
CHAPTER 7

SKILLS

REQUIREMENT

7.1 INTRODUCTION AND METHODOLOGY

The greater diffusion of hydrogen and hydrogen-related technologies within the energy system will be dependent on an appropriate skills base within the work force. This chapter explores the potential skills requirement of a future hydrogen scenario, considering the extent to which existing skills may be of relevance to hydrogen and hydrogen-related technologies, and the extent to which new skills may be required.

The primary focus of this chapter is to consider the various skill requirements that would be called upon under a near-term Hydrogen HFC Market scenario, as described and discussed in previous chapters of this White Paper. However we also consider what could be the requirements of a longer-term scenario with a more ubiquitous use of hydrogen as an energy vector. For this we draw on the “Full Contribution” Scenario described by Hart et al.⁵⁵

The near-term Hydrogen HFC Market scenario ‘focusses mainly on the replacement of petrol and diesel in cars with hydrogen, with some attention to the manufacture and uptake of hydrogen-ready cars’ (this report, Section 3.1). This could involve requirements for skills upgrades in a range of areas. As well as vehicle manufacturing, it would also seem likely that a scenario with any significant use of hydrogen would also require some UK-based hydrogen production facilities, for example from electrolysis, biomass-based or fossil fuel-based production. However, it is also possible that the UK could import its hydrogen from a bulk producer in another country, in liquefied form. A scenario with significant penetration of hydrogen vehicles would also require skilled workers in the areas of hydrogen vehicle maintenance and repair.

The extent to which the scenario would require skills in the handling, transmission and distribution of hydrogen, in liquid or gaseous states, could vary depending on the specifics of the scenario. Significant amounts of new hydrogen infrastructure and hydrogen handling could be avoided in a distributed electrolysis-based scenario, which relied on the existing electricity grid to enable production of hydrogen more or less at the point of delivery. Alternatively in a scenario with more large-scale centralised production of hydrogen, the requirement for skills in the construction of transmission and distribution pipelines, and in the handling of hydrogen in various states, potentially including in liquefied form, would be significant. The operation and maintenance of hydrogen refuelling stations would also require different skills to the operation of conventional refuelling stations.

In addition to the above, Hart et al.’s ‘Full Contribution’ scenario envisages the use of hydrogen as a heating and cooking fuel in buildings. This would require further extension of distribution networks, companies that can produce hydrogen compatible domestic appliances, and a cohort of gas maintenance engineers qualified to work with hydrogen and hydrogen-related appliances.

⁵⁵ Hart D, Howes J, Lehner F, Dodds PE, Hughes N, Fais B, Sabio N, Crowther M. Scenarios for deployment of hydrogen in contributing to meeting carbon budgets and the 2050 target. London, UK: Committee on Climate Change; 2015. Available at: www.theccc.org.uk/wp-content/uploads/2015/11/E4tech-for-CCC-Scenarios-for-deployment-of-hydrogen-in-contributing-to-meeting-carbon-budgets.pdf.

As shown in modelling results from Chapters 6–10, hydrogen supply chains will also involve a lot of service sector activity. As discussed in Section 4.3.2, and shown in Figures 4.1 and 4.2, the impact of a shift to a hydrogen economy could be widespread, including on sectors such as administrative and support services, agriculture and food, and electricity, gas, water and waste. However, expansions of employment in sectors such as these would largely draw on existing skills, and as such would present no major challenge in terms of a skills gap. The focus of this chapter is on those skills areas for which there is a greater possibility of a skills gap, due to the fact that the areas do not constitute established economic activities at the present time. Thus we focus in this chapter on the hydrogen-specific skills areas summarised in the previous paragraphs of this section.

In the following sections we consider in some more detail the skills requirements in each of these areas. In each case we consider the applicability of existing skills to the new hydrogen-related activities, to what extent hydrogen-related activities might require skills upgrades, and how demanding or complex such skills upgrades might be. The main research method for this chapter is literature review from both academic and grey literature sources. The availability of applicable data within these literatures is therefore a key constraint on this analysis. Supplementary insight is also provided by reporting on personal communications with actors in relevant industrial sectors. Section 7.2 considers the automotive sector, Section 7.3 considers hydrogen production, Section 7.4 considers hydrogen transmission, distribution and refuelling infrastructure, and Section 7.5 considers hydrogen in buildings – not part of the near-term Hydrogen HFC Market scenario, but potentially part of a “full contribution” scenario. Section 7.6 then considers overall skills gaps and priorities, and finally Section 7.7 draws conclusions.

7.2 AUTOMOTIVE SECTOR

Across the automotive sector, some skills will need updating in the case of a hydrogen transition, though many would not change, or would evolve more incrementally. A study of skills for green jobs in the UK notes that ‘across the automotive sector, skilled employees including managers, professionals, supervisors, technicians, craftspersons, operators and assemblers account for 68% of the total workforce’. Because of anticipated future technological changes to motor vehicles, ‘occupations such as repair technicians will therefore need to update their skills’. However, ‘other skills such as welding car bodies, can be transferred from manufacturing of traditional (diesel/petrol) automotives to the manufacturing of low carbon vehicles’.⁵⁶ Similarly, considering jobs and skills impacts more specifically of hydrogen technologies, the US DOE notes that, ‘some tasks within the automotive sectors will remain the same, such as tasks involved in producing and assembling certain automotive parts, e.g. automobile wheels. But new skills will be required in other tasks, such as producing and installing fuel cells new powertrains and other associated equipment’.⁵⁷

56 CEDEFOP. Skills for green jobs. Country report: United Kingdom. European Centre for the Development of Vocational Training; 2010. Available at: www.ilo.org/global/publications/lang-en/index.htm.

57 US DOE. Effects of a transition to a hydrogen economy on employment in the United States. Report to Congress. USA: Department of Energy; 2008.

7.2.1 Automotive manufacturing

(Note – US DOE reference – quotes refer to this reference unless otherwise stated)

White-collar workers, including ‘engineers, engineering managers, drafters, and engineering technicians’, are a key component of automotive manufacturing. The DOE conducted interviews with industry, and report that most interviewees ‘believed that the current set of engineering skills used for conventional internal combustion engine vehicles will likely change significantly... mechanical engineering skills will focus less on purely mechanical functions and more on developing electro-mechanical systems’, although ‘non-propulsion-related systems such as heating and cooling systems will likely employ the same mechanical engineering skills that are in use today’.

However, changes in engineering skills will be **‘evolutionary rather than revolutionary’**, e.g. ‘introductions of the front-wheel drive system and various fuel injection systems, and the use of different on-board computer systems. In all of these cases, the automotive industry will rely upon internal re-training and on-the-job experience, as well as changes in curricula at universities and community colleges to support the turnover in new skills’. Further, because of work on hybrid electric vehicles, ‘there are already a significant number of engineers with either educational backgrounds or on-the-job experience’ in relevant system aspects. ‘New elements required in a fuel cell vehicle system include the fuel stack and some attendant sensing and control systems. But a great many system requirements are already present in conventional and hybrid vehicle systems’.

There is a possibility of short run problems with skills availability of high skilled graduate and post-graduate engineers if there is a particularly rapid expansion of hydrogen technologies in early years. Undergraduate engineering programmes are liable to adapt as industrial needs evolve. Evolution would incorporate hydrogen and fuel cell technology elements specifically – but equally would be losing some of the older elements which are becoming redundant. ‘It takes approximately 4 to 8 years for engineers to complete professional education, including undergraduate and graduate schools’. Hence there is some risk of some shortage of graduate level engineers if there was a rapid initial hydrogen market expansion. That said, as ‘the absolute number of engineers in these industries is small’, this is liable to present itself as a short term problem only. Note also that provision can be made for retraining of existing graduate and postgraduate qualified staff which can be relatively fast and would not involve the full 4–8 year period mentioned.

‘Blue collar workers’ are defined by DOE as including ‘manufacturing employees, construction employees, automotive service and repair technicians, service station attendants, and hydrogen fuel deliverers. Blue collar workers obtain training from vocational and technical schools where necessary’.

The DOE report that ‘computer literacy skills, knowledge of electrical systems, and the ability to use computerized diagnostic equipment will be particularly important for assembly skills in the future. Machining skills related to internal combustion

engine construction are not likely to be needed, as fuel cell stacks require little to no machining and are unlikely to be manufactured by the automobile companies themselves. Skills related to assembly of electro-mechanical systems and computer hardware would be in greater need. The balance of components required to complete the fuel cell system requires skills for assembly similar to those for a traditional gasoline engine’.

Assemblers and machine operators may be affected by changing production lines. ‘Laborers may need safety training for working with hydrogen pipelines, while plumbers, pipe fitters and welders may need training on new piping specifications and safety requirements’.

However, ‘as with engineering skill development, interviewees believed that training will be *evolutionary rather than revolutionary*’, and can be delivered through training courses and on-the-job training. Further, ‘the development of hybrid vehicles has provided an environment for the development of new manufacturing skills’. Re-training for manufacturing and construction workers may also be achieved through ‘on-the-job training sponsored by employers’.

In the UK context, graduate and post graduate level skills can be expected to develop in the same manner as the above US model and there are no obvious factors which might contest that view. In the case of UK ‘Blue collar workers’, formal craft level training generally comprises of NVQ/SVQ modules at appropriate levels to the apprenticeships or national awards being sought. Apprentice specific college provision is usually developed by colleges, qualifying authorities and industry working in concert. This is a good basis from which it can be expected that appropriate existing modules and new modules will develop. As per the US view, evolution rather than revolution is a predictable model of adaptation in the UK.

In factories owned by automotive companies which begin to produce hydrogen vehicles, internal retraining is simply necessary and will include apprenticeships. Examples of such programmes can already be seen in the case of electric vehicles. For example,⁵⁸ in preparation for producing a new electric vehicle, the French car producer Heuliez established a training plan to upgrade skills in electricity competencies of staff at its Poitou Charentes plant (p. 73 and 304). While Nissan was planning the creation of its battery manufacturing plant in Sunderland, it was reportedly expecting that the skills for its technician level jobs – representing just under half of total jobs at the plant – were to be acquired through apprenticeship schemes mostly funded by the state (p. 73).

From a manufacturing perspective, the greatest changes would come from the fuel cell stack and the hydrogen storage tank. Automotive manufacturers would need either to form partnerships with OEMs specialising in such components, or

58 Strietska-Ilina O, Hofmann C, Durán Haro M, Jeon S. Skills for green jobs: a global view: synthesis report based on 21 country studies. Geneva: International Labour Office, Skills and Employability Department, Job Creation and Enterprise Development Department; 2011.

to develop the expertise in-house. In one example, the fuel cell stacks for Toyota's Mirai FCV are assembled 'in-house'.⁵⁹

7.2.2 Automotive servicing and repair

For vehicle service and repair, 'the most significant skill set change will be in troubleshooting, repair, and service of propulsion systems... technicians will have to become more competent in computer and electrical system maintenance. However modularization of key components such as batteries, fuel cell stacks, and power converters, may reduce the amount of re-training needed. Similar to production, hybrid vehicle maintenance will provide a means of developing new repair and maintenance skills'. However safety training will be required because of the 'use of hydrogen and high-voltage electrical systems'.

Training and re-training implications are different for those specialising in mechanical elements like suspension and brake systems and those specialising in electric drive train and HFC technology. Depending on the role, re-training may range from 'as little as basic safety training to very specialized automotive technician training'. Workers of this kind are also more widely geographically distributed – in contrast to automotive manufacturing workers, who would be typically be clustered in large plants owned and operated by automotive manufacturing companies, servicing and repair technicians are typically spread through numerous small businesses.

In the UK context we can expect college provision located adjacent to automotive manufacturing to offer more specialised training options tuned to that local commercial activity, whilst other colleges offer more general options. It is important to observe that many UK technicians undertake both general college training and bespoke manufacturer specific training via the franchise dealer system. There is no reason to imagine that this form of twinned public and commercial training model will not continue as is.

There are a variety of different ways in which such training or re-training may be achieved. The US model is not very different to that employed in the UK and serves conveniently to illustrate the pattern.

Automotive service technicians and mechanics 'receive training at vocational and technical schools, and most take standard certification tests in order to be qualified to work on vehicles'. Automotive vocational and technical training based on ICEs is available at approximately 2,100 schools across the US, typically taking 1 to 2 years to complete. For hydrogen, initial training and re-training will be needed. For the years in which both technologies overlap, both conventional and electric-drive train teaching will be required. There may be some need for additional tutors and facilities (or facility modifications) to deal with overlap but the net increase in tutoring personnel and capital resource requirements are probably quite small. Conventional facilities are subject to periodic renewal in any case and local demand can be expected to lead local investment decisions.

⁵⁹ Hunt, J. *Toyota and the Hydrogen Society. The Commercialisation of Hydrogen and Fuel Cell Technology*. Birmingham, UK; 2016. Available at: www.climate-change-solutions.co.uk/wp-content/uploads/2016/03/JonHunt.pdf.

There are already some indications of how such training could be delivered. In California, the College of the Desert runs an ‘Advanced Transportation Technologies’ degree, and an ‘Automotive Alternate Fuels Certificate of Achievement’, which include a module on ‘hybrid, fuel cell and electric technology’.⁶⁰ The National Alternative Fuel Training Consortium, at the University of West Virginia, offers a 2 day course, “An overview of alternative fuel and advanced technology vehicles”;⁶¹ and a 4 hour workshop on hydrogen as a vehicle fuel, including fuel composition and safety requirements.⁶²

Indications of possible means of delivering training on technical aspects of alternative vehicles can also be gleaned from current approaches to delivering training on electric vehicles. For example, in the UK, the Institute of the Motor Industry (IMI) offers a qualification in ‘hybrid electric vehicle repair and replacement’,⁶³ as well as an accreditation of electric vehicle maintenance and repair.⁶⁴

IMI offer a number of courses within the category “Technical – hybrid and electric vehicles”⁶⁵ (p. 90–101). These range from 2–8 hour introductory courses, to more technical 1–2-day courses dealing with maintenance and repair of hybrid and electric vehicles, and replacement of high voltage components, which enable participants to gain IMI accreditation in the relevant areas. The IMI’s 2016/17 Professional Development Course Guide does not include a specific course on hydrogen and fuel cell vehicles, although their introductory course on “Electric Vehicle Batteries” also offers to provide ‘an understanding of fuel cells, super-capacitors and flywheels when used with hybrid vehicles as a form of energy storage’. Clearly an expansion of the learning programme in the areas of hydrogen and fuel cell technologies would be an important part of supporting the technician and vehicle servicing sectors in any hydrogen transition. However the UK institutions exist to do this, and it would be a case of building on existing programmes rather than starting from scratch. Further, if the training offered by IMI on electric vehicles can be taken as any kind of guide, it seems likely that a mechanic qualified to work on conventional vehicles could achieve proficiency for hydrogen vehicles by attending targeted technical training of the order of a few days.

Such training and accreditation developments would also need to be supported by regulations which require mechanics to be qualified and accredited in order to work

60 College of the Desert. 2016/17 Catalog – Programs of Study – Advanced Transportation Technologies. Accessed: 27th January. Palm Desert, CA: College of the Desert; 2016. Available at: <http://catalog.collegeofthedesert.edu/programs/advanced-transportation-technologies/> – coursestext.

61 NAFTC. Clean air and energy independence: an overview of alternative fuel and advanced technology vehicles. Accessed: 27th January. West Virginia University, USA: National Alternative Fuels Training Consortium; 2017. Available at: http://naftccourses.wvu.edu/?page_id=31.

62 NAFTC. Petroleum reduction technologies: hydrogen fleet applications. Accessed: 27th January. West Virginia University, USA: National Alternative Fuels Training Consortium; 2017. Available at: http://naftccourses.wvu.edu/?page_id=381.

63 IMI. L3 award in hybrid electric vehicle repair and replacement. Accessed: 25th January. Brickendon, UK: Institute of the Motor Industry; 2017. Available at: <http://awarding.theimi.org.uk/Qualifications/L3-Award-in-Hybrid-Electric-Vehicle-Repair-and-Replacement>.

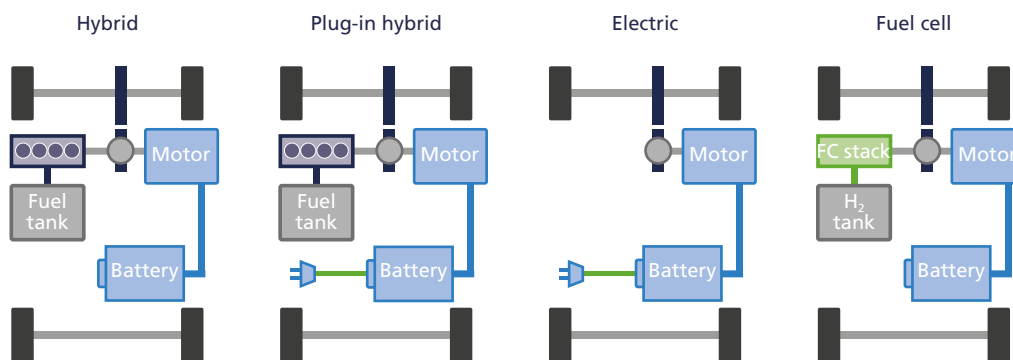
64 IMI. IMI accreditation electric vehicle. Accessed: 25th January. Brickendon, UK: Institute of the Motor Industry; 2017. Available at: <http://accreditation.theimi.org.uk/electric-vehicle-route>.

65 IMI. IMI Professional Development Course Guide. Brickendon, UK: Institute of the Motor Industry; 2016. Available at: www.theimi.org.uk/sites/default/files/documents/177830_3.pdf.

on hydrogen vehicles. The IMI has already called for such regulation to prevent unqualified mechanics servicing electric vehicles.⁶⁶

The idea that the growing experience with and training around the maintenance of EVs, could make the step up to FCVs less daunting, is also given weight by Toyota's reports of progress developing their Mirai FCV. Figure 7.1 schematically illustrates how the layout of their FCV compares to previous EV and hybrid designs. In this figure, Toyota are suggesting that the FCV design is a relatively incremental step from previous vehicle designs, being 'nestled in our hybrid DNA'.⁶⁷ The Figure indicates that much of the FCV's drive train and architecture would be employing components familiar from the EV and hybrid designs.

Figure 7.1 Schematic comparing designs of Toyota's hybrid, plug-in hybrid, electric and fuel cell vehicle designs. Source: Toyota.⁶⁸



Toyota also suggest that because the fuel cell stack has no moving parts, it will experience 'no wear', will require 'virtually no maintenance' and indeed 'will last longer than the life of the car'.⁶⁹ If this is the case, it would help to confirm the idea that this part of the system would require little if any attention from a mechanic, thereby meaning that the maintenance requirements of an FCV would not differ substantially from those of an EV.

However, a note of caution was sounded by one UK hydrogen industry actor, who made a general observation that 'hydrogen needs to be understood as a completely different gas to natural gas', and that it was at the present time 'difficult to imagine a back-yard MOT guy checking over a hydrogen vehicle'.⁷⁰ Although the specific

66 Johnston I. Electric cars: Mechanics with no specialist training 'risk death when tinkering with the vehicles'. Independent. London 16th January 2016. Available at: www.independent.co.uk/life-style/motoring/motoring-news/electric-cars-mechanics-with-no-specialist-training-risk-death-when-tinkering-with-the-vehicles-a6816786.html.

67 Hunt, J. Toyota and the Hydrogen Society. The Commercialisation of Hydrogen and Fuel Cell Technology. Birmingham, UK; 2016. Available at: www.climate-change-solutions.co.uk/wp-content/uploads/2016/03/JonHunt.pdf.

68 Hunt, J. Toyota and the Hydrogen Society. The Commercialisation of Hydrogen and Fuel Cell Technology. Birmingham, UK; 2016. Available at: www.climate-change-solutions.co.uk/wp-content/uploads/2016/03/JonHunt.pdf.

69 Hunt, J. Powering the future with H2. Energy 2016. Birmingham, UK; 2016. Available at: www.climate-change-solutions.co.uk/wp-content/uploads/2016/10/ToyotaEnergy-hub.pdf.

70 Newborough, M. ITM Power. Personal communication, 1st February 2017.

maintenance requirements of the fuel cell stack, and potentially the hydrogen storage tanks as well, might be limited, with any occasional problems requiring recall to the manufacturer rather than routine servicing by mechanics, nonetheless it should be recalled that the presence of hydrogen vehicles in maintenance situations would require mechanics to have at the very least training in hydrogen safety and the location of the hydrogen specific components within the vehicle architecture.

7.3 HYDROGEN PRODUCTION

7.3.1 SMR and fossil fuels

The technology used in producing hydrogen from fossil fuels is not uncommon in the UK. All refineries employ steam methane reforming (SMR) as a key element of extracting the maximum value from their crude oil feedstock. SMR technology is also found across a range of chemical process industries, while the oil and gas sector itself often deals with hydrogen. As a result of these activities, there has long since been a UK need to train pipefitters, safety operatives and other trades working in these sectors to safely handle and deal with hydrogen. Historically the need was even greater when around half of the UK's town gas was hydrogen. The UK has a strong trades' skills basis on which to build a more substantial production and use of hydrogen sector.

Existing training takes the form of mixed college and in-house employer training during apprenticeships mainly. With hydrogen almost certain to be a more geographically distributed economic activity than the industries referred to above, it can safely be predicted that more people will need to be trained in these skills and trades, but the UK competence base on which to do that already exists. As per the automotive examples, some evolution in NVQ/SVQ modules will be required, but these are continually reviewed and updated in any case.

Again with hydrogen liable to become more widespread and presenting somewhat different potential hazards to natural gas, there is obvious wisdom in developing appropriate NVQ hydrogen safety modules, not just for those trades working directly with hydrogen but also suitable other trades liable to encounter it.

7.3.2 Electrolysis

Currently, there are relatively few large scale electrolyzers in the UK – if we define large scale as 1MW+ input capacity – but a number of electrolyzers of around that 1MW capacity have emerged in relation to HFC demonstration projects in recent years. On the face of it SMR/fossil derived hydrogen is much cheaper than using an electricity energy input basis, but that tends to ignore constrained renewables generation capacity which is available in significant volumes in some parts of the UK, and the value in absorbing conventional excess capacity for grid balancing purposes. These sources currently represent potentially very low cost electricity, which might otherwise go unused, and which instead could be used to produce value in the form of hydrogen. Evidently renewables- and nuclear electrolysis-derived hydrogen presents a virtually carbon free means of decarbonising transport in particular. It is also worth noting that there are areas of the UK without access to mains gas, but virtually none without access to either national grid or locally produced and

networked electricity. The *prima facie* cost differential between renewables/nuclear- and SMR-derived hydrogen is likely to narrow markedly when CCS costs are factored into SMR production.

In regards to electrolysis-related skills directly, the skills involved in the electricity generation sector, and in particular renewables and nuclear components of those come to the fore, but these can be regarded as service/supply chain. More specifically the proliferation of electrolysis facilities in areas which can make best advantage of them will require both manufacturing and service skill sets. It is likely that manufacturers will be able to undertake in-house training at that level of requirement from a basis of regular manufacturing and engineering skills relatively common in electrical/electronic-related manufacturing. Wider UK service skills can readily derive from a similar more generic skills basis. As per automotive, the formal/public training provision is likely to take the form of generic NVQ modules with again, hydrogen safety being an underpinning element.

7.3.3 Summary of hydrogen production

There are clear existing skills bases from which hydrogen production could be scaled if demand was clear and growing. However, rather than being a highly distributed challenge of training up thousands of engineers across the country, a scale up in hydrogen production is likely to be led by companies with existing related specialist expertise, developing and training engineers internally. Formal/public provision is liable to take the form of NVQ modules with a focus on safety in particular.

7.4 HYDROGEN TRANSMISSION, DISTRIBUTION AND REFUELLING INFRASTRUCTURE

The extent to which a dedicated transmission and distribution infrastructure of pipes capable of carrying hydrogen would be needed, depends both on the extent and distribution of hydrogen demand, and the methods with which it was produced. In a scenario in which hydrogen demand was primarily at refuelling stations for vehicles, hydrogen could be produced from distributed electrolysers at the refuelling stations, avoiding the need for any hydrogen pipeline infrastructure. On the other hand, a hydrogen scenario with either alternative methods of production that are inherently large-scale and cannot be easily distributed, or with a more ubiquitous demand for hydrogen including as a cooking and heating fuel in buildings, would require consideration of hydrogen transmission and distribution.

Hydrogen can cause embrittlement and failure of iron-derived piping, however the UK gas network has been undertaking an Iron Mains Replacement Programme (IMRP)⁷¹ since 2002, which aims to upgrade the majority of the existing gas distribution pipes from iron to polyethylene, for health and safety reasons. The dense polythene piping is also suitable for the transmission of hydrogen. This opens the potential for the repurposing of existing network infrastructure, but also means that the skills set required for laying a hydrogen network already exists. Hydrogen

71 www.hse.gov.uk/gas/supply/mainsreplacement/index.htm.

transmission pipelines can already be found on many refinery and chemical process sectors facilities.

The transportation of gases and chemicals, including liquefied natural gas (LNG) in tankers and tube-trailers is also a well-established industrial system. As with all of the areas discussed in this chapter, some retraining to ensure awareness of the different properties of hydrogen would be necessary, but these are likely to be relatively modular upgrades to knowledge, rather than the type of retraining associated with an entire career change.

On the other hand, while specific training upgrade needs for individuals already working in comparable industries may be modest, as with other areas considered in this chapter, the overall roll-out of such training upgrades if required to cover a large number of workers over a relatively short time period in the case of rapid a hydrogen transition scenario, could be a logistical challenge, or hold up the progress of such a scenario if not well-planned. As observed by one UK hydrogen industry actor, ‘the hydrogen grid changes everything by orders of magnitude... you’re then running a gas industry’.⁷²

DOE note that training will also be needed for service station operatives and truck drivers who deliver hydrogen. The formal/public component of that falls into the same type of NVQ arrangements described above, with a focus on operative and customer safety. The UK regulatory regime for vehicles currently carrying bulk liquid fuels and other hazardous materials, including hydrogen, is already well established and those operating/active within this transport sector already deliver qualifying training for those involved.

7.5 HYDROGEN IN BUILDINGS – GAS ENGINEERS AND TECHNICIANS

In addition to using hydrogen as a vehicle fuel, Hart et al⁷³ describe a ‘full contribution’ scenario, in which hydrogen also becomes used extensively in buildings for CHP and other applications. The main additional skill area would need to be achieved by gas engineers repairing and replacing hydrogen gas components in buildings. In a similar manner to the issue of vehicle technicians and mechanics, a potential challenge here is the large number of gas engineers throughout the country, offering a potential risk of lagging the transition if it proceeded very quickly in the early years. In a parallel manner to the IMI, the role of the Institution of Gas Engineers and Managers (IGEM) could be crucial in ensuring the availability of training and accreditation programmes. Regulation would also need to be adapted to ensure that hydrogen systems can only be worked on by qualified hydrogen gas engineers.

If a particularly rapid transition to widespread use of hydrogen in buildings was being contemplated, a more nationally coordinated approach to the mass re-training of existing qualified gas engineers might be required. Here a relevant analogy is

⁷² Newborough, M. ITM Power. Personal communication, 1st February 2017.

⁷³ Hart D, Howes J, Lehner F, Dodds PE, Hughes N, Fais B, Sabio N, Crowther M. Scenarios for deployment of hydrogen in contributing to meeting carbon budgets and the 2050 target. London, UK: Committee on Climate Change; 2015. Available at: www.theccc.org.uk/wp-content/uploads/2015/11/E4tech-for-CCC-Scenarios-for-deployment-of-hydrogen-in-contributing-to-meeting-carbon-budgets.pdf.

offered by the GB transition from town gas to natural gas. At this time the Gas Council coordinated training programmes, which were organised by the Area Boards or by private contractors.⁷⁴ This would be more of an organisational coordination challenge, then a major technical barrier. However, the availability of a mass cohort of such re-trained engineers would be vital to a smooth “switchover” programme.

The development of appropriate health and safety regulation, as well as linked training and accreditation, would be crucial to support and protect manufacturers and technicians, as well as consumers and building occupants.

7.6 SKILLS GAPS AND PRIORITIES

The previous sections have reviewed the skills categories deemed to be required for the near term HFC Market scenario, and additionally for a more comprehensive ‘full contribution scenario’. These sections have considered in each area, the closest related skills that we have in sectors that currently exist; the gap between these skills and the skills required for hydrogen scenarios; the adjustments to training programmes, and other regulatory arrangements that would be required; and any lead time issues concerned with having a cohort of hydrogen-skilled workers in each area on a timeframe that does not lag the desired speed of the transition.

The key issues are summarised in the table opposite.

At present it seems that the retraining of individuals with experience in parallel industries for the handling of hydrogen is highly achievable on a case by case basis, perhaps through short courses or in-house training of manufacturers and other large employers. The challenge potentially arises if there is a wish to provide such retraining to large numbers of people very quickly. However, such a programme could be made smoother if there was a general increase in awareness of hydrogen and increase in hydrogen-related modules within relevant engineering and technical courses. As one participant noted, ‘we also need the educational sector to get to grips with hydrogen and put it in their courses. It is not necessarily an urgent issue now, but it will be five years from now, and more after that. This applies to technician courses, as well as to undergraduate gas engineering courses, which would produce the people designing the future systems.’ If hydrogen was deployed at scale, ‘there would need to be proper training at technical colleges, with additional modules. Hydrogen would need to be properly integrated into initial training, making technicians able to work with hydrogen, not just natural gas. There would probably also need to be short courses available for mid-career technicians’.⁷⁵

74 Arapostathis S, Carlsson-Hyslop A, Pearson PJG, Thornton J, Gradillas M, Laczay S, Wallis S. Governing transitions: Cases and insights from two periods in the history of the UK gas industry. *Energy Policy*. 2013;52:25–44.

75 Newborough, M. ITM Power. Personal communication, 1st February 2017.

Hydrogen component	Associated actors and organisations	Existing relevant skill base	Required new skills	Actions needed to roll out new skills	Lead-time of skills roll out
Vehicle manufacture	Automotive manufacturers and their employees	Conventional manufacturing Existing experience with EVs	Some additional electronic components and integration of fuel cell stack within BOP	Internal retraining and apprenticeships. Formal development of college NVQ/SVQ provision	Development of modules for under- and post-graduates and for professional re-training. In-house commercial (re-) training
Vehicle servicing and repair	Existing largely independent service sector The IMI	Conventional vehicles skills base. Growing knowledge of EVs	Some additional electronic components and integration of fuel cell stack within BOP Hydrogen safety awareness	Regulation, training schemes and accreditation need to be developed and made available, through colleges and the IMI	Mechanics can add hydrogen skills with on the job training, as is currently the case with EV qualifications
SMR and fossil fuels production	O&G, Refinery and chemical process sector RSC, IChemEng, IMechE <i>et sim</i>	O&G, Refinery and chemical process sector	None	–	–
Electrolysis	Electrolyser companies	Electrolyser companies Gas/elec service sectors	Service sector awareness, retraining	In-house commercial training Formal college NVQ/SVQ	Short
Transmission and distribution	Existing Utilities and subcontractors Ofgem, HSE, trade bodies etc.	Widespread	None	–	–

7.7 CONCLUSION

This chapter has considered the potential skills requirements of future hydrogen scenarios, in comparison to existing UK skills bases.

Across all of the areas considered we find evidence that workers looking to upgrade their skills to be able to work with hydrogen would not be starting from scratch. Existing skills within industries that involve the handling of gaseous fuels, as well as the manufacture and repair of vehicles, particularly hybrid and electric vehicles, already provide important and highly relevant skills bases for working with hydrogen and hydrogen technologies.

From this perspective, in most cases we find that the hydrogen skills need may be more a case of a modular ‘upgrade’ than of a complete reorientation. However there are some notes of caution to sound. Even if for any individual worker the skills upgrade need may be a relatively modest and achievable commitment, achieving the same thing for thousands of workers over a short space of time, as might be required if a very rapid transition was planned, would at the very least be a logistical challenge. In the case of a rapid transition, the skills roll out might need to be delivered in the form of a planned, national programme. The historical example of the transition from town gas to natural gas offers evidence of how this can be achieved. Alternatively, the way in which regulation, training and accreditation has kept pace with electric vehicle deployment, gives an example of a slower, more gradual and responsive market-led transition.

Further, although hydrogen is, in some senses, ‘just another gaseous fuel’, it also has different qualities which affect the way it is handled, and these need to be understood by everyone that comes into contact with the fuel or a related technology. Safety standards and regulation, and availability of training and accreditation programmes are crucial to protect not only public consumers, but also the independent and semi-independent workers such as gas technicians and vehicle mechanics, who will be required to engage with hydrogen and its related technologies.

In summary our key recommendations are:

- Work with FE and HE colleges to ensure their engineering and technical courses are gradually expanding to include hydrogen and fuel cell aspects.
- Work with bodies such as IMI, IGEM⁷⁶ and other equivalents, to ensure that their courses are gradually expanding to include hydrogen and fuel cell aspects, and that their accreditations are expanding in this way too, in a way that keeps pace with the development of any planned roadmap.
- Gradually develop legislation to ensure that as hydrogen products and appliances reach the market the legislation is up to date to ensure that anyone who carries out repairs on it is obliged to have achieved the abovementioned accreditation (and same for gas and other applications).
- Work with apprenticeship schemes to ensure they are adapting to potentially new areas of hydrogen related work, such as in fuel cell manufacture, electrolysis

⁷⁶ www.igem.org.uk.

Although for any individual worker, the skills gap may not be huge, it is still one that must be crossed before they can work with hydrogen. Thus if a rapid transition is envisaged, a coordinated skills rollout programme could be required, to ensure that enough workers are able to achieve the necessary skills upgrade in the right timeframe.