters are most likely to gain information about future changes to industry, such as the introduction of hydrogen fuels. Knowledge of hydrogen was gained by direct participation in industry groups and committees (not including manufacturers) (n=3); self-initiated discussion with manufacturers (n=3); Master Plumbers, VBA and ESV led training/information sessions (n=2); research (n=2); Emails from VBA, Master Plumbers and ESV and social media (n=2) or working with hydrogen in the commercial sector (n=1).

7.1.2 Formal and informal ongoing learning

In addition to perceptions of hydrogen, interviews also explored:

- how and where gasfitters sourced information to support their daily work practice,
- gasfitters' views on training and upskilling including whether this should be mandatory and
- gasfitters' training preferences especially as relevant for a transition to hydrogen and any required training.

7.1.2.1 Informal learning 'on the job'

Gasfitters identified and discussed a range of sources of knowledge which inform and are significant to the successful completion of their day-to-day work practices.. Such sources of knowledge are important for

understanding how gasfitters gain information and where they look to for advice and why. Such sources therefore also provide potential pathways for communication regarding hydrogen. Overall, many interviewees expressed the view that their learning was a result of work experience, rather than formal training. For example one gasfitter stated that “service work has always been a build-up of knowledge from hands-on [experience]” [P17], and another argued that training was second in importance to work practice citing that a “lot of it [experience] comes from practical experience and from being on the job training rather than in the training facility”’ [P29]. Participant 31 went as far to say that ”90 per cent of what I know has been learnt on the job, in terms of gas – when it comes to gas servicing or any gas work that we do ‘[P31]. This does not mean that gas fitters operate simply by trial and error but rather they consult expert sources when faced with a specific task. Key sources of information that informed the day to day working practices of gasfitters interviewed included:

- Standards & regulation documents
- Manufacturers’ information phone lines
- VBA emails and information phone lines
- ESV Toolkit, emails and information phone lines
- Master Plumbers workshops and emails
- Seeking information from peers / word of mouth
- Social Media (Facebook groups)
- New products

Gasfitters noted drawing on multiple sources of information but generally each individual prefers one or a small number of specific sources. For example: ‘all of us at work all help each other. If you get to a job and you get stuck you can ring someone else and – But normally we would ring the manufacturer and go to their technical department’ [P21], and ‘I’m always referring to my regulations… I’ve got a lot of stuff online as well’ [P27]. It is important to note that knowledge and information sources appeared to differ between gasfitters due to the type of gasfitting work they are involved in. As one interviewee explained;

> As far as the piping goes, that’s all in the regulations… Installation would be more the plumbing regs… Whereas servicing and maintenance work would be more manufacturer based, fault finding would be more manufacturer based’ [P21].

Another gasfitter commented that their copy of the gas regulations was their ‘bible’, ‘I’ve got my bible sitting next to me which is my gas reg. And I pull them out – I won’t say daily, but probably about least once or twice a week’ [P27]. Another commented that ‘I carry the regulations in my truck. I’ve got a little book… the Australian gasfitting regs. And I refer to that’ [P31].

ESV were noted by some gasfitters as being ‘helpful’, ‘fantastic’, ‘professional’, ‘technically savy’ [P22]. Additionally, a number of gasfitters felt that Master Plumbers were a valuable source of information particularly about changes, for example:

> I find our best source is the Master Plumbers… as a member… they come to us, and say, "Hey listen, this change is coming in." … go out of their way to keep their members up to date. They just put it [information] in a way that's not overwhelming …they tend to present the rule changes or law changes in a common-sense version. [P19]

Interviewees noted the gasfitters Toolkit online “that’s extremely helpful. In fact, I probably lean on that more these days than I actually do VBA…” [P27]. Some of those interviewed noted the VBA’s emails and information line, for example ‘We normally get emails [from the VBA]. I get emails direct to me. Or the company, the boss might get something that he'll print out or let us all know, if something’s changing’. Despite the VBA being a source of information, the value of information from the VBA was questioned by some interviewees: ‘you'd normally get an email and it says log on for a late night meeting and they're a little bit outdated and not very exciting and to be honest, I haven't logged on for one for a few years. You normally just work out what they've said over the next few months and that's it’ [P23]. In addition, VBA was noted by interviewees as not providing adequate assistance to interpret the regulations ‘if you ring the [VBA] and you say, “Oh look, I’ve got a question about this,” well no-one wants to tell you anything. They’ll just direct you to a clause’ [P18]. The direction to a clause was noted as problematic in situations where regulations are outdated or ambiguous:

> Everything we have to do comes out of the regs or the Australian standards. They were written a long time ago and a lot of things are outdated and the authority who covers them, the VBA, don't really give

> you an answer. They'll say, "Refer to the regs." But sometimes they can be contradicting other things in the regs. There's no one you can really call and say, "Hey, this is my issue. How do I go about it?" They just say, "Refer to the regs" and if you stuff up, they tell you to do it again. So… I don't feel really supported or anything in learning or understanding them. It's just kind of fend for yourself and hope it doesn't go wrong. [P23].

The final source of knowledge mentioned by interviewees were the appliance manufacturers. Those working in gas servicing relied particularly on appliance manufacturers for information, for example Participant 17 stated that "because I work on appliances, most of my info comes directly from the manufacturers. Participant 21 commented that the type of work they do may also affect the flow of information between the manufacturer and the gasfitter "because they know all we do is hot water they're keen for us – And we do warranty work for a few of the manufacturers, so they like you to know everything about their appliances obviously'. As explained by the gasfitter, this relationship is commercially advantageous for the manufacturer. Manufacturers were forthcoming with information about their product when they had an established relationship with a particular gasfitter. However, many gasfitters noted that the ability to gain information from manufacturers when pre-existing relationship did not exist was challenging and sometimes prohibitive in terms of their ability to service appliances.

Seventy-three per cent (n=11/15) interviewees noted that manufacturers at some point had been unwilling to provide them information or support with appliances. One participant stated that getting appliance information from manufacturers is 'like asking for blood. No-one really wants to give it' [P18] while another participant described it as 'like drawing blood out of a stone' [P21]. It was noted that when gasfitters 'consult the manufacturer, no one picks up the phone or they refuse due to intellectual property to give out information' [P15]. Another interviewee with experience working with a manufacturer stated that 'all of the information was sort of kept in-house or close to [the manufacturer's] chest' [P28]. This is important to understand in the context of hydrogen appliances as not all gasfitters will be able to gain information about appliances to inform their practice.

As noted earlier, gaining information from manufacturers depended largely on the size and type of business and the relationships established with the manufacturer. As participant 20 stated 'I've got a good relationship with them now because I've been dealing with them for quite some period of time and they don't mind sharing their details with me' [P20]. Another stated that 'I'm fortunate that I have grey hairs on my head, so they're more likely to think that I'm experienced. So, I'm able to glean information off those that I've dealt with for a number of years because hopefully they assume that I'm not a time-waster' [P22]. According to another participant in relation to gasfitting work and access to information from manufacturers, 'it all depends on who you are and where you are in the food chain in the world, just as to the training and the technology you get given, and the opportunities' [P26].

Manufacturers contract their own service technicians and some interviewees noted that they prefer to use these contractors for work on their own appliances. 'They keep a lot to themselves too that they don't tell anybody about. Which is fair enough too, because sometimes they like to send their own people out' [P20]. There is also an intellectual property issue with 'getting printed information and training manuals and things like that' [P17] which one participant noted that 'you'll never get them unless you work for [the manufacturers] [P17].

One implication of this for gas appliances was that appliances tend to be replaced, rather than repaired/serviced, when the necessary information is not available. 'So, it's become a changeover game for the general plumbing industry. It's actually a bit concerning. Because most stuff you can fix, in my experience' [P28].

7.1.2.2 Views on formal learning or upskilling

Gasfitters were asked about their views on continuing formal training which includes such activities as events, webinars or face-to-face training sessions that are specifically designed for learning and take place in addition to the informal learning that occurs 'on the job'. Given the Victorian Government is currently reviewing the need for mandatory professional development among plumbers and the adoption of hydrogen would require potentially mandatory training, interviewees were also asked about their views on mandatory professional development. This data provides insight into the preferences for further training delivery and ways that hydrogen training can be designed to meet existing gasfitter needs.

The majority of interviewees felt ongoing training was important for their trades practice for a number of reasons including personal development as explained by Participant 31:

> it's a personal development thing. If you've been doing gas work for years and years, and you're limited in what you can do and what you can sign off on, and what your knowledge is, obviously you'd like to expand that, as any professional person would [P31]

Participant 29 felt that further training was important for enhancing communication between regulatory authorities and the plumbing community as well as being 'key to training good plumbers into the future' [P29]. For another interviewee, ongoing training was part of managing safety risk and legal liability to ensure they had the skills and qualifications to do the work they were undertaking:

> I used to… change elements and things like that in hot water services, which most plumbers will probably do. But I realised that I didn't have the legal accreditation which means that if I make an honest mistake… or there's an issue at the property and that I don't pick it up because I haven't got the qualification… and somebody's hurt, obviously then – I mean, I'm looking out from the wrong side of the bars [P18].

As briefly noted in Section 7.1.1.2, all interviewees recognised the need for additional learning of some kind when working with hydrogen, for example 'I wouldn't have any worry on taking on any extra training [for hydrogen], to put it simply' [P31]. Gasfitters spoken to recognise the need for training for practical as well as safety reasons. Practically they will need to know how to install, service and repair new applications designed for hydrogen gas. This is explained by the following statement: 'whether you had to replace the appliance or you might be able to just put a kit in that changes the injectors and that sort of thing, that's something that you'd obviously need training on. And servicing it and maintenance' [P21]. Further, gasfitters recognise the need for new skills to ensure their practice is safe for both themselves and the consumer. 'could you imagine just putting a heater in someone's home that's running on hydrogen, and if you hadn't been skilled enough or trained correctly or done the qualification, the next thing… you see this central heater getting blown out of someone's house roof, and then the tradesman goes "Well I didn't know"'. [P20].

7.1.2.3 Making ongoing learning a licencing requirement

There were mixed responses from participants when asked whether ongoing training should be mandatory as is being currently proposed in the Victorian Government's review into CPD. Some interviewees argued that CPD was important while others did not. Some gasfitters fully embraced the idea of having mandatory professional development to inform their practice as it is 'definitely the way to go' [P29] to 'ensure that you're following the right regulations… and to make sure you're not missing out on any vital information' [P29], and to also fulfil licensing requirements as 'it is our responsibility to stay up to date' [P17]. Others felt that while they preferred that gasfitters took responsibility for their own learning, they noted that for many gasfitters 'a kick in the bum where [training is] mandatory may be a good thing' [P17]. Some participants commented on the role of mandatory professional development in transitioning to hydrogen, with one participant stating that 'a change like this [in training for hydrogen] would have to be mandatory' [P19]. Gasfitters who did not feel mandatory CPD was important explained that this was because of their extensive experience, Participant 19 stating that '…if we're already up to date, proving that will be annoying.'

Ensuring that content is relevant and up to date for any mandatory training was important for five participants who drew on past experiences with training courses when they made comments such as 'the last [training session] that I sat through, they just seem to be regurgitating the same stuff year after year. It's a waste of my time, to be perfectly honest' [P28]. It was also highlighted that training must be relevant to a plumber's scope of work 'we don't really want to put something, a roofing module in for a CPD points, if you're working on hydrogen. So, it's got to be specific for that area' [P20]. Effective delivery of any mandatory training was also noted as important for gasfitters' willingness and interest in participating in mandatory training. Preferred approaches to delivery are described in the following section.

7.1.2.4 Preferences for delivery of training

As outlined previously, while no gasfitters expressed a reluctance to undertake additional training or gain further information to inform their trade practice, if additional training was undertaken, it was recognised that this would need to be relevant to a gasfitters scope of work and presented in a way that related or applied information to practice. Within this context, a range of preferences for further training were expressed by participants which included face-to-face training, online workshops and on the job training. These cited preferences differed depending on the circumstances of the individual gasfitters. For example, one gasfitter employing a large number of gasfitters felt that structured educational workplace discussions are useful when the work crew can undertake

them together at the office without the need to all travel to a different place to undertake training. They currently hold ToolBox talks with the staff once a month for the purposes of ongoing professional development:

> So within our team, we have Toolbox talks once a month and then we'll have a different topic every month when it comes to plumbing and plumbing issues and anything new that we find about that we think the guys should know about… It promotes conversation around different techniques and different ideas and things, some knowledge base on where they're at... So we find that an open conversation with a group is definitely the way to go because you get to cover different points of view and you also understand something that you might not have known before. [P29].

This gasfitter articulated several ways his team could be upskilled for a new fuel type such as hydrogen, first 'would be in a classroom situation where the details are being dealt out and how it's going to affect everyone operating it' [P29]. Participant 29 then expanded by suggesting that their employer could facilitate further learning and sharing of information after formal training has taken place. At this point it was recognised that the team would 'then have a million questions. So, there will be more digesting the information and coming back as a group in a Toolbox Talk in a small group later on to discuss it more and how it will affect us day-to-day.' This insight into how trades learn illustrates the shared responsibility between the practitioner and the employee and that regardless of experience, learning is constructed from theory, practice, reflection and guidance.

Another participant felt that online training, for example from Master Plumbers, was really useful to support an employer-led training session:

> online to me is the way to go. Like, if we go to a Master Plumbers' venue somewhere, it's like herding cats, getting everyone there at the right time. And you're interrupting their life more so than saying, "Oh look, we just need to stay back at the office, or meet back at the office at 6:00 o'clock for an hour webinar. We'll get some food and we'll have a chat afterwards. And to me, that's the best, because no-one's in a hurry to get home [P19].

This approach to learning appeared useful because it integrated into the existing workday of employees in this particular business. The use of online delivery of information through webinars was also supported by Participant 27 who made a similar comment regarding the ability to integrate training into their day rather than attending a face-to-face training session. This, they noted, has resulted in them participating in more training sessions:

> with Zoom now, it's very easy to just make a time that you can sit in your car on the side of the road and do it… Prior to COVID… we always got sent upgrades to regulations, either via email and by mail, but they're not really information and training sessions. Whereas since COVID's been around, everybody's jumped on Zoom. Yeah, that's made life so much easier for everybody. It's convenient… They're all free too. You don't have to pay for them [P27].

While online learning was preferable for some participants, others felt that 'face to face is better. I've gone online for the last probably 12 or 18 months doing my diploma and it's a lot harder. I learn a lot better face to face' [P23]. Another participant felt that 'online's fine. But it may well be that there's aspects of it that need a face-to-face or a workshop type of application so that people can actually see it in the flesh' [P30]. The time efficiency of a face-face course however is also a consideration, as one interviewee noted 'I think a lot of the training organisations, they offer a 12 week course that could probably be taught in about three weeks… plumbing has become a pretty profitable education area' [P23]. This interviewee noted that they would prefer in the field training over classroom training. This approach was also preferred by two other gasfitters interviewed who felt they would prefer to be trained in any new technologies for hydrogen on site with 'in the field training' [P23] while installing or converting appliances. Another participant suggested that this on the job training could be provided by the regulators.

A number of participants viewed manufacturers as a vital element of training for hydrogen given the importance of appliances in such a transition and the information and access to future hydrogen technologies that manufacturers can provide. Participant 21 explains that they anticipate that the manufacturer will be a key source of knowledge and training when stating 'We'll go to Bosch [for our product knowledge]', but this training would need to fit in with existing work schedules. Participant 26 made a similar point about the role of manufacturers in further training commenting that 'if the manufacturers are going to be distributing it, they will have to train us. And they need people to distribute the products through. So that will be people like myself that they will distribute the product through. So they'll have to train us to be able to supply and install them.' This view of the role of manufacturers is important to note, given than many expressed barriers to gaining information from the manufacturers to inform their day to day work practices. As Participant 26 noted earlier, the access to training

opportunities and information provided by the manufacturers depended on where you were in the 'food chain', therefore, access to manufacturers and training opportunities in the transition hydrogen is an important consideration.

7.1.3 Contemporary practice and implications for adoption of hydrogen

Interviewees discussed a range of challenges they had experienced within their trades practice that they felt impacted the quality and safety of the work undertaken by gasfitters. While some interviewees noted that a transition to hydrogen with improved licensing requirements has the potential to weed out poor practitioners from working in gasfitting, some noted that existing challenges would remain regardless of what gaseous fuel is supplied to homes. These challenges included issues with regulatory oversight which resulted in incompetent gasfitting plumbers working in the sector with limited regulatory or market incentives to undertake training or upskilling. These challenges were driven by a number of noted issues and had a number of effects according to the participants.

7.1.3.1 Regulatory oversight

Regulatory oversight was recognised as a process that ensured trades completed their work to minimum standards of accepted practice. VBA conducts risk based audits, inspecting a percentage of work undertaken in which plumbers have issued compliance certificates. The effectiveness of this arrangement to ensure acceptable outcomes were achieved and non-compliance work practices were identified and addressed accordingly was questioned by some participants. Regulatory oversight of practice and quality of work was recognised as important in relation to the introduction of a new fuel such as hydrogen as such a transition requires new practices and skills. A few notable issues within contemporary practice were raised by the gasfitters interviewed including: auditing of five per cent of work undertaken within a 12-month period of certificates lodged was not viewed as enough of a sample to ensure quality of practice; certificates only lodged for work greater than $750 failed to capture a significant quantity of work undertaken within the sector; and, unqualified/inexperienced tradesmen working in a system with limited regulatory oversight.

The amount of auditing of gasfitting work that takes place in Victoria was of particular concern for six participants. These participants felt that auditing had 'fallen over here in Victoria at the moment' [P20] because the auditing of work is 'about two per cent of your overall work for the 12-month period, of certificates lodged' [P20]. Gas servicing was noted to be an issue in particular because of the requirements for issuing a compliance certificate for gas servicing work:

> when we go and do service work, because it's not over $750, and we don't actually go and modify anything, we're just replacing like for like, it doesn't incur a certificate of compliance… that gives regulatory oversight, who's been there, who did it and possibly a random audit of five per cent of those certificates. With gas servicing… there's no automatic auditing occurring of that space of work [P15].

An effective auditing process was viewed as essential where there are 'unqualified tradesmen or inexperienced tradesmen… At 5 per cent [of jobs audited], if you do 20 jobs identical and you get audited on the last one, yes, you'll be ordered to fix up whatever issues there are with that, but if you've done 20 other similar jobs, those other 19 are out there' [P18]. There is also no requirement placed on the gasfitter to undertake additional training if their work has been identified as non-compliant by the VBA. Compounding this issue of a limited number of audits, those 'not putting in the appropriate paperwork, they're not checked because the job according to the VBA doesn't exist' [P17]. Because of these auditing issues, one participant argued that the VBA 'need to go back to a full inspection service instead of this audit nonsense' [P22]. Better auditing was also seen as important because of the grandfathering clause that allowed existing gasfitters to also do serving work when the regulations for licensing changed in 2008. When this happened, 'everyone got type A servicing' and as a result 'you've now got 6000 plumbers that don't know the back of or the inside of a hot water unit or a gas heater, but essentially they're licensed to go out and do that work' [P15].

The issues with auditing then have an impact on the quality of work performed and the skills a tradesperson is expected to have, for example:

> First and foremost, there's an erosion of skills and abilities because the audit process is only that random sample. So, a lot of very poor workmanship goes through and is accepted and there is a real loss of skills because of that. [P22]

Accountability for poor workmanship was one role that auditing plays in ensuring practitioners have the required skills, another is the learning opportunities that auditing provides. Another participant commented that the auditing process provides an opportunity ‘highlight if we’re slipping’ [P19] and therefore were viewed as a source of feedback on practice that promoted learning.

These issues noted by interviewees regarding lack of regulatory oversight are allowing those who do not work within regulations to continue practicing according to some interviewees. Such tradespeople were referred to as ‘cowboys’, who are tradespeople ‘out there just kind of slapping in whatever’ [P23] and there is perceived to be ‘nothing done to kind of punish the people that did it initially’ [P23], which results in a ‘lack of plumbers being held accountable’ [P17]. The ‘cowboys’ were said to offer cheaper services than others that are more skilled in the work, which consumers then agree to, and this also impacts on the quality of skills of gasfitters. ’If you want to pay peanuts you’re going to end up with monkeys. You’re not going to end up with anybody that knows anything. And that’s where the market is’ [P18].

Concerns about regulatory oversight were compounded by the introduction of hydrogen. Some gasfitters felt that additional oversight in the form of auditing was required within the current regime and this would intensify when dealing with new regulations and skills in practice. For some gasfitters, adequate regulation of the industry with the introduction of hydrogen was assumed in how they saw the transition occurring. Gasfitters participating in this research articulated their level of confidence working with hydrogen based on the view that it would be regulated by ESV and the VBA: ‘there’s obviously going to be a new set of regulations through Australian standards and through Master Plumbers and VBA and everyone else’ [P29]. This regulation would ensure the fuel was safe within clearly developed professional standards and regulations. As Participant 22 stated: ‘There won't be any problems. There would be a ten-step guide I would imagine, which would be changing jets, changing gas valves, adjusting regulators, those sorts of things’. Gasfitters stated that there was a significant role in the auditing of subsequent practice ‘The industry would have to provide us with parameters that have to be met, and yes random audit, that sort of thing, which currently happens, but probably focus on it for a little while’ [P19].

7.1.3.2 Skilled gasfitters

A number of gasfitters interviewed noted a decline in quality of skilled work they had witnessed in the course of undertaking their practice and also a decline in the number of skilled gasfitters to meet current demand. This was a result of a number of factors which included: a limited number of training options available; a decline in the quality of education; and, the inability to train apprentices due to their business structure and associated costs.

A number of participants commented on the limited availability of courses that provide the qualifications required for Type A gas servicing licensing. Several participants expressed the desire to upskill or support their staff to upskill; however, access to training providers was identified as a barrier, with comments made regarding long wait times for admission into gas servicing course coupled with minimal training locations outside of Melbourne. One participant said they were aware of people traveling to Queensland to access timely training to become a licensed gas servicer in Victoria. Just under half of the gasfitters spoken to (n=7/15) noted limited availability of RTOs that provided training for gas servicing class of plumbing either for themselves or their employees. For example, ‘right now there's only two RTOs delivering [type A servicing] and the wait for them to get into do this disconnect reconnect course is 18 months’ [P15]. The reported number of RTOs delivering Type A Servicing varied between one and two. The authors of this report can only establish that there is one RTO delivering this qualification at the time of writing the report.

Other participants commented that quality of education delivered to RTOs training apprentices differed considerably. For example, one gasfitter felt ‘frustrated with some of the trade schools’ stating that despite learning on the job their ‘five or six apprentices we’ve got here… they’re not tending to get the same sort of learning capacity in the training facilities’ [P29].

When asked about whether the participants employ apprentices, many felt the costs associated made apprentices ‘prohibitively expensive to employ’ [P22], and that the specialisation of their work limited their ability to train an apprentice appropriately as explained by Participants 21 and 27, ‘Because all we do is hot water’ [P21] and that ‘it only takes one person to go to a job and fix the job’ [P27]. These factors appeared to be an issue for those involved in gas servicing, rather than the larger companies involved in gas installation work. Another participant would like to employ apprentices however the difficulty in finding suitable apprentices and the length of time it takes to train an apprentice impacted on their ability to do this.

> I could put on at the moment, probably about 30 people if they were licensed and competent in the work I need done. But I (1) can't find them, (2) takes me six years to train one up [P15].

Given the issues identified with the employment of apprentices some participants reflected on the poor workplace education that they saw fledgling trades experience. Participant 22 recognised that apprenticeships can often 'veer into… cheap labour, which… I think that's fairly common' and Participant 18 reflected that employers 'get kids in there, they get the government subsidies, and basically run those kids doing one thing' . Another participant 'point[ed] the finger pretty strongly at the volume builder type market where there's plumbing companies that are on such tight bloody margins that they all they do is employ apprentices and all they do is the same thing day in and day out, and they're like bloody puppy factories' [P32].

The noted challenges for employing apprentices in gas serving results in fewer apprentices that are trained well by those well experienced in gas work. As one younger gasfitter described 'you still need the training from someone who's had the experience' [P31].

7.2 Training sector perspectives

This section reports on the views of six qualified gasfitter trainers employed in senior educational or management positions within the plumbing departments of RTOs (five from Victorian RTOs, one from RTO in the Australian Capital Territory), and two training professionals involved in the development of national training packages for the national plumbing qualifications. Those trainers working in RTOs were also licensed or registered gasfitters, with some currently working in the sector while also working predominately as trainers. All eight participants were interviewed to ascertain their views on hydrogen, the implications for gasfitting practice, and their thoughts on where hydrogen training would best sit within existing training structures. Participants were also asked about the process of amending national training packages and their subsequent delivery including challenges and the potential implications for hydrogen.

7.2.1 Views on hydrogen and implications for work practice

All eight participants interviewed were aware of the potential inclusion of hydrogen as a future fuel blended with or replacing natural gas. While all participants discussed the use of hydrogen as a household combustion fuel, there was also recognition by some interviewed that working with hydrogen may extend to fuel cells and electrolysers which could result in the creation of a new trade that sat somewhere between an electrician and gasfitter. The different uses, applications of hydrogen and associated tasks were recognised as having different implications for training and subsequent practice. What was clear from the interviews was that there exists 'a lot of uncertainty' [P14] about what hydrogen would look like in gasfitting practice. Interviewees expressed the need for clear leadership and associated plans that define the future market and guides the evolution of industry and associated training. Leadership from governments was cited as important for ensuring the 'right market drivers, underpinned by appropriate policy', otherwise the hydrogen economy 'is going nowhere' [P14].

Of those interviewed, all saw a clear emerging pathway for gasfitters working with hydrogen as a combustion fuel in a domestic setting. This is illustrated by Participant 14 who stated 'we're not seeing, to be honest, the emergence of a new superhero, the hydrogen worker'. From this perspective, the training need was viewed as the inclusion of additional units of competence on hydrogen as a marginal change to existing gasfitting training. Similar to the gasfitters interviewed, all trainers felt that 'a gas is a gas is gas'[P16]. The view that hydrogen is simply another gas saw seven of the eight participants reflect that the required skills when working with hydrogen would be the same as working with natural gas. However, participants noted that there would still need to be some additional training to ensure a clear understanding of the properties of hydrogen and emerging appliances, materials and fittings were understood by those working in plumbing as well as those specialising in gasfitting classes. This type of training already occurs for different gas types currently in use. For example, Participant 14 commented that 'gasfitters are already trained to deal with multiple gases, and in fact, when you start getting into the industrial settings, they already work with hydrogen." Interestingly, this view of hydrogen as 'another gas' was noted by Participant 24 as one reason why changes have not yet been made to the existing national plumbing competencies. They described a view held among some groups influential in training package revision that training for hydrogen 'is just duplicating the existing outcomes; gas is the same as hydrogen' [P24]. These insights into how trainers (also licensed and registered gasfitters) perceive hydrogen, as just 'another gas', indicate that if changes to the national training package are needed, due to the adoption hydrogen, they would be readily accepted. However, they also indicate that, the implications of working with hydrogen must clearly be

articulated to those involved in training package updates so that the key differences are overtly understood and subsequently articulated.

7.2.2 Views on where hydrogen fits in existing training structures

Different approaches to the incorporation or addition of hydrogen into existing training structures were expressed by interviewees. The differences expressed were a reflection of the different role that trainers perceive a gasfitter would play in the emerging market. Eighty per cent of participants (n=6/8) felt that hydrogen and associated training competencies could be included as part of the existing training package for gasfitters. Rather than create a separate training program or qualification, additional units of competencies could be developed and included as part of the mandatory competencies that already exist. While this would be sufficient for hydrogen in the role of a combustible fuel, working on hydrogen appliances linked to domestic fuel cells would likely require a different approach. The emerging new roles of gasfitters coupled with the existing tasks could result in a combination of both additional units of competency for hydrogen in the mandatory unit and separate training for the emerging skills required. For example:

> we're likely to see the hydrogen and Type A appliances becoming part of a standard stream within plumbing apprenticeship, I would have thought, and we're likely to see fuel cells as possibly a post trade Certificate IV skillset [P25]

Another participant suggested and expressed willingness to establish a 'Skills Set' course, which is a selection of units of competency by the RTO, that could be used as a pilot for hydrogen training and also help to train the trainers that will be delivering hydrogen training in the future. They commented that their RTO had the facilities available to develop hydrogen training and willingness from their management, it just required input from industry and regulators.

As discussed in the beginning of this section, different views amongst participants about the role of the gasfitter in future hydrogen work beyond hydrogen used as a combustion fuel in the reticulated network emerged from the interviews. One participant was of the view that a 'hydrogen worker' will be:

> very different and the skills are going to be quite broad and I think there's a real coming together of different skillsets, so it's not just gasfitting. There's some electrical going to be required. There may be a bit of plumbing involved as well, particularly if we're working with some of the fuel cells [P11].

This view saw the discussion of having a separate trade and qualification for plumbing work where hydrogen was used as a combustion fuel and those emerging practitioners working with hydrogen in alternative ways with new technology. This is reflected in the comment made by Participant 13 who argued that hydrogen should stand alone as its own trade due to the challenges in both regulating plumbing and getting existing and older plumbing trainers on board to train in hydrogen, as reflected in the following statement:

> if you were looking at hydrogen technology, it would be a completely separate trade. It wouldn't be plumbing and gasfitting embracing it, it would be a hydrogen engineer… if we're going to start taking [hydrogen] gas and renewables seriously, there needs to be a line and it needs to be drawn, and it needs to be taken away from plumbing because some of the plumbers, they don't value it and they don't understand it. Even some of the teachers [P13]

Participants additionally recognised that training needs would also differ depending on whether the cohort are undertaking their initial training or if they are an existing gasfitter.

> the training that an apprentice gets… is probably going to be a lot different to what an existing gas worker gets because they've already got all the skills around the installation and all those transferable skills already exist with that person [P11].

Overall, what training for hydrogen would look like depends very much on the type of work undertaken and what trades are involved. The uncertainty about these factors in a future hydrogen economy therefore impacts on clarity of what training would look like.

7.2.3 Updating training packages for hydrogen

If hydrogen were to be included at a Certificate III or IV level for plumbing in Australia, then the national training package would need to be updated. Those involved in updating the national training package commented on the complexity of the process and the need for agreement from a range of industry, associations, education, local,

state, and national government stakeholders with differing needs regarding both delivery and competency outcomes. The complex process involves 'around 49 or 52 step[s]'[P25] from the initial 'Case for Change' put forward from the SSO with support from industry to the Australian Industry Skills Committee (the Commonwealth sign off point) for approval, to the final endorsement of a developed or updated training package. One interviewee noted that the most recent update to the plumbing training package took two years while other training package updates they have experienced have taken a decade or more to be completed. It was noted by those involved in training package updates that the recently prepared Case for Change for the inclusion of hydrogen in the national training package for plumbing is categorised as a 'complex' update. This was due to the undefined future hydrogen market and the lack of existing industry use/experience to inform training development.

Further, licensing and regulations informed by Australian standards, which are yet to be developed for hydrogen and associated gasfitting practices, also play a key role in informing training package development. As cited by participant 24, 'our units are written to the Australian Standard, so whether and how they can feed into the project, and vice versa, would be very important as we go along.' Standards and regulations for hydrogen are yet to be developed or incorporated into existing Standards and regulations. Updates to Standards were viewed as an essential part of the training process for hydrogen by three participants. For example:

> There are going to be massive works required that are underway by Standards Australia… so once we get some of those recipe books recalibrated for the underpinning standards that people need to work to, then – and I'm not trying to trivialise that, there's a fair bit to go into that – … we'll just vacuum that up [P14].

Licensing requirements were also indicated as key to the development of training deliverables. One interviewee involved in training package design commented that the training packages for building and construction, including plumbing, are largely driven by the licensing requirements in each state and this is why it takes time to reach agreement on updates to national training packages:

> plumbing including, obviously, hydrogen in time, when its ready, is highly regulated for public safety, and each state has its own policy rulings and ways of managing that regulation. So, coming to a national agreement on a plumber's licence – is basically what we were negotiating, what a plumber's licence looks like… it just takes time [P25].

How the structure of future licensing requirements for hydrogen could potentially influence the training delivered was elaborated on by two participants. Participants 14 and 16 saw hydrogen as an 'addition to the endorsement of type A appliance servicing' and therefore this would result in 'post apprenticeship training' [P16] for gasfitters to get a 'higher level training for hydrogen' [P14] for additional endorsement.

The undefined future hydrogen market and yet to be established licensing requirements and Standards, therefore have implications for the complexity of updating the national training package for hydrogen.

7.2.3.1 Role of trainers in training package updates

RTOs have an opportunity to provide input as a stakeholder in the training package update process. However, the interviews indicated that RTOs have differing levels of influence in the training package development depending on where they are positioned in industry. For example, industry associations appeared to have a greater role in consulting on training packages. It was also noted by some trainers that training packages are designed by industry, and that RTOs have to deliver what industry has produced. For example:

> You have to understand we are not industry… our opinion is not regarded as the be all and end all for the forming of a training package. Industry… directs what needs to be taught, we get told what we need to teach, and you have to accept that [P13]

And

> 'we very much are a slave to the product that industry is looking for' [P16]

Interviewees expressed varying levels of satisfaction with this process. Some participants felt that there were opportunities to review training package updates throughout the process and were satisfied with their level of involvement, while others felt that the IRCs themselves could benefit from what they felt would be better representation of gasfitters, for example:

> The plumbing training packages have just gone through an upgrade and there was minimal practising plumber/drainer/gasfitters sitting in those groups and they're making a decision about what's required for the training [P11].

The need for adequality skilled and informed stakeholders therefore is an important consideration and challenge in the context of a hydrogen, where a domestic supply industry is yet to be established. Furthermore, as shown below, trainers interviewed expressed their views on what they perceived as a number of existing challenges, and potential challenges in transitioning to hydrogen, that may need to be considered in the revision of the national training package.

7.2.4 Challenges in delivering hydrogen training

After a training package is endorsed at the national level, the RTOs work on transitioning to the new training package, upskilling their trainers to deliver any new content, modifying training facilities, choosing electives and designing the curriculum informed by the national units of competency. These activities undertaken by the RTOs are done in consultation with industry and regulators to determine the best balance between local industry, market and regulatory needs and the capacity of the RTO to deliver

It is important to highlight that the training package established at the national level provides the skeleton or backbone of the unit and assessment of competency as described by Participant 33, there 'are 43 core units that we have to deliver, and there is about 40 to 50 elective units.' RTOs must choose the electives they believe relevant. This is often done in consultation with trainers, RTO management and also industry and regulators. The range of stakeholders involved in the process means there is a variety of competing influences over the choice of electives such as time and cost, facilities and skills available among the trainers. Curricula and supporting material are then developed by the RTO as each 'unit of competency has its own training package… we unpack it, we write resources for it. We work out a schedule, how we're going to deliver it' [P34]. Time and resource constraints on RTOs and trainers were identified as influencing how well curriculum is developed. Participant 34 commented on the pressure faced within RTOs and the impact on curriculum development 'my role as a senior educator…, was to try and give the teachers the best delivery material I could…, but really, I'm on the run.' Participant 34 further expanded by identifying other aspects of the workload of trainers such as 'administration stuff, confirmations and things that I feel is not what a teacher's role should be' took time away from developing quality teaching materials for staff. The reason for this was stated as not having any support from the larger RTO, along with funding to invest in learning resources and online teaching tools. For example: 'There's no support. The teachers seem to have less and less time to do anything that they should be doing…' [P34]. This trainer commented that despite the fact that their course materials are compliant according to the RTO's internal quality assurance processes and also with the national regulator, due to time constraints and lack of resources, 'the delivery material, it's just not going to be there' [P34].

Time and resources pressures expressed by Participant 34, however, did not appear to be an issue for some other interviewees depending on the RTOs in which they work. Those RTOs dedicated to teaching plumbing did not indicate issues with time or resources constraints in delivering training, while the large, 'volume' [P14] RTOs, as one interviewee put it, are at a 'disadvantage' [P14] because of the competing priorities and qualifications within the one organisation so the focus that smaller RTOs have is 'not easily replicated' [P14]. While the type and management approach was indicated by the interview data to influence what participants perceived to be the quality of delivery in plumbing courses, the amount of training that needs to be delivered for a Certificate III level qualification to train apprentices for licensing requirements in plumbing was also noted as a challenge for trainers:

> …although I understand the geographical reasons as to why everyone needs to have a broader knowledge of plumbing, there's just so much information to take in. Roofing, draining, sanitary, gas, water and then you've got the mechanical stream, the heating and cooling side. There's just such a massive amount of knowledge that needs to be taken in, it's not absorbed, and there's not enough time to teach it properly [P13].

From a delivery point of view, RTOs hold a significant level of responsibility for designing the curriculum materials to successfully and meaningfully delivery the national training package requirements. There are several financial and resource constraints faced by some RTOs, more than others, in developing effective curricula. This is an important consideration for training for hydrogen as some RTOs may be better placed in terms of resources available to update units of competency or write additional curriculum for units in hydrogen. Those that do not

have the resources may require additional support in this part of training delivery. The other challenges noted by interviewees were training the trainers in hydrogen.

7.2.4.1 Training the trainers in hydrogen

While it is too early to say what hydrogen training will involve, upskilling those delivering the training was a key consideration for many of the interviewees. Given the hydrogen market 'has not been defined yet' [P25], as discussed in other parts of this report, there are equally as many questions about what trainers delivering hydrogen training will need to know as there are for gasfitters. This is reflected in the comment made by Participant 11:

> I think for RTOs it's going to be a little bit of a struggle to develop the skills in the training staff because nobody has the skills now. So, we'd be having to work out how we're going to gain those skills. [P11]

In addition to the requirement for RTOs to ensure trainers are suitably qualified and that they maintain industry currency, updates to a national training package may also place a requirement on trainers to be qualified to deliver training in hydrogen, however 'there's going to be great difficulty in drilling down to the specifics of knowledge and the work practice components' [P25] given 'the void of real industry players' [P25] in Australia.

With limited hydrogen examples and facilities with which to upskill trainers, the focus was placed on manufacturers and regulators to support the upskilling of trainers for hydrogen 'we'd be working with our regulator and manufacturers, whether it's appliance or pipe systems, in getting the skills required' [P11]. According to another interviewee:

> from a training point of view, the first thing that we would do of course is send our training staff out into industry to be trained by people who are at the pointy end of the development of all of this [hydrogen technology]. And that might be… with Energy Safe Victoria. It could be looking at what happens from a manufacture point of view [P16].

The view from those trainers interviewed regarding the willingness of their training staff to upskill for hydrogen was mixed. Some felt that 'probably 80 per cent of our teaching staff would be no problems' [P33], while another manager felt that most of their trainers acted like plumbers working in the trade, resisting the notion of upskilling despite their role and responsibilities as trainers:

> you can't just jump in and tell someone they're not good enough now. We've got this new fuel coming in, you're not good enough to do it now, you need to do upskilling. There's this continual resentment within the industry about "why should I do professional development" [P13].

This participant was of the view that as a manager in an RTO:

> 'we need to convince these people that they're not tradesmen anymore, they're professional educators, that their subject matter is their trade. And that's the key, is convincing these people… the younger teachers understand that concept, that you're no longer a tradesman, you're a professional educator [P13].

This presents a challenge given the dual role that trainers play with many of those interviewed working in plumbing, training and curriculum design. For example: 'I'm a licensed plumber. I work in an RTO and I have been for quite some years, but I still do plumbing work' [P11]. While this dual role may present a challenge for creating 'professional educator' identities amongst trainers, working in industry while training is seen as an important part of maintaining 'industry currency'. For example, another interviewee commented that 'it's hard to sustain industry connectedness unless you happen to be in some way, shape or form, part of the industry. It's like someone standing on the riverbank and watching what's flowing by' [P14].

Given these challenges and considerations in training trainers, special consideration must be given to how existing trainers that will be delivering hydrogen training can be effectively upskilled to ensure that they are qualified to do so. There will likely be a role for regulators and manufacturers in providing or informing the opportunities for training the trainers in hydrogen.

7.2.4.2 Facilities and technologies for hydrogen training

In addition to ensuring staff are qualified to undertake training for hydrogen, another challenge is providing the facilities and equipment for training. Participants 16 stated that their 'biggest challenge will be to make sure that we have appropriate equipment to do the delivery.' In addition to ensuring 'training staff are suitably qualified and experienced in the space to offer that training' [P16] one interviewee indicated that facilities were an important consideration, along with teaching methodologies for hydrogen, 'we're already thinking about the design of our gas training facilities to incorporate hydrogen … about how do we re-sculpt the current facilities' [P14]. The use of technology was another aspect that was considered by this same interviewee in delivering hydrogen training. They commented that in addition to having the physical training facilities, there's also the opportunity to draw on other teaching technologies such as virtual reality to 'simulate' work practices so 'you can actually get them working on this sort of stuff [hydrogen] in a very realistic way without actually having to find a large electrolyser or equivalent bit of kit to do that training' [P14]. Part of providing technologies for hydrogen training was the ability to train students on real hydrogen appliances and therefore manufacturers play a role in providing adequate facilities and technologies to support training, for example:

> we would be doing is just ensuring that we have appliances from manufacturers that are hydrogen ready. And then, we would develop specific training around those hydrogen installations, and the appliances, so we could take the apprentices through what is needed [P16].

Access to hydrogen appliances will be an integral part of training according to the interviewees. The role manufacturers play in providing these resources will likely be key and ensuring that each RTO delivering hydrogen training has adequate access to hydrogen technology and associated information will be an important part of effective training.

7.2.4.3 Timing of training

Eighty per cent (n=6/8) of trainers expressed an urgency to immediately commence updates to training based on the length of time it takes to update a training package and for the VET sector to respond. Participant 25 described the relationship between training package review and VET sector repose as a 'hockey curve' [P25] or hockey stick type scenario where technologies quickly advance and there is a 'lag' [P11] in skills and that this may leave the VET sector 'completely unready' [P25]. One participant felt that the industry, governments and training sector had already 'missed the boat' [P13] and that there was going to be issues in meeting demand for hydrogen technologies with supply of qualified tradespeople stating that: 'We should have been training in lieu of ready for this day to come because it was always going to come' [P13]. Another participant felt that 'from an industry perspective, [RTOs] are always a little bit behind. Probably by about five years, sometimes even a little bit longer, because of how rapidly and quickly technology, and changes' [P33]. This participant under their own initiative went outside of the national curriculum to research hydrogen with the intention of ensuring students were up-date of the latest industry trends. The potential lag in skills is exacerbated due to the embryonic state of the hydrogen market and the inability to determine the competencies required as stated by Participant 11:

> I think everybody's grappling with something new and because it's new we don't have the usual things that we would have in place in preparation to train people's skills. So, we don't know what combustion appliances look like. We don't know what the standards look like. We don't know how that's going to impact on building design [P11].

Given the perceived lag in response time between training package development and the response form RTOs, it is critical that plans for hydrogen are pre-empted. The implications for gasfitting practice should be established and plans to support a timely update to the training package put in place. Concurrently, initiatives to upskill trainers, facilities and curriculum materials would also ensure there is as little lag as possible in providing training to meet the skills needs of emerging hydrogen market.

7.2.5 Apprenticeship model

A fundamental component of training for the Certificate III level qualification in plumbing, including gasfitting, is the apprenticeship. Apprentices currently only 'spend around about 18 per cent of their time' [P16] with the RTO in formal training, and the 'majority of their learning will take place on the job' [P16]. Therefore, their learning is significantly shaped by their work with their employers. As this participant reflected:

> I think we have the apprentice for about 106 days and they spend about a thousand days with their employer. So, where is the learning really happening? We can train somebody's skills against a unit-of-

> competence-requirement or outcome… But all of the skill development, it'd be unrealistic to think that they get all of that in the hundred days that they spend with us [P11].

As with the gasfitters interviewed, trainers also noted challenges in this model for training plumbers. One issue noted was the lack of mentorship from qualified plumbers, particularly with apprentices working with volume builders, for example:

> You find out with larger companies that are working on volume builder stuff you'll get a fourth year apprentice teaching a third year, teaching a second year, teaching a first year. So what you've got is you've got apprentices training apprentices, and every one of them shaves a little bit [P13].

With this model, there were implications for fully appreciating the rationale for work practices according to another interviewee:

> It's like Chinese whispers. You just have one apprentice telling another apprentice something and is that true? It may not be true, because this kid's only a kid as well. He's just learnt that and doesn't know the full impact or the regulations and standards behind what he's doing and why he's doing it. And so, he's telling this younger kid falsities a lot of the time [P34].

In addition to apprentices training apprentices, some interviewed also felt that the scope of work that apprentices are given is limited, 'they might make the apprentice just run duct under a house all day long [or] just passing sheets up all day long every day… the better guys are laying them and doing the flashing [P33]. This had implications for qualification of apprentices if they did not have a breadth of practical experience to support what they are learning in formal training with their RTO.

Another factor impacting the quality of on the job learning that trainers perceived was the skill level and experience of the employers. Some participants expressed the view that those gasfitters who were trained in gasfitting prior to 1995 by the Victorian Gas and Fuel Corporation (the government-owned supplier of household gas between 1950-1995) held a higher level of competency with regards to gasfitting knowledge and safety, than gasfitters who have been trained in the current VET based apprenticeship model. Apprentices employed by former Gas and Fuel Corporation gasfitters were therefore able to benefit from this knowledge and experience. For example:

> The key factors to success with regards to gasfitting are if an apprentice has got exposure to a plumber gasfitter that used to work for the Gas and Fuel. You generally find if you've got an apprentice that's got exposure to one of those tradesmen, their sense of understanding, their sense of knowledge, their sense of safety is that bit higher. It's still not great, but it's definitely that bit higher than if you were talking to a general plumber that may be going around putting drains and putting roof sheets on [P13]

One interview called for a review of the apprentice structure because 'the traditional methods now have got to change' this is 'because there's a lot of problems with them' [P33]. A key issue noted by this participant was the completion rate for apprentices in Victoria.

> where we take on about 2000 new apprentices every year in Victoria, but we only complete about 700, or 800. So, over that three-to-four-year period, we're losing, over a half, 60 to 70 odd percent, of apprentices that start their training. [P33]

Given that apprenticeship will be a critical part of learning that includes hydrogen for those in initial training, these challenges are of importance in supporting the successful integration of hydrogen skills amongst future gasfitters. No doubt many apprentices are successfully complete their qualification to the required standard and yet issues with the quality of supervision on the job including the skills and experiences of supervisors, the scope of work that apprentices are provided with on the job and retaining apprentices all play a key role in achieving quality learning and skills outcomes in the future domestic hydrogen industry.

7.3 Industry association perspectives

Four interviews were undertaken with professionals working in four different associations related to plumbing work. These four organisations play an influential role in advocacy work in plumbing industry and with regulators as well as provide training to their members.

7.3.1 Views on hydrogen

All four industry association participants explained that they see hydrogen is the future of gas in Australia however a range of reasons for this were provided from safety, to market opportunity, to sustainability. Participant 12 attributed this view to it being a safer alternative to natural gas because it does not come with the carbon monoxide risks that are shifting people away from using gas. They also felt that there was a market opportunity for the gasfitting industry in replacing 'x million gas appliances' [P12] with those compatible with hydrogen. Participant 03, who also works in manufacturing in addition to their role with the association, was 'excited' for hydrogen because it provides a future for gas manufacturing in Australia as it is 'essentially our solar panels' [P03]. Therefore, hydrogen was viewed as a way for the gas industry to transition to low carbon fuels as electricity is doing with solar energy. In a similar view, Participant 35 described a transition to hydrogen as being just part of a broader transition towards sustainability in plumbing, which started with water efficiency training and technologies because of the drought over a decade ago. This participant viewed hydrogen as a way of meeting energy needs in homes and industry as part of a range of low carbon energy technologies including solar, wind and batteries.

All four industry association interviewees noted that hydrogen has different properties to natural gas however did not feel this would 'be a major change in the kind of skills' [P05] found in existing gasfitting work. As participant 12 noted:

> We're used to dealing with a dangerous flammable gas, we're used to dealing with pressures… currently we deal with about five different gases now… we still don't see that this would be a whole different industry… It sits in the gas industry, it would be regulated the same way etc. [P12]

Participant 35 strongly asserted that their organisation viewed hydrogen as 'nothing new', with just a short course required to become competent in gasfitting for hydrogen. Hydrogen based gasfitting work was anticipated to be part of an additional endorsement to an existing gasfitting licence which could be obtained by those currently licensed in Type A Appliance work or Type A appliance Servicing work. Regardless, the level of training required will be informed by the level of change to the relevant Australian Standard. The point here is that gasfitters feel comfortable and industry supports working with hydrogen as a combustion fuel.

7.3.2 Fuel cells

In addition to using hydrogen as a combustion fuel that was described by all participants, two participants, one based in Victoria and one in the ACT, saw domestic hydrogen fuel cells as a significant part of a hydrogen economy in Australia. Participant 12 felt that it is assumed that hydrogen will be manufactured and supplied through the gas network however, 'technology's moved on' and what 'we're seeing at the moment around fuel cells etc means that it's quite achievable to have these localised' [P12] hydrogen production and storage units, even at a domestic scale. Participant 05, who is based in the ACT, emphasised that hydrogen fuel cells are a rapidly developing technology in Australia, and that there will be a 'neck and neck race between hydrogen combustion and stationary fuel cells for domestic and commercial purposes' [P05]. In fact, they felt that in the future, fuel cell technology would outcompete hydrogen for combustion and that gasfitting would evolve to work on fuel cells in this future scenario. Participant 05 felt that the focus on hydrogen for combustion uses was 'Victorian-centric' and that training needed to be developed that considered the potential uses across Australia. Participant 12 agreed with this idea, noting that it is no secret that it is 'hard to get a national perspective' on gasfitting practice because of the diverse environmental conditions across Australia and the different needs for energy and energy types because of these differing geographic contexts.

Both participants P05 and P12 saw that fuel cell technologies would broaden the scope of gasfitting to include electrical work and also knowledge of chemistry in an 'amalgam of trades' [P12].

7.3.3 Need for national policy and coordination across sectors

Interviewees also all noted that there was a need for national policy and coordination across sectors or governments to incentivise and guide the transition hydrogen. In the absence of such an approach, there is a pending lag in skills to meet changing demand for technologies, lost opportunities and unspent investment potential in a hydrogen industry, and potential for safety risks as technologies develop without adequate standards and skills in place. Participant 05 observed that the transition to hydrogen is coming a lot quicker than people may think, which is likely to result in a lag in skills. This lag is due to the time it takes for the training sector to respond to quickly changing markets and the number of stakeholders involved in agreeing to training needs at a national level. This issue may also be compounded by a lack of gasfitters but interviewees themselves did not

cite this as a problem. As a result of this, Participant 05 stated, ‘I think there’s going to be products launched in Australia before there’s going to be any skills that are available to work on them’ [P05].

Participant 12 commented on the lost opportunities because of a lack of coordinated action on sustainable energy. Instead of developing our clean energy industries, states have been competing over what technologies to support based on their own geographic needs. The situation we find ourselves in is that we are ‘still feeling our way with it [hydrogen]’ [P12] and ‘it’s about us paying the price for not being a lot greener earlier… the fact that we didn’t have a national view on sustainable energy. We still don’t. It’s crazy’ [P12].

Participant 35 held a similar sentiment arguing that the industry is just waiting for the right policy to begin investing ‘billions’ of dollars into developing the hydrogen economy. A lack of leadership on energy policy at a national level as well as issues with carbon trading policy in the past had impacted the innovation that could be achieved in hydrogen fuel.

A coordinated approach to the transition would ensure that standards, regulations and training are in place and well managed before hydrogen appliances enter the market. Participant 03 commented, ‘we get one chance at this. If we don’t get this right as a gas industry and there is an incident, it will be the end of hydrogen … We need to move at a good pace, so we’re not left behind. But at the same time, not overstep the mark too quickly to the point where we make a mistake and there is an unsafe situation that occurs because that will be the end of it. We’ll dig our own grave’ [P03].

Due to this complexity and lack of coordination noted by participants, Participant 12 argued that the transition to hydrogen ‘cries out for a central body’ [P12] to coordinate training, assessment, licensing and regulation, ‘whether it's an industry body that really grabs hold of it says 'this will be the epicentre for all this stuff'; or whether it's a quasi-government… body that wants to take hold of it [P12]. This participant reflected on what they saw as the benefits of having a centralised body in the transition from towns gas to natural gas:

> We had the Gas and Fuel, who not only had the full charge of gas, so they looked after the infrastructure, how it was transmitted, all the way through to how each appliance was installed and serviced. So, they had their guys under their envelope, all undertaking conversions of existing town gas appliances over to natural gas, changing the jets over and all the rest of it. We had this whole history or background of training that went on during that period and people were upskilled to be able to convert over to natural gas [P12].

The transition from towns gas is often cited as an example of how the industry can easily transition from one gas to the next, however the governance context of this historical transition was only mentioned by Participant 12.

7.3.4 Standards, appliances and training or ‘Chicken and egg’

The important role that standards play in informing training was again noted by this group of interviewees. Participant 12 noted that the traditional drivers changes to our national training package are changes to the relevant Australian standards. However, with hydrogen we are seeing a chicken and egg situation with training, standards and appliance development happening in parallel:

> The difficulty for us at the training perspective is that we still don't know what that looks like, so we still haven't got a standard. We don't even have an appliance that's been certified in Australia that could run off hydrogen. It's a chicken-and-egg thing. We don't create an appliance until we've got a supply of hydrogen and we don't have a supply of hydrogen because nobody's got appliances. [P12]

Having the right standards in place for hydrogen was ‘imperative’ for Participant 03. Based on their experience in working with appliances that are not to standard, Participant 03 explained that it is possible for appliance types to not come under a standard, however, without the standards, gasfitters will not be trained, because training is based on the standard and anything outside the standard is ‘missed out on in the training schools’ [P03]. This again underscores the need for a coordinated approach to the transition of hydrogen that ensures that standards, appliances and training are developed in unison.

7.3.5 Role of manufacturers in training

As with gasfitters and trainers, the industry association interviewees also noted a key role for manufacturers in training for hydrogen. Participant 03 explained the role of manufacturers usually play in providing training and assistance to those gasfitters working as service agents with their products. Assistance extended beyond providing telephone support to supplying the tools required to service appliances to service agents around

Australia. Unlike the RTOs, manufacturers only train to maintain, service and repair their own products or those for which they act as an Australian distributor. In fact, in the example provided by Participant 03, manufacturers will not assist gasfitters that are not trained by them to install their appliances because 'they haven't been trained and they don't know what they are doing' [P03].

Participant 03 commented that in the context of hydrogen appliances 'the manufacturers will provide the training' [P03]. However, depending on the implications of hydrogen for gasfitting work and materials, the manufacturer cannot be relied on to solely provide training. This was due to the aspects of gasfitting work that fall outside of the scope of the appliance that need to be understood first, before gasfitters undertake any training on appliances with the manufacturers. Gasfitters need training in hydrogen properties, materials and fittings and that 'needs to happen well before' [P03] they undertake training with a manufacturer. Speaking from their role in manufacturing and training, Participant 03 explained that gasfitters 'need to be trained on that [fitting appliances] well before they're installing the appliance because the pipe's already been run… before they've put the walls up' [P03].

7.3.6 Capacity of RTOs to train in hydrogen

The capacity of RTOs to delivery hydrogen training was discussed by three of the participants. These participants commented on the high demand for specialised plumbing courses, the ability for larger RTOs to deliver specialised courses and the need for access to appliances to deliver effective hydrogen training. For example, Participant 12 noted that there is huge demand for Type A service training and only one provider of this type of training that trains about 200 plumbers per year for Gas Servicing Type A. As stated earlier, the authors of this report can only establish that there is one RTO delivering this qualification at the time of writing the report. They attribute the demand for this to changes to residential tenancy regulations requiring gas heaters to be tested each year. Based on these comments, this demand provides an indication of how much a change in regulation can influence decisions to upskill and the subsequent demands placed on training providers that offer such training. Access to Type A servicing courses was noted by gasfitters interviewed and findings presented earlier.

While there are 16 RTOs that provide plumbing training in Victoria, Participant 35 argued that not all RTOs have the capacity to train for hydrogen. 'Volume trainers', they noted, in reference to the larger RTOs delivering a wide range of qualifications, are not well placed to deliver training compared to more niche RTOs that specialise in plumbing. This was due to the number of students per trainer, the contact hours they have with the trainers and also access to manufacturers and their appliances. Participant 05 noted that RTOs are going to need appliances provided to them by manufacturers in order to adequately train [P05]. Therefore, it is indicated by these interviews, that some RTOs will be better placed than others to offer training for reasons noted by Participant 35, however potential demand for hydrogen training means that more RTOs would need to be resourced to provide training to ensure this is undertaken in time to meet market demand for hydrogen appliances.

7.4 Implications for future fuels

Both the literature and interviews identified a lack of certainty of skills required for a future hydrogen economy, specifically related to gasfitting practices. However, both gasfitters and trainers felt that this presented an issue of timing and the industry's ability to respond to the transition rather than an issue for working with the gas itself. Confidence with working with hydrogen was as a result of gasfitters trust in the development of both standards and regulation of safety by ESV, coupled with their sense of responsibility when working with gaseous fuels.

All participants recognised that gasfitters, in order to ensure professional currency to remain competitive in the marketplace and ensure quality of work, would need to undertake any required additional training for working with hydrogen. However, this training would need to be specifically targeted to those undertaking the work and delivered in a variety of ways to meet differing learning preferences and time constraints. Additionally, the VET sector was seen as a suitable place for the addition of relevant competencies for hydrogen to educate apprentices and provide opportunities for licensed and registered gasfitters to gain professional currency and competencies for additional licensing requirements for hydrogen work as, and if, required by the regulator. The VBA, ESV and manufacturers were also recognised as playing a critical role to the emergent training requirements for existing practitioners. The complexity of multiple stakeholders involved in supporting ongoing learning highlights the need and importance of having a coordinated approach between information sources with the introduction of hydrogen.

The diversity of RTO organisation types and their associated competing objectives, coupled with the time duration for updated training packages to be endorsed and delivered, raised concerns from participants about the

quality of future training and the ability for it to be delivered to the industry in a timely manner. This is where manufacturers and regulators play a role in standardising the quality of delivery across the sectors, for example, all RTOs being able to access emerging technologies for training purposes and also to upskill trainers in hydrogen. Some RTO's are better placed than others in regard to access to resources to deliver hydrogen training. As described in Section 4.3, PICAC are already planning for provision of initial and ongoing gasfitter training for hydrogen and collaborative work is underway between Deakin's Hycel Pilot Project in Warrnambool and SouthWest TAFE. These RTOs are at an advantage with funding to provide dedicated hydrogen training and industry connections to support such training delivery.

Participants identified that regulation of practice failed to adequately capture non-compliant work due to poor practice and lack of skills and that this situation could be exacerbated when transitioning to hydrogen fuel. This is important for ongoing learning because regulatory oversight was identified as key to maintaining skills amongst gasfitters. Ensuring that there is adequate oversight is therefore essential to ensuring work practice currency in an emerging market. As is the case with trainers, regulators would also need to be to be trained in these new skills. Non-compliant work regularly identified could then inform future professional development. Regulation through auditing was identified as an opportunity to leverage further education and training and refine existing training programs.

It is important to note that the data presented in Chapter 7 is based on in-depth qualitative interviews with a sample of stakeholders from industry and the VET sector. Because the intention of qualitative research is to gain an in-depth understanding of a phenomenon and identify lived experiences and perspectives, the data cannot be used to make generalisations to a larger population (Dworkin, 2012). Therefore, it is important to note that while there is significant value in understanding the perspectives of the stakeholder groups interviewed, individual perspectives reported here are influenced by a range of factors and experiences and further research would be required to determine if such views are found in the broader population.

8 Implications for training and upskilling for Future Fuels in Victoria

The whole hydrogen phenomenon represents new territory for Australian policy makers and challenges the Australian policy architecture. At a practical industry level, incorporating hydrogen is essentially a matter of providing for its regulatory definitions and scopes of works, and adding new training units to the existing Construction, Plumbing and Services Training Package. From a broader community acceptance perspective, hydrogen might be seen more as an entirely new energy source. Hydrogen is a new substance to most practitioners and the public. Its properties and behaviour in different conditions and settings is not well understood at a practitioner, consumer or policy maker level. Building confidence in hydrogen within the gasfitting practitioner cohort through training and upskilling will help alleviate perceptions around risk and help build community confidence and acceptance of hydrogen by ensuring those working with hydrogen are competent to do so and also through gasfitters' role in providing advice and support to their customers.

The recently released Victorian Renewable Hydrogen Industry Development Plan is clear that the intent of the State Government is for domestic gas networks to have a pathway to renewable hydrogen (Victorian Government, 2021c). Gasfitters who work on domestic gas infrastructure will clearly have a role in this, but details are as yet uncertain. Some uncertainties are technical and significant new knowledge is being developed in this area (not least by FFCRC) to understand and document exactly how gasfitting work practices would need to change on a day to day basis in a hydrogen economy.

The greater uncertainty is in the way in which the domestic market for hydrogen will develop. Differing scenarios have significantly differing implications for training, registration and licensing of gasfitters. This includes both the changes to existing skills required and the level of resources needed.

Based on the literature reviewed and interviews with stakeholders familiar with trials underway and/or work on hydrogen standards, we can begin to construct a picture of potential end uses of hydrogen in Victorian homes and the associated implications for gasfitting work. As was found amongst interviewees, the pace of development of training for gasfitters which will be required to deliver the necessary skills in an emergent hydrogen market is being set by uncertainties in the hydrogen economy overall.

The structure of the existing system for managing competency of gas fitters provides some advantages in ensuring a competent workforce for the hydrogen economy. Having said that, there are a number of challenges in the existing system that may be exacerbated by the introduction of a major change. These include challenges with initial training, licensing and ongoing learning through practice in Victoria, as summarised in Table 15.

Table 15 Advantages and challenges within the current training and professional practice framework for updating training requirements and upskilling practitioners

Leaning stage	Advantages	Challenges for hydrogen transition
Initial training	• National training packages. • Work commenced on updating training package.	• Partial understanding of skills needs for hydrogen and associated changes in practices with no existing industry practice/experience to inform skills needs. • Time associated with updating and delivering updates to the Construction, Plumbing and Services Training Package in the past. The addition of hydrogen to the training package is classified as a 'complex project'. • Individual RTOs responsible for up-skilling trainers who in turn are also responsible for designing curriculum that reflects the identified competences in the training package. • Readiness of RTOs to deliver hydrogen training including upskilled trainers and facilities. • Providing on the job experience for apprentices in hydrogen when the market is yet to be established.

		• Ensuring those supervising apprentices working with hydrogen have the requisite competency to do so.
Registration and Licensing	• Registration and licensing requirements align with national units of competency and can be updated to include any future hydrogen competencies as needed.	• Variation in registration and licensing requirements between states and territories. Depending on the structure of the hydrogen-based units of competency, these may not be required for licensing/registration.
Ongoing practice	• Australian Standards used in each state. • Building Act 1993 amendments to allow CPD requirements in plumbing regulations. • Ability for regulators to make new hydrogen competencies a requirement for licensing/registration for those undertaking such work.	• Ongoing training is voluntary which has implications for updating gasfitters on hydrogen transitions and associated requirements. • Limited research on plumbing practice and professional learning to ground best practice training delivery for hydrogen, as required.

It is apparent from the desktop review and interviews undertaken that training of gasfitters in Victoria is informed by a complex mix of national and state actors from the training sector, industry, government and state regulators of gas, gasfitting and training. Recent updates to the Construction, Plumbing and Services Training Package and professional development for carbon monoxide testing, have all responded to existing industry challenges and changes. In the case of hydrogen, the skills required and the market need are evolving in parallel with updates to the training itself. Developing initial and ongoing training for hydrogen, therefore, differs significantly from the usual factors that prompt professional development sessions or updates to National Training packages. A number of participants used the 'chicken and egg' metaphor to describe the current situation where training is dependent on standards, which are dependent on technologies, which are dependent on markets, which are dependent on training, and so on. In the context of training, the VET sector in Australia is designed to respond to market and industry needs, which presents a key challenge in the undefined hydrogen market. All interviewees from all stakeholder groups indicated a lack of clarity about what the hydrogen market would look like in the domestic sector and what would be the exact implications for hydrogen work. Actions required to ensure sufficient competent gasfitters are available to support the sector cannot be clearly defined until the sector itself develops a clearer forward plan. This is constrained by other factors and yet unless some broad parameters can be established, lack of trade resources may become a significant limiting factor in the development of a hydrogen economy going forward.

A key issue raised by many interviewees was the lack of leadership, planning and coordination at a macro level to encourage the development of the hydrogen industry including the investment, and training that interviewees indicated was waiting for policy direction. Such coordination appears essential given the different climate and energy use needs across Australia and the implications this has for how hydrogen might be used in homes. These geographic differences influence skills required to perform gasfitting work which then informs registration and licensing requirements in each state, including Victoria. Therefore, in the context of formal training through RTOs and the National Training Package, Victoria is very much reliant and a part of a larger nationwide discussion on what hydrogen end use applications are and what gasfitting skills will be required. Once these are decided upon at a national level and developed into units of competency, then Victorian regulators, the VBA and ESV, can determine what units of competency will be required for registration and licensing for gasfitting work with hydrogen. As a result, meeting skills needs for the transition to hydrogen would benefit significantly from national leadership and coordination. As shown in this report, there are several components of hydrogen industry development for which the Federal Government is responsible and are necessary to inform skills requirements and training at a state level including National Training Package(s), National Standards development, and also product certification schemes. Progress is being made in all three of these areas, as well as a state level, however there is no one national body or agency taking a holistic or overarching role, or coordinating the various initiatives, trials, reviews, and projects being progressed around the country. An existing national group such as the Gas Technical Regulators Committee, could assist in driving national consistency and supporting coordination between initiatives and stakeholders.

Given the level of uncertainty in the future hydrogen industry, this report presents three potential end use scenarios with differing implications for training of gasfitters, noting that the scenarios are not necessarily

mutually exclusive. The three scenarios are: hydrogen enrichment of up to 10 per cent hydrogen in the gas networks, the supply of 100 per cent hydrogen in existing gas networks and the use of home fuel cells. Each scenario will require different types of training (both content and structure) due to the different implications for practice and associated learning needed. The associated implications for training for each of these scenarios are shown in Table 16.

Table 16: Implications training for different hydrogen end use scenarios

Scenario 1: ***Up to10 per cent hydrogen blend with natural gas***	Based on education research, increasing knowledge of hydrogen properties can be achieved through a transmissive training approach such as an information session, video, short online course or other materials that can be studied by gasfitters to achieve the required knowledge outcomes.
Scenario 2: ***100 per cent reticulated hydrogen***	In the 100 per cent hydrogen scenario, hydrogen would need to be included in initial gasfitter training and also in upskilling training for gasfitters that will be working with hydrogen fuel. Depending on the approach taken to the hydrogen roll out, some gasfitters who wish to undertake hydrogen gasfitting work may complete additional training. If 100 per cent hydrogen was supplied in all existing gas network to homes for domestic end uses, then all gasfitters would need to undertake training to expand their knowledge of hydrogen properties and the skills needed to safely work with hydrogen and hydrogen appliances and/or undertake appliance conversion work, if and where, this is needed. This raises the question of the number of existing gasfitters currently in Victoria and the number of Victorian homes that would require appliance upgrades or conversion in the 100 per cent hydrogen scenario. As stated in Section 6.2.1, by 2030, between 2 and 2.5 million homes in Victoria are likely to be connected to gas and currently there are 20,262 gasfitter plumbers which includes 8,8676 plumbers licensed and 11,586 plumbers registered in gasfitting work. Depending on the hydrogen roll out, some or all of these gasfitters would need to be competent in working with 100 per cent hydrogen.
Scenario 3: ***Fuel cells***	Based on the interviews and desktop review, those undertaking work with residential electrolysers/fuel cells will need specific training in areas traditionally outside of gasfitting units of competency. As a fuel cell is an appliance which is installed in a home and under the current market based approach, would be the choice of the home owner to install or the housing developer, it is not necessary for all gasfitters to be trained in such work, however upskilling is likely required for existing gasfitters who wish to undertake work with fuel cells.

Each of these training options is dependent on other aspects of hydrogen industry development outside the training sector. Table 17 outlines the potential training options available, what type of learning outcomes can be achieved through each of these and the conditions on which these options depend.

Table 17 Learning opportunities available

Potential implementation	Learning outcome	Conditions for implementation
Information via updates, guides and online videos regarding any changes to standards and licensing/registration requirements. **Massive Open Online Courses (MOOCs)**	Provide information about hydrogen properties, career opportunities and technological changes and innovations.	Pending a better understanding of the implications of hydrogen on appliances and end uses gained from testing of appliances and installations.
Hydrogen units added and amendments made to include hydrogen in the National Training Package	Initial training in Certificate III and upskilling (via RTO training) if hydrogen gasfitting were to be a class or additional endorsement of a plumbing licence. Formal training and upskilling can develop in depth knowledge and skills for working with hydrogen.	Pending standards updates, testing of appliances and installations and updates to National Training Package and implementation by RTOs, and updates to licensing and registration requirements.
Training from appliance manufacturers and distributers	Provide opportunities for training on hydrogen appliances to develop in depth knowledge and skills for working with specific hydrogen appliances.	Pending Standards updates, testing of appliances and installations and hydrogen appliance development.
Hydrogen pilot projects as training facilities	Opportunities to demonstrate hydrogen installations to schools and other interested professionals to gain better understanding of hydrogen technology and associated installation and maintenance considerations.	Accessible hydrogen trial projects.
Professional development sessions run by associations and government	Webinars or face-to-face training on particular aspects of working hydrogen to build general knowledge and skills.	Pending Standards updates, testing of appliances and installations and hydrogen appliance development.

Based on the desktop review and interviews, the approaches to training and upskilling listed in Table 17 are already provided by industry and government with the aim to ensure gasfitters are qualified and maintain their industry currency. At this stage, hydrogen pilot projects can provide a source of learning through demonstration and information about what we know about hydrogen and potential uses can be shared through updates, guides and online videos or MOOCs. Beyond this, further development of the hydrogen industry is needed including updated standards, appliance and installation testing, and appliance development will be needed to inform these forms of training. For training through RTOs, updates to the National Training Package will also be required. The interview data has shown that all the approaches to training in Table 17 are currently undertaken by RTOs, industry and government regulators and are of value to gasfitters, although individual preferences for training might vary. There are cost considerations with regards to training delivery, but it is beyond the scope of this study to address this.

While these options support initial training and upskilling for hydrogen, looking ahead, regulators and manufacturers will likely play a key role in ensuring the quality of gasfitting work including hydrogen. Based on the desktop review and interview data, this will likely be done through regulatory oversight and auditing of work

undertaken by the governing body, professional development programs to keep gasfitters skills and knowledge current, and training and information about appliances provided by the manufacturers to those working on them. All these sources of ongoing learning ensure that gasfitters remain informed, can learn from errors through effective regulatory oversight and can gain important information about appliances and changes in technologies form the manufacturers and regulators. The interviews show that all these sources of knowledge are important for informing gasfitters learning on the job and support quality of work and safety outcomes. Existing issues and gaps noted by interviewees, and the literature, will need to be addressed to ensure this framework effectively supports good gasfitting practices for hydrogen.

Given these unique circumstances and the public safety perception risks attached to hydrogen energy, there is a discussion to be had, about whether a higher bar needs to be set – and be seen to be set - for hydrogen training and qualification. Adopting an "abundance of caution" approach sends strong messages to the public that the industry "has got this", and that industry and government have considered all the safety issues and put in place mitigation strategies (training and licensing). Potentially, settings could be adjusted over time, as training needs become more refined and focussed, and as practitioner and public levels of comfort with hydrogen increase.

8.1 Summary of findings and implications

With the context described above in mind, this report has focused on understanding the existing frameworks for initial training and ongoing learning for Type A gasfitting in the State of Victoria and implications for supporting training and upskilling of gasfitters to be competent in working with future fuels. Table 18 provides a summary of key considerations raised in this report and their potential implications for supporting gasfitting competency when working with hydrogen fuel and appliances. Given that this is the first of three reports as part of this project, these implications provide the basis for further exploration in the later stages of the project. The next step will determine if similar or different considerations exist in South Australia. This will be followed by an investigation into competence development frameworks used in other trades, particularly during technology transitions. Drawing on the cumulative research findings, the project will present recommendations and principles in a final report due to be completed in November 2022.

Table 18 Summary of key considerations and potential implications

Consideration	Relevant Scenario*	Implications
Hydrogen standard development and appliance trials	2,3	Understanding implications of hydrogen on gasfitting work and the development of the national hydrogen standard will be essential for informing the Construction, Plumbing and Services Training Package update and licensing and registration requirements. This work is already being undertaken by Standards Australia's ME-093: Hydrogen Technologies committee. Hydrogen trials underway will also inform skills needs and hydrogen standards.
Updating and delivering the revised national training package	2, 3	Given that the inclusion of hydrogen into the Construction, Plumbing and Services Training Package is classified as a 'complex project', coordination of stakeholders is important to support the update and ensure training package delivery aligns with the establishment of the hydrogen market.
	2, 3	Initiatives such as PICAC's Centre for Excellence and Deakin University's Hycel Hydrogen hub, who are working on future hydrogen awareness and training initiatives, can provide insight and guidance on potential hydrogen training delivery while the National Training Package is being developed.
	2, 3	Preparing the VET sector for hydrogen training is critical but ultimately will be market driven. Preparedness can be assisted by establishing hydrogen training hubs for VET trainers, regulators and associations to gain knowledge of hydrogen appliances and skills as they emerge through trial projects and standards development. Such

		initiatives could be supported by the Department of Education and Training's Clean Economy Workforce Skills Initiative. Funded hydrogen training initiatives including PICAC's Centre for Excellence and Deakin University's Hycel Hydrogen hub could provide industry led hydrogen training to support upskilling of VET trainers more broadly.
Gasfitters competency to work with 100 per cent hydrogen or fuel cells and supervise apprentices	2, 3	Gaining a better understanding of the work involved in appliance change over, conversion (and fuel cells as relevant) and estimating the market requirement for gasfitters to undertake such work will provide the foundation to identify the competency and associated training requirements for existing gasfitters.
	2, 3	Ensuring that upskilling for hydrogen and verification of competency is a licensing and registration requirement for those who will be working with hydrogen and hydrogen appliances is critical. Taking an 'abundance of caution' approach for ensuring those working with hydrogen have the requisite training and qualifications to ensure competency will support a safe and successful transition to hydrogen.
	2,3	Those currently undertaking gasfitting work and gas servicing work without the required licensing or registration endorsement may be 'out of sight' yet these workers will still require upskilling so as to safely undertake hydrogen work.
Multiple situations and knowledge sources from which gasfitters learn	1,2,3	Given that gasfitters gain their knowledge and skills from a wide range of sources, coordinating and utilising each of these sources in the delivery of hydrogen information and training, as relevant to desired learning outcomes, means that gasfitters will most effectively receive the necessary information.
Defining a fuel cell practitioner	3	A better understanding of the work involved in fuel cells (involving both traditional gas fitting and electrical trades tasks) and competency requirements for practitioners to undertake such work is needed if fuel cell technologies become available for domestic uses. It is possible that there is justification for a new trade – a fuel cell practitioner.
Regulatory oversight	2,3	Effective regulatory oversight of gasfitting work including compliance and enforcement strategies will be advantageous for a safe and successful fuel transition. With effective regulatory oversight strategies, areas of non-compliance in hydrogen work can be used to also inform ongoing learning initiatives by various stakeholders such as regulators, industry associations and manufacturers.

*Scenarios as described in Table 16: Scenario 1: Up to 10 per cent hydrogen blend with natural gas; Scenario 2: 100 per cent reticulated hydrogen; Scenario 3: Fuel cells

9 Next steps and future work

This is the first report produced from the project RP2.3-04 Gasfitting practices for future fuels: Opportunities for training and upskilling in Victoria and South Australia.

Effort will now focus on the South Australian system for gasfitter training with a desktop review and further interviews. Following this, later stages of the project will investigate competence development frameworks used in other trades, particularly during technology transitions with a view to establishing a best practice model. Drawing on the cumulative findings, recommendations and principles will be developed for a final report in late 2022.

10 Appendices

10.1 Interview questions

Background:

- Could you start by telling us a little about your current role and prior experience?
- [if relevant] Can you describe the hydrogen related projects that you are involved with broadly? Or if not involved with any specific projects, are you involved in any hydrogen research, discussions or projects, and if so how?

For those involved in hydrogen projects:

- In your view, what are some differences between natural gas and hydrogen fuel that will need to be considered in the transition to future fuels for domestic use?
- What are some considerations or challenges for hydrogen in end-use appliances, such as domestic installations?
- Does this differ with blends of hydrogen and 100 per cent hydrogen?
- [if relevant] What are the implications for gasfitting work with different blends of hydrogen?

For gasfitters:

- As practices and products evolve, where do you acquire your professional knowledge?
- How much of your professional practice today is informed by your initial training and how much has been acquired through your professional experience?
- Do you feel you learn from your work, if so how/ in what ways?
- Do you undertake any continuing professional development as a gasfitter? If so, why?
- What challenges do you foresee, or that you may have experienced, for you personally and professionally, in undertaking continuing professional development?
- Are there any challenges that you see currently facing the industry?
- There are plans and trials underway to inject hydrogen into Australia's gas distribution systems. A blend of 10 or 15% or hydrogen with natural gas is said to not affect appliances, however higher blends of hydrogen in natural gas will require changes to Type A appliances and associated practices. Are you aware of these plans?
- What are your views on injecting hydrogen into the existing gas distribution network for residential use?
- What are your views on how this may affect gasfitting practices?
- Do you think you will need to upskill and what is your view on doing any further training?
- Do you anticipate any challenges in accommodating a transition away from natural gas to hydrogen in your gasfitting practice?
- Do you anticipate any challenges in accommodating a transition away from natural gas to hydrogen in your clients?
- Do you feel there is currently enough support systems in place to assist you in continuing your professional practice with a change from natural gas to hydrogen in domestic appliances? If not, what would be needed, if so, how are you currently supported?
- Do you have, or have you had, any apprentices? If so, what do you see your role as encompassing when working with apprentices?

For training organisations/trainers:

- Could you walk us through the processes or stages for training plumber gasfitters in Victoria?
- How much learning occurs in the classroom compared with on the job for apprentice training?
- Could you please walk us through how changes to the plumbing curriculum are made? i.e. if there is a new technology or skill that is identified for gasfitting work or change to standards?
- In your experience, are there any challenges within the current system for RTOs and trainers to support good learning outcomes for gasfitters?
- Are you aware of plans to transition to hydrogen in the residential sector?
    - If so, do you foresee any additional skills needs and or changes to current training frameworks?
    - If not, go to next question
- How do you see the current training system for gasfitters working with the introduction of a new fuel such as hydrogen?
- What aspects of managing the change would be the responsibility of the RTO?
- If Australia decides to switch to 100% hydrogen tomorrow, what would be the timeframe for RTOs and trainers to be adequately prepared to deliver training for any new skills and what you need to support you to undertake this?
- Are there any challenges, that you can think of, in training gasfitters for a new fuel such as hydrogen and associated technologies?

- Do you feel the training sector adequately positioned and resourced to support any additional training needs of gasfitters to accommodate hydrogen? Why/why not?
- Do you see a role for RTOs in professional development or upskilling of existing gasfitters?

10.2 Gasfitting units of competency for licensing and registration

According to the VBA:

> To be eligible to register in the Gasfitting class, you must be able to show:
>
> - you have the relevant competencies **plus** recent and relevant experience in work related to the gasfitting class of plumbing, **or**
> - you have knowledge equal to the competencies of Certificate III for Gasfitting work, **plus** at least four years of experience while working under the supervision of a plumber who is licensed in Gasfitting work.
>
> You must also prove you successfully completed an accredited training course in Install Trench Support (VBA, 2021a).

According to the VBA, there are eight units of competency that must be completed to gain registration in Victoria for all classes of plumbing (except for Refrigerated Air-conditioning and Type B Gasfitting), These are:

- Carry out interactive workplace communication (CPCPCM2039A)
- Read plans and calculate plumbing quantities (CPCPCM2040A)
- Work effectively in the plumbing and services sector (CPCPCM2041A)
- Carry out WHS requirements (CPCPCM2043A)
- Handle and store plumbing materials (CPCPCM2045A)
- Use plumbing hand and power tools (CPCPCM2046A)
- Carry out levelling (CPCPCM2047A)
- Provide basic emergency life support (HLTFA211AP)

For licensing, the eight units above are required along with three additional units:

- Establish legal and risk management requirements of small business (BSBSMB401A)
- Carry out work based risk control processes (CPCPCM4011A)
- Estimate and cost work (CPCPCM4012A)

In addition, 23 units must be completed specifically for registration in the gasfitting Type A class of plumbing. One additional unit of competency in addition to the 23 gasfitting special class units must be completed in order to gain licensing in the gasfitting Type A class of plumbing. These units of competency are shown in **Error! R eference source not found.**.

Table 19 Class specific unit of competency requirements for gasfitting Type A in Victoria

Class specific unit of competency required in Victoria	Registration/Licensing
Work safely on roofs (CPCPCM2055A)	Registration
Carry out simple concreting and rendering (CPCPCM2054A)	Registration
Flash penetrations through roofs and walls (CPCPCM3021A)	Registration
Cut and join sheet metal (CPCPCM2048A)	Registration
Mark out materials (CPCPCM2050A)	Registration
Weld using oxy-acetylene equipment (CPCPCM2052A)	Registration
Cut with Oxy-LPG / Acetylene equipment (CPCPCM2049A)	Registration
Fabricate and install non-ferrous pressure piping (CPCPCM3023A)	Registration

Install trench support (RIICCM210A)	Registration
Install LPG systems in caravans, mobile homes and mobile workplaces (CPCPGS3046A)	Registration
Install LPG systems in marine craft (CPCPGS3047A)	Registration
Install gas pressure control equipment (CPCPGS3048A)	Registration
Install Type A appliance flues (CPCPGS3049A)	Registration
Install Type B gas appliance flues (CPCPGS3050A)	Registration
Purge consumer piping (CPCPGS3051A)	Registration
Maintain Type A gas appliances (CPCPGS3052A)	Registration
Disconnect and reconnect Type A gas appliances (CPCPGS3053A)	Registration
Calculate and install natural ventilation for Type A gas appliances (CPCPGS3054A)	Registration
Install gas piping systems (CPCPGS3056A)	Registration
Size consumer gas piping systems (CPCPGS3057A)	Registration
Install LPG storage of aggregate storage capacity up to 500 litres (CPCPGS3059A)	Registration
Install LPG storage of aggregate storage capacity exceeding 500 litres and less than 8 KL (CPCPGS3060A)	Registration
Install and commission Type A gas appliances (CPCPGS3061A)	Registration
Design and size consumer gas installations (CPCPGS4011C)	Licensing

Additional competencies are required for registration or licensing in specialised classes of plumbing work which include Type A Appliance Servicing and Type A Appliance Conversion (VBA, 2021b). These requirements have recently been updated. For registration in Type A Appliance Servicing or Type A Appliance Conversion there is one additional competency:

- CPCPGS4022 Service Type A gas appliances

For licensing in Type A Appliance Servicing or Type A Appliance Conversion there are five additional competencies:

- BSBESB402 Establish legal and risk management requirements of new business ventures
- CPCCBC4012 Read and interpret plans and specifications
- CPCPCM4011 Carry out work-based risk control processes
- CPCPCM4012 Estimate and cost work
- CPCPCM4015 Access and interpret regulatory requirements for the plumbing and services industry

Prior to 2021, no additional units of competency were required for registration in Type A Appliance Conversion work, and only BSBESB402, CPCPCM4011 and CPCPCM4012 were required for licensing in Type A Appliance Conversion work. Registration in Type A Appliance Servicing work had the same requirements previously, while licensing in Type A Appliance Servicing required completion of BSBESB402, CPCPCM4011 and CPCPCM4012 and CPCPGS402 (VBA, 2018).

10.3 Plumbing Industry Commission Victoria - Principles and goals to inform CPD

Goals:	A CPD program should ensure that plumbers keep up to date with changing technology and regulatory requirements as they naturally evolve in a dynamic industry. Acknowledging the pace of change and dynamic nature of the plumbing industry, an effective CPD program should improve the skills, knowledge and standards of the profession – maintaining the status quo is not sufficient and will not protect the community health which is an enduring responsibility of plumbers as a licensed trade.

Principle:	A Plumbing CPD program should cover all registered and licensed plumbers who practice in Victoria along with those directly involved in oversighting and teaching the technical and regulatory aspects of the trade (i.e. inspectors, auditors and plumbing teachers).
Principle:	General categories for CPD should reflect technical and non-technical skills to form a balanced approach that meet the individual needs of plumbers and industry needs as identified by the regulator.
Principle:	CPD point requirements for plumbers registered in one category of plumbing should be less than the requirement for plumbing practitioners with more than one category of registration. However, the number of points that are required by a plumber registered in a single category of plumbing should reflect the deeper knowledge required.
Principle:	A CPD program for plumbers will need a well known simple source of listed CPD activities that is accessible to all plumbing practitioners to easily locate relevant activities.
Principle:	Critical to the success of a plumbing CPD program will be the development of sufficiently large array of specific and practical CPD activities to meet the practitioner demand for relevant activities which are useful to their personal situation. Many challenges become lessened if the CPD activity is seen as relevant and beneficial to a plumber's working environment.
Framework:	A voluntary CPD program should be implemented with a clear intent of progressing into a mandatory CPD program within the next five years. The ultimate deciding factor on this transition will be the measured outcomes of the program against the goals of the CPD program.
Principle:	The PIC has broad industry support to administer the Victorian Plumbing CPD program. Whilst the policy development and administrative management of the program will reside with the PIC, the success of the program will require a strong engagement with the wider plumbing industry.

(Walker and Powers, 2010: xi)

10.4 Hy4Heat Units of Hydrogen Competency

Hydrogen Core Competencies (Units of Competency)	Hours	Performance Criteria	Knowledge and Understanding criteria
Safety, Legislation and Standards	1	None	In relation to working on hydrogen gas installations the learner will need to demonstrate knowledge and understanding of the following aspects, as they apply to the range of both domestic and non-domestic installations and appliances: • K1 Application of the Gas Safety Installation and Use Regulations. (H/2 Section 3.2). • K2 Specific requirements relating to hydrogen installations and appliances. (H/2 Section 8). • K3 Safety precautions when other hazardous materials are encountered whilst working on hydrogen installations. (H/2 Section 4). • K4 The learner responsibilities regarding health, safety, and the environment. (H/2 Section 4). • K5 Use of personal protective equipment. (H/2 Section 4). • K6 New Standards, Engineering Instructions and/or Codes of Practice relating specifically to hydrogen installations and applications (H/2 all Sections). • K7 Risk assessment methodology as applied to the suitability of existing installation

			pipework and Equipment (H/2 Section 5). • K8 Record keeping and filing of risk assessment, as necessary (H/2 Section 4.1). • K9 Suitable, approved and prohibited materials for use with hydrogen installations and appliances (H/2 Section 7).
Products and Characteristics of Hydrogen Combustion	3	In relation to complete combustion, the learner will need to be able to: • State significant behavioural differences of hydrogen compared with hydrocarbon gases (H/2 all Sections). • P2 Identify correct flame performance (H/2 Sections 8.1.3, 8.1.4). • P3 Analyse products of combustion for correct oxygen content (H/2 Sections 8.1.3, 10.4.6). • P4 Identify false positives and early warning devices of a hydrogen gas escape (H/2 Section 3.2). In relation to approved gas detectors and indicators, the learner will need to be able to: • P5 Identify and operate approved gas detectors for use with hydrogen. (H/2 Section 3.2). In relation to combustion performance analysis, the learner will need to be able to: • P6 Undertake combustion performance analysis on a hydrogen appliance. (H/2 Section 8.1.3).	In relation to complete and incomplete combustion, the learner will need to know and understand: • K1 Combustion equations relating to hydrogen. • K2 Oxygen requirements for complete combustion. In relation to combustion performance analysis, the learner will need to know and understand: • K3 Actions to take when undertaking combustion performance analysis. (H/2 Section 8.1.3). In relation to combustion and its controls, the learner will need to know and understand: • K4 Why hydrogen is not subject to incomplete combustion. • K5 Products and characteristics of combustion. • K6 Ignition temperature and flammable range. • K7 How to use a gas analyser to measure oxygen content. • K8 Flame picture, flame lift and light back. • K9 Burner types. • K10 Gas controls. • K11 Fault diagnosis • K12 Safety devices • K13 Condensate requirements • K14 CO Alarm false positive alarms on hydrogen gas escapes
Ventilation for Hydrogen Gas Burning Appliances	1	In relation to providing ventilation for domestic gas burning appliances, the learner will need to be able to: (H/2 Section 8.1.2) • P1 Explain procedures for the control of moisture from hydrogen appliances • P2 Identify correct and incorrect ventilation provision. • P3 State the importance of, and requirements for compartment ventilation	In relation to providing ventilation for domestic gas burning appliances, the learner will need to know and understand: (H/2 Section 8.1.2) • K1 Factors affecting ventilation. • K2 Design and types of ventilation provision. • K3 Calculating ventilation requirements for hydrogen installations. • K4 Ventilation labels and notices. • K5 Air supply requirements for cooling and combustion. • K6 Mechanical ventilation and extraction. • K7 Design and materials. • K8 Free area and position. • K9 Route and configuration.

			• K10 Maintenance.
Installation of Pipework and Fittings	1	None	*In relation to the installation of domestic pipework and fittings, the learner will need to know and understand:* • K1 Factors to consider when installing gas installation pipework for use with hydrogen. • K2 Copper and mild steel pipe and fittings standards, suitability, and use. • K3 Approved Jointing and cleaning agents for jointing copper and threaded pipework fittings. • K4 Restrictions on use of union and compression fittings. • K5 Pipe sizing for hydrogen installations.
Tightness Testing and Purging	3	*In relation to testing and purging domestic hydrogen gas installations, the learner will need to be able to:* • P1 Test low-pressure Hydrogen gas installations for tightness using gas. • P2 Purge low-pressure hydrogen gas installations. • P3 Trace and repair a downstream hydrogen gas escape.	*In relation to testing and purging domestic natural gas installations, the learner will need to know and understand:* • K1 Define operating pressures for hydrogen installations • K2 Types of pressure gauge and perceptible movement. • K3 Application of permissible pressure loss. • K4 Dealing with let by. • K5 Actions to take when a smell of gas persists after a satisfactory test or after the ECV has been turned off. • K6 Calculating installation and purge volumes • K7 Potential need for inert purging of existing installations • K8 Testing pipework of diameter > 35 mm or total IV > 0.035 m^3. • K9 Testing before working on an installation.
Metering Installations	1	*In relation to checking and/or setting meter regulators on natural gas installations, the learner will need to be able to:* • P1 Check that the meter fitted is for use with hydrogen • P2 Check that the hydrogen meter is correctly located, installed, and labelled • P3 Measure and record the installation standing pressure. • P4 Measure and record the installation working pressure. • P5 Determine if the installation working pressure is correct or incorrect. • P6 State the actions to take if the working pressure is incorrect. • P7 Test and adjust the operation of Excess Flow Valves as necessary	*In relation to checking and/or setting meter regulators on hydrogen gas installations, the learner will need to know and understand:* • K1 The correct types of meter approved for use with hydrogen. • K2 The need for, and purpose of an Excess Flow Valve on a hydrogen installation. • K3 Meter box and enclosures approved for use with hydrogen meters. • K4 Safety notices and labels. • K5 Location criteria for hydrogen meter installations. • K6 Meter installation, exchange, and removal of hydrogen meters. • K7 Operation of Smart Meter excess flow valve.

Unsafe Situations, Emergency Notices and Warning Labels	1	*In relation to unsafe situations, emergency notices and warning labels, the learner will need to be able to:* • P1 Identify and classify different categories of unsafe situations. • P2 Demonstrate the procedure to follow for each classification of unsafe situation. • P3 Complete, explain and issue appropriate warning/advisory labels and notices.	*In relation to unsafe situations, emergency notices and warning labels, the learner will need to know and understand:* • K1 IGEM/G/11 - Gas Industry Unsafe Situation Procedure (GIUSR). • K2 Situations reportable under RIDDOR. • K3 Situations reportable to Gas Safe Register and/or HSE which are not RIDDOR reportable. • K4 Correct use of notices and labels.
Checking and Setting Hydrogen Appliance Burner Pressures and Gas Rates	2	*In relation to checking and setting hydrogen appliance burner pressures and gas rates, the learner will need to be able to:* • P1 Measure an appliance operating pressure. • P2 Measure an appliance gas rate.	*In relation to checking and setting appliance burner pressures and gas rates, the learner will need to know and understand:* • K1 Requirements for range rated appliances. • K2 Requirements for variable-rated appliances • K3 Causes and effects of pressure loss. • K4 Use of electronic pressure gauge.
Operation and Checking of Hydrogen Appliance Gas Safety Devices and Controls	2	*In relation to gas safety devices and controls the learner will need to be able to:* • P1 Identify hydrogen gas specific safety devices and controls. • P2 Check gas safety devices and controls for correct operation and carry out any corrective action where necessary. • P3 Explain the operation of gas safety devices and controls.	*In relation to gas safety devices and controls the learner will need to know and understand:* • K1 The principles of operation of hydrogen gas safety devices and controls. • K2 The sequence of operation of hydrogen gas safety devices and controls.
Chimney and Condensate Installation, Inspection and Testing	2	*In relation to chimney testing the learner will need to be able to:* • P1 Visually inspect chimney systems to confirm correct and incorrect installation. • P2 Perform a spillage test on a hydrogen appliance connected to an open flue system. • P3 Carry out a Flue Flow Test • P4 Perform a combustion case seal test on a room sealed fan assisted positive pressure appliance.	*In relation to chimney installation inspection and testing the learner will need to know and understand:* • K1 Causes of leakage of combustion products from room sealed positive combustion chamber pressure appliances. • K2 Condensate management and discharge to waste • K3 Condensate production from hydrogen appliances • K4 How and where condensate may be discharged • K5 Actions to take when inspection hatches are not available for flues in voids.
Re-establish Existing Gas Supply and Re-light Appliances	2	*In relation to re-establishing an existing hydrogen gas supply and re-lighting the appliances, the learner will need to be able to:* • P1 Check the installation is gas tight. • P2 Purge the installation and appliances of air.	*In relation to re-establishing an existing hydrogen gas supply and re-lighting the appliances, the learner will need to know and understand:* • K1 Actions to take when an un-commissioned appliance is identified. • K2 Actions to take if pipework and appliance(s) are not tested

		• P3 Establish a stable flame on each appliance. • P4 Check operation of any Flame Failure Device (FFD). • P5 Visually inspect each appliance for unsafe situations. • P6 Confirm satisfactory operation of user controls.	(commissioned) when the gas supply is re-established.
Commissioning of Appliances	1	*With reference to the range of domestic or non-domestic appliances, some of which may have specialist requirements, the learner will need to be able to:* • P1 Demonstrate the ability to commission a hydrogen appliance in accordance with Manufacturer's Instructions.	*In relation to appliance commissioning, the learner will need to know and understand:* • K1 Specific commissioning requirements of hydrogen appliances • K2 Operational checks and procedures required prior to handover • K3 Sources of additional information or support for hydrogen installations • K4 Essential information on hydrogen usage to communicate with the end user
Handover and Customer Engagement	1	*On completion and commissioning of a hydrogen appliance and installation, ready for handover to a consumer, the learner will need to be able to:* • P1 Handover the appliance to the end user, explaining appliance operation in accordance with manufacturer's instructions. (H/2 Sections 4.1, 8.1.3). • P2 Explain and demonstrate specific new features of hydrogen appliances (H/2 Sections 4.1, 8.1.3).	*To complete a successful handover procedure, the learner will need to know and understand:* • K1 Background to hydrogen transition. • K1 Development, research and testing to confirm safety of hydrogen as an alternative to natural gas. • K3 Benefits to consumers of hydrogen as a fuel.
Service and Maintenance	1	*Notwithstanding differences between types of domestic and non-domestic appliances, the learner will need to be able to:* • P1 Demonstrate the ability to adjust appliance components as necessary to manufacturer's instructions. • P2 Recommission hydrogen appliances to full working operation.	*In relation to the maintenance of appliances, the learner will need to know and understand:* • K1 Specific maintenance and servicing requirements of hydrogen appliances. • K2 Operational maintenance procedures. • K3 Appliance performance checks to be carried out following maintenance work. • K4 Combustion products checks and analysis. • K5 Interpretation of data resulting from combustion product analysis.
Gas Emergency Actions and Procedures	1	*None*	*In relation to emergency actions, the learner will need to know and understand:* • K1 Properties and characteristics of Hydrogen gas. • K2 Priorities and actions when dealing with hydrogen gas escapes and incidents.

Dealing with Reported Gas Escapes	2	*All engineers carrying out work on hydrogen installations must have the capability to act appropriately in the event of a potential reported, or actual leakage of hydrogen from the installation.* *Performance Criteria (H/2 Sections 4.1, 9.2, 9.3, 10.4.6)* • P1 Carry out immediate steps to make the installation safe • P2 Complete tightness testing in accordance with hydrogen specific procedures • P3 Initiate appropriate actions dependent upon tightness test outcome • P4 Demonstrate correct use of appropriate gas detection equipment	*To deal effectively with reported hydrogen gas escapes, the learner will need to know and understand:* • K1 Hydrogen Installation Emergency Procedures • K2 Evacuation criteria and procedures • K3 Essential communication with customer(s) • K4 Sources of support and additional resources if required • K5 Effective liaison with Network Distribution personnel assisting in detection and repair • K6 Communication with third parties such as emergency services

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