VDE/DVGW Discussion Paper

Discussion Paper – Hydrogen (re)skilling

The ramp-up of the hydrogen market means that skilled workers are needed now

Skills shortages are neither new nor limited to specific sectors. However, if they are compounded by technological change, there is a risk that the new requirements could give rise to major capacity bottlenecks and knowledge gaps. When niche technologies become widely used, new skills and (possibly also) new job specialisations are needed. In some cases these could potentially have a disruptive effect on existing occupations, or at least require them to be reconsidered. The integration of hydrogen into our existing infrastructure systems is now triggering such a chain reaction. Furthermore, the worsening problem of climate change is also increasing the pressure, and the self-imposed climate targets are creating their own time frames. This discussion paper provides an initial overview of the skills sets required by the hydrogen sector and raises important questions with the aim of sensitising educational institutions to the complexities of the topic.

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Abstract

While the plans for hydrogen demand and production projects are increasing every day, the need for expertise is becoming more important. It is more urgent to implement the “Energiewende” than ever before.
The role of hydrogen in this transition is important because of its great potential for reducing emissions in many sectors. Within eight years, it is planned to meet strict emission reduction goals in all sectors, yet there is still a distinct lack of the experts needed to meet these targets. The shortage of skilled labour has long been a challenge in many fields. Remedying the shortage of skilled labour in areas vital to the energy transition is crucial if we are to fulfil the climate goals within the remaining years. In the context of the hydrogen roll-out, the precise extent of the required re-skilling is not known yet.
This article shall provide an overview of the different fields of education and training in the hydrogen value chain and its cross-cutting topics. It also contains a practical view of the attractive employment opportunities in the hydrogen sector. The authors do not claim to provide a comprehensive overview in this article. Rather, this paper intends to present a basis for further discussions on the topic of knowledge development in hydrogen, providing an overview and giving guidance to people involved in the ongoing change.

ENERGIE region Wir gestalten Energie. Gemeinsam.

2030 is already looming on the horizon, yet it takes time to create a skilled workforce

Appropriate technological solutions will be needed to ensure that the energy sector alone can reduce its emissions from the currently permitted 257 million tonnes of CO_2 equivalent to just 108 million tonnes by 2030 (Bundesamt für Justiz 2019). The short amount of time available means that it is clearly not possible simply to wait for a new generation to gravitate towards the new occupations – occupations which have not yet even been defined (BIBB 2022). It is important to start appropriating skilled workers from other fields for the hydrogen economy through retraining and further education measures. In demand are training and skills in the technical, legal (licensing, regulation), business management (economic feasibility) and planning areas. This demand will spread from the academic to the vocational and craft sectors as the hydrogen market ramps up.

According to the German Hydrogen and Fuel-Cell Association (Deutscher Wasserstoff- und Brennstoffzellen Verband - DWV), more than 1.5 million people were employed by DWV member companies in 2020. In 2018, the DWV predicted that an additional 70,000 jobs will be required in the hydrogen sector by 2030. The 2021 publication on hydrogen skills issued by the Institute for Employment Research (IAB) of the Federal Employment Agency stated that no adequate overview of the hydrogen labour market is currently available. Various jobs are already being advertised in areas such as research and development, mechanical and production engineering, electrical engineering, chemistry, power engineering, purchasing and sales, as well as in corporate strategy development. In 2019, these jobs were predominantly classified as "highly complex" activities. (Grimm, Jansen, und Stops 2021)

France Hydrogène has described in detail why the development of knowledge and skills is essential for growing the hydrogen economy and has drawn up a list of competences. In addition, it found that of the 84 occupations considered, 27 require specialist knowledge about hydrogen, 41 require basic knowledge and 16 require no specific knowledge (France Hydrogène 2021). It can be concluded from this that there is great variation in the complexity of the relevant activities. In some fields, it is a matter of training skilled workers both in the handling of hydrogen facilities, but also in the safe operation of the equipment and in integrating it into existing infrastructures. Other fields have a systemic rather than a technical focus.
In Germany, the handling of gas-powered systems with a gas-electricity interface is nothing new. Specialists who work at or on such plants are usually conversant with both areas, but in many cases are unfamiliar with the specific chemical and physical properties of hydrogen. This is important because special precautions apply with regard to explosion protection in electrical installations, for instance.

It is not only Germany and France which have drawn up plans for the broad-based integration of hydrogen. Efforts are being made worldwide to establish a hydrogen economy, including all that it involves. Many nations are therefore facing similar issues relating to knowledge management and the skilling of the workforce. Here, it makes sense for the countries to support each other because the practical aspects are similar – despite the significant differences in the respective education systems. For example, elementary hydrogen curricula are being developed within the "H2Brasil" initiative. These address the growing needs of the Brazilian hydrogen economy with job specialisations such as "gas transport logistician", "technical specialist in the operation of green hydrogen production plants" and "specialist in green hydrogen systems" (GIZ 2022).

The diversity of the above examples indicates the complexity of the required changes in the labour market. A look at the hydrogen value chain suggests that other areas, and thus many occupational groups, will be affected by the transition.

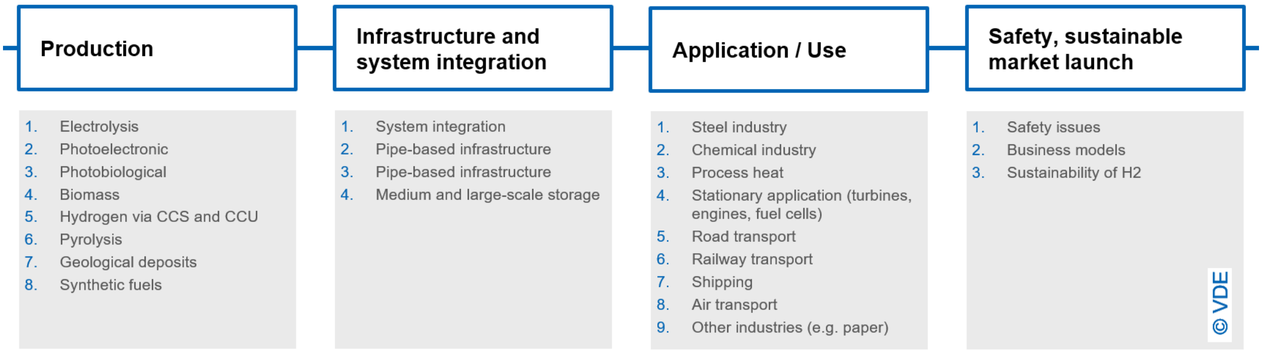

Figure 1 The specific sectors in the hydrogen value chain (VDE chart)

The transformation of our energy systems is bringing about change in the working environment of many people. In some cases, this will be to their advantage. In addition, the complexity of the energy transition and the associated increase in demand for hydrogen are currently creating a veritable boom in the related training market. This is making it difficult for interested parties and relevant target groups to find appropriate training with the appropriate practical content.
At many points within the hydrogen value chain it is also still unclear what forms of knowledge enhancement are needed. It is not yet always apparent which occupational groups are part of the value chain and what specific knowledge needs to be obtained. Cross-cutting issues between the individual areas have also not yet been fully explored. What is certain is that a growing number of employees will be faced with the necessity of undertaking retraining or further education/training in their field.

In order to be able to set up the requisite training and study modules in good time, the skills and training requirements need to be defined in concrete terms within the different stages of the hydrogen value chain and within the existing job specialisations. The present discussion paper is intended to provide initial input with the aim of bringing clarity to the complex issue of (re)skilling in the field of hydrogen. It should be seen as complementary to other work (e.g. by France Hydrogène, IHK and HWK Lüneburg) and serve to initiate discussion in selected areas.

The "Occupational groups involved" and "Cross-cutting aspects" of the individual areas of the hydrogen value chain are examined in greater detail below in order to provide an initial insight[1] into the educational/training needs. Basic knowledge in chemical-physical aspects as well as in occupational safety, in particular explosion protection in relation to hydrogen, is <u>required in all</u> respective areas and occupational groups. The following areas (links) from the value chain are considered in the discussion paper:

1) Production	2) Infrastructure and system integration	3) Application / Use
▪ Electrolytic production ▪ Production based on carbon capture and storage (also known as blue hydrogen)	▪ System integration ▪ Pipe-based infrastructure	▪ Stationary applications

Figure 2 Value chain areas considered (VDE chart)

[1] This paper makes no claim to provide an exhaustive overview of the training requirements in the hydrogen sector. Rather, it is intended as a basis for dialogue and discussion, and ultimately for the creation of a comprehensive overview for orientation in the transformation.

1) Production

In **electrolytic production**, the following occupational groups may be affected by the cross-cutting aspects listed.

Occupational groups involved	Cross-cutting aspects
▪ Electrical engineers ▪ Mechanical engineers ▪ Project planners / engineers for storage facilities and renewable energies ▪ Plant engineers (electrolysis) ▪ Network engineers	Electricity ▪ Power generation plants, especially renewable power plants (focus on electricity procurement and availability) ▪ Grid connection conditions ▪ Power electronics ▪ Positive impact on network / system (electricity markets in general) Gas ▪ Network connection conditions (e.g. gas pressure regulation, gas quality, odorisation) ▪ Transport technologies in general (e.g. trailers, carrier medium, etc.) ▪ Storage technologies in general (e.g. physical state, storage infrastructure) ▪ Costs (transport costs, energy demand, capacity) ▪ Gas quality Water ▪ Water availability, supply and delivery ▪ Required water quality (degree of treatment, impurities, hardness, etc.) ▪ Water demand ▪ Water storage ▪ Hydraulics Economy ▪ Hydrogen trading ▪ Electricity/gas markets / Energy markets in general ▪ Basic legal framework

In production based on **carbon capture and storage processes (focus on blue hydrogen**), the following occupational groups may be affected by the cross-cutting aspects listed

Occupational groups involved	Cross-cutting aspects
▪ Employees of gas supply companies ▪ Employees of gas network operators ▪ Plant engineers (natural gas) ▪ Skilled workers, master craftsmen and women, technicians and engineers ▪ Contract installation companies ▪ Control room staff	Gas ▪ Basic knowledge of carbon compounds ▪ Expenses (transport costs, energy requirement) ▪ Gas quality ▪ Technological knowledge of emission control for natural gas Electricity ▪ Electricity requirement of the plant itself Geology ▪ Geological features in general ▪ Drilling ▪ Storage facilities Economy ▪ Knowledge of carbon market ▪ Small-scale applications

2) Infrastructure and system integration

System integration concerns the precisely coordinated integration of all energy systems, such as electrolysers and fuel cells, into the existing systems (electricity and gas). In system integration, the following occupational groups may be affected by the cross-cutting aspects listed.

Occupational groups involved	Cross-cutting aspects
▪ Infrastructure planners / project engineers ▪ Plant engineers / network fitters (electricity and gas) ▪ Staff in administrative bodies ▪ Electrical engineers ▪ Utility engineers Mechanical engineers ▪ Master (network) technicians ▪ Distribution network technology specialists	Long-term regional functionality ▪ Supra-regional contexts (role of hydrogen worldwide, import conditions, etc.) ▪ Demand planning and balancing ▪ Economy and market interdependencies Electricity ▪ Project planning (renewables coupled to electrolysers incl. storage units and reconversion) ▪ Power grid capacity ▪ Network monitoring Gas ▪ Project planning incl. local hydrogen requirements ▪ Network calculation (transport and distribution network) ▪ Gas storage capacity Water ▪ Water availability ▪ Water management – general Communications infrastructure ▪ Local considerations – Smart grid ▪ Cybersecurity Administration ▪ Legal framework ▪ Approval / licensing processes Miscellaneous ▪ Geology ▪ Geography

The following occupational groups can be affected by the cross-cutting issues listed in the field of **pipe/wire-based infrastructure**.

Occupational groups involved	Cross-cutting aspects
▪ Network engineers ▪ Welding engineers ▪ Plant technicians / mechanics for pipe system technology ▪ Master network technicians ▪ Specialists in distribution network technology ▪ Pipe fitters ▪ Welders	Gas ▪ Materials science ▪ Connection methods and fittings ▪ Compressor technology, compressor stations, gas pressure control ▪ Network calculation ▪ Storage ▪ Odorisation ▪ Network connection ▪ Welding Communication ▪ Monitoring / sensor technology (leak monitoring and detection) ▪ Quantity measurement, calibration Miscellaneous ▪ Geology ▪ Geography

3) Application / Use

The following occupational groups can be affected by the cross-cutting issues listed in the field of **stationary applications** (fuel cell). The France Hydrogène study shows how 55 professions are involved in stationary applications of hydrogen – especially those related to fuel cells.

Occupational groups involved	Cross-cutting aspects
▪ Plant engineers ▪ Planners ▪ Civil engineers ▪ Fitters ▪ Plant operators	Electricity ▪ Grid connection conditions ▪ Project planning / design (power and heat demand) ▪ Power generation plants, especially renewable power plants (focus on electricity procurement and availability) Gas ▪ Gas network connection (gas pressure control, gas flow monitor, odorisation) ▪ Materials science ▪ Transport technologies – general (delivery of H2) ▪ Expenses (transport costs, energy requirement) ▪ Gas quality Economy ▪ Hydrogen trading ▪ Electricity / energy markets – general ▪ Basic legal framework

General recommendations to educational institutions (universities, schools, further education institutions)

There is a wide range of cross-cutting aspects in the individual links of the hydrogen value chain. In some of these, the interfaces are already familiar. In many cases, the natural gas component is often simply replaced by hydrogen. Knowledge about hydrogen at the chemical-physical level is therefore needed here. Some occupational groups are broadening their scope to include further aspects such as water availability and comprehensive framework conditions from system integration. This applies to planners, project planners and network engineers, among others. Technologies are successively being replaced or expanded in other occupational groups (e.g. in the mobility sector). Other occupational groups in the value chain calculate that the need for further training will not come until a later stage. This is the case in the area of stationary fuel cells and the corresponding occupational group of fitters, as they are bound to the decisions of the end consumers, who in turn are dependent on the supply infrastructure. Here, the demand for fuel cell installations is currently relatively modest, meaning that fitters are waiting for the market to develop (Tietze 2022; IHK-Lueneburg und HWK BLS 2022). Nevertheless, hydrogen is already covered in "Technical Rules for Gas Installation Training" (TRGI training) under "H_2 readiness". This is because H_2 readiness is now gaining in importance in households.

From this description it is apparent that the acute need for **(re)skilling** can vary greatly within the individual occupational groups and fields. In addition, attention also needs to be paid to workers with different skill sets; this will facilitate transfers from other fields. Here, retraining or "transition training" should teach precisely tailored content. A wide range of work-based further education/training options or additional qualifications are currently available for acquiring the necessary skills. Care should be taken, however, in identifying which training courses are suitable for which area; ideally, training courses can even be tailored to the needs of individual companies (IHK-Lüneburg und HWK BLS 2022).
The DVGW and VDE advocate the development of standardised training certificates which would include knowledge of the necessary regulations and render the different training programmes comparable. The IHK

and HWK Lüneburg study also concludes: "If possible, courses should culminate with a certificate that qualifies participants to perform certain tasks. [...]. The general intention behind the regulations is to impose specific qualification requirements on employees working with hydrogen (IHK-Lüneburg und HWK BLS 2022, 36)."

In the **training and apprenticeship sector**, it makes little sense to develop new training programmes, but to build on existing ones instead. To this end, vocational colleges, chambers of skilled crafts, and chambers of industry and commerce have already carried out initial trials of advanced modules. In south Thuringia, a basic module was developed for apprentices in technical fields such as mechatronics and electronics. This functions as a complementary element to the established dual vocational training system; mechanisms are needed which recognise informally acquired skills and abilities, but which also enable not only workers from outside the trade but also unskilled and semi-skilled workers to transfer across (Westdeutscher Handwerkskammertag 2022). For the group of semi-skilled and unskilled workers, "limited occupational profile" models are to be developed which enable entry into the corresponding fields of activity but also permit further training towards obtaining a regular qualification under the dual training system.

Many cross-cutting aspects can also be covered through the modular and interdisciplinary expansion of existing **degree programmes** to include hydrogen. At present, it does not appear expedient to set up new technical degree programmes explicitly for hydrogen (Wald, Grigorjan, und Uhlmann 2022). In mechanical and electrical engineering degree programmes, for example, modules could be created which focus on fuel cells and hydrogen combustion engines. Likewise, hydrogen could be covered more fully in the materials science modules. For decades now, there have been various courses of study in Germany, such as Environmental Technology, Environmental Management or Energy Technology, which include and teach the topic of hydrogen as part of the syllabus. Further interdisciplinary degree programmes are being established throughout Germany. The core elements of these programmes are production processes, renewable energy, the energy industry in general, basic physical and chemical principles, control and regulation technology, safety, distribution, storage and application.

Although the main focus is currently on initial and further vocational training for employees, **school education** should not be disregarded, as pupils in the higher years will ideally be given orientation for later career options and study/training opportunities. In STEM subjects, pupils should not only be familiarised with the basic principles of hydrogen but also explore the opportunities and limits of the hydrogen economy. In Germany, projects such as "HYPOS macht Schule" or the educational partnerships of the "Nürnberg hy+" hydrogen metropolitan region can serve as initial starting points. Here, teachers are given specially devised educational components (such as excursions, career information days, teaching materials) suitable for integrating the topic of hydrogen into lessons. In addition, workshops are also offered to the teaching staff to help them incorporate the subject matter on the basis of practice-oriented toolkits. It also makes sense to offer further training for teachers because, according to Wald et al., there is not always a clear transformation link between science teaching and pupils' later careers (Wald, Grigorjan, und Uhlmann 2022). Pupils can also be introduced to the topic through direct measures such as "Kinder-Uni" workshops (special schemes run by universities for schoolchildren) or external laboratory courses. Non-school-based learning schemes, such as STEM (Science, technology, engineering, mathematics) initiatives, fab labs, maker spaces or technical museums, also play an important role in this context.

Lastly, recruitment and further education initiatives should be arranged in the area of **research and development**; after all, the technologies which are currently available are subject to constant further development. This requires appropriate skills and specialists.

Market ramp-up and knowledge management are ultimately closely linked. The faster the pace of the market ramp-up, the sooner the skills will be needed – and the more skills which are available, the faster the market ramp-up can be implemented. This is particularly evident in the skilled trades, as the expansion of renewable energies is already expected to create a significant shortage of skilled workers.

The ramp-up of the hydrogen economy provides an opportunity to develop uniform educational/training standards along with the new technical and regulatory standards as they emerge (Krichewsky-Wegener, Abel, und Bovenschulte 2020). This brings with it numerous opportunities and a number of potential hazards, but it does ensure the safe handling and operation of hydrogen-based systems. Based on extensive experience in various sectors (for example in the chemical industry), in some cases accrued over decades, it makes sense to develop a universal "hydrogen" safety curriculum and to anchor it internationally (Skiba 2020). These measures apply to the production, storage, transport and use of hydrogen, including all power-to-X energy options.

Fundamentally, it is recommended that initial and further training extend beyond system boundaries (water, electricity, gas, mobility, communication). The complexity of climate change is affecting our energy flows at all levels. It is crucial that any specific knowledge obtained in a particular area is understood in terms of its interactions with other fields. (DIHK 2022)

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