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Hydrogen as a Future Topic in German VET? – Research Design and Initial Findings from the Research Project H2PRO

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Abstract

Context: Hydrogen is a crucial element in the transition towards a green economy. In various sectors, hydrogen opens up decarbonization paths where direct or battery electric systems cannot meet high energy demands or where no other alternatives to fossil raw and auxiliary materials are applicable. Qualified workers are a crucial factor for the successful establishment of the hydrogen economy. The research project H2PRO at the German Federal Institute for Vocational Education and Training (BIBB) addresses the questions of how skills requirements in training occupations change due to hydrogen, and what measures are necessary in German vocational education and training policy and practice to support hydrogen-related skills development.
Methods: The project uses a qualitative research design consisting of sector analyses, expert interviews, and case studies, and examines the entire hydrogen value chain from production to application areas such as steel, chemicals, mobility, and heat supply.
Findings: The contribution focuses on the mobility and transport sector, specifically on skilled workers in automotive workshops. At this point, initial results suggest that there is no need for a specific hydrogen training occupation. Instead, specific training offers are required in vocational education and training to address qualification gaps in specific occupations, ensuring that skilled workers are prepared to work with hydrogen technologies.

Keywords

hydrogen, green transition, VET, mobility and transport

1 VET as a blind spot in discussions about Hydrogen

Hydrogen and it´s secondary products are a key component in the transition towards a greener economy. In the transformation of the energy system, hydrogen offers a promising opportunity to replace fossil energy carriers where battery or direct electric systems cannot meet high energy demands, such as for mobility applications or heat supply (Fraunhofer IPT, 2021). In the chemical and steel industry, hydrogen will be decisive to replace fossil raw and auxiliary materials and to avoid process emissions (IEA, 2020). Generally speaking, power-to-X technologies enable a deep integration of energy sector infrastructures, industries, and the transportation sector (sector coupling) to provide a comprehensive supply of renewable energy. Thanks to its flexible production and storage options, hydrogen also enables more efficient system integration of renewable energies, especially when surplus electricity cannot be fed into the grid during particularly windy or sunny phases (Wietschel et al., 2018).

In 2020, Germany introduced its National Hydrogen Strategy, an ambitious roadmap to build a large-scale hydrogen economy through the market ramp-up of hydrogen technologies, fostering research and development, and building international markets and partnerships. With the coalition agreement the new government signed in 2021, the initial goal to reach hydrogen productions capacities of 5 GW by 2030 was even doubled to 10 GW (Federal Ministry for Economic Affairs and Energy, 2020). Skilled workers, who manufacture hydrogen technologies, maintain day-to-day operations and contribute important impulses for innovation are indispensable for putting the hydrogen strategy into practice (Steeg et al., 2022). However, political hydrogen strategies at the federal, state and regional levels in Germany often recognise the need to strengthen vocational education and training for the hydrogen economy, but they do not name specific measures or need for action. In general, workforce-related discussions regarding hydrogen largely focus on academically trained professions, while the VET level is often neglected. While quantitatively oriented studies predict a high employment potential in the hydrogen economy (e.g. RolandBerger, 2020), qualitative employment issues have so far been little examined in Germany. From the perspective of vocational education and training research, there is a research gap regarding the question of how work tasks, work processes, and skills requirements change along the hydrogen value chain and whether existing occupational profiles and regulatory instruments are sufficient.

2 H2PRO: Skills anticipation and research design

The goal of the project H2PRO at the German Federal Institute for Vocational Education and Training (BIBB) is to identify new skills requirements and qualification needs in mid-level professions along the hydrogen value chain and to derive recommendations for action for political and practice-supporting actors in initial and further training. The project ties in with the German National Hydrogen Strategy, which aims at "further developing vocational [...]training in the field of hydrogen technologies" (Federal Ministry for Economic Affairs and Energy, 2020, S. 24). Throughout the project, the entire hydrogen value chain, spanning from production to application areas such as the steel and chemical industry, mobility, and heat supply, will be analysed.

The following questions will be answered in the course of the project:

I. Which training professions and further training strategies are of particular importance at the intermediate skilled worker level for the implementation of the hydrogen strategy?
II. What additional qualitative qualification requirements are likely to arise?
III. Are the necessary qualification contents already anchored to a sufficient extent in the regulatory instruments?
IV. What recommendations for regulatory and practice-supporting measures are derived on the basis of the identified qualification needs?

Since hydrogen is a new field of technology that many companies are slowly integrating into their portfolios and production processes, changes on work levels have not yet unfolded on a broad scale. Therefore, the research represents a skills anticipation approach to identify changes in work tasks, as well as new knowledge and skills needs that could become standard requirements in the different areas of the hydrogen economy. Skills anticipation in occupational sciences aims to sustainably secure vocational competence and prevent skills mismatches in light of new technologies and forms of labour (Spöttl & Windelband, 2006). This information provides stakeholders with a more precise direction for skills investments and for designing future-oriented vocational profiles (CEDEFOP, 2017; ILO, 2017). To accurately determine how work tasks, work processes, and skills requirements are changing and whether profiles of training occupations need to be adjusted, a qualitative research design is used that consists of a sectoral analysis, expert interviews and case studies.

- **Sectoral analysis:** The sectoral analysis opens up a structured approach to the research field. In the case of the hydrogen economy, the primary aim is to discuss sector-specific structures and changes associated with the manufacture and application of hydrogen technologies at the product, production, market and organizational levels, and from there shed light on "dimensions of skilled labour" (Spöttl, 2005). At the occupational level, the sector analysis will provide initial delineations of areas of work and professional profiles, and highlight forward-looking qualification activities.
- **Expert interviews:** Building on the interim results of the sector analysis, guided expert interviews will be conducted with persons from associations, chambers, research institutions, educational institutions and companies.
- **Case studies:** The core of the research project consists of case studies, in which work tasks and processes are analysed, taking into account the respective workplace and operational structure. Hydrogen is a relatively young technology field that encompasses very heterogeneous industries and types of companies. Therefore, the case studies should also reflect the company's level of technology and market experience. To examine and reflect work tasks and skills requirements within the different operational contexts, processes und situations, work process studies, in which expert interviews and observation methods are combined (Becker, 2018a; Röben, 2018), are the main focus of the case studies.

3 VET for the green economy in Germany

The research on skills requirements for the hydrogen economy provides an extension of earlier research on VET for the green economy in Germany, which mainly focusses on renewable energy and energy efficiency. It is important to note that the German VET system is strongly institutionalised and characterised by federally recognised occupations with defined occupational profiles that are trained through a dual system of vocational school and in-company training. Training regulations which comprise occupational profiles and standards and contents for in-company-training are developed through negotiations between the government, employers' associations and unions (BIBB, 2014).

The example of renewable energy shows that there was no need to establish a specific occupation. Instead, new technologies and learning content were integrated into the training regulations and curricula of existing occupations. Technical occupations often have broad skills profiles that provide a solid foundation for many tasks in the green economy. Furthermore, training regulations and curricula are usually formulated in a way that enables companies and schools to incorporate technological innovations into vocational and educational training if necessary. Skilled workers can build on their basic training by specializing in specific technologies and areas of work through further training and certificates offered by chambers and other training providers.

4 The role of hydrogen in the mobility and transport sector

With its Federal Climate Change Act the German government set the goal to reduce CO_2 emission of the mobility and transport sector to 85 mio. t by 2030. In 2021 the mobility and transport sector emitted around 148 mio. t of CO_2-equivalents. In January 2023, little over one million BEV (battery electric vehicles) were sold in Germany. While for passenger cars BEV are expected to be the dominant solution towards zero emission due to their better efficiency and their driving range continuously improving, hydrogen brings the opportunity to replace fossil fuels in segments where battery electric powertrains are not able to serve high energy demands or that require long driving range and quick refuelling. Therefore, hydrogen-based powertrains are gaining relevance in fields such as heavy-duty transportation, public transportation and agricultural and construction machinery (Fraunhofer IPT, 2021). The dominant type of hydrogen-powered vehicles is FCEV (fuel cell electric vehicles). Fuel cells convert hydrogen into electrical power through chemical reaction, which powers an electric drive train. Besides that, hydrogen can be used in combustion engines or as a basic material for synthetic fuels. In heavy-duty transportation, non-European manufacturers are already offering fuel cell trucks, and several European manufacturers have announced plans to begin serial production between 2025 and 2028. In public transportation, around one hundred fuel cell buses are already in use in various German cities, and their numbers are expected to grow rapidly over the next few years due to the Clean Vehicles Directive, which sets national targets for the procurement of low- and zero-emission vehicles in the public sector (European Union, 2019). In the agricultural and construction machinery sectors, where attachments and working functions of the vehicles require additional energy and long working hours are needed, battery electric systems are not sufficient. As a result, some manufacturers are developing prototypes that use fuel cells or hydrogen combustion engines.

In the automotive and supplier industry as well as in affiliated service areas, hydrogen is part of a broad structural change, which is being driven forward by the shift from combustion engines to electric powertrains. Electric powertrains comprise significantly fewer parts and components and require new production structures and processes with higher potentials for automation, which results in lower employment requirements and electrical and IT occupations gaining relevance (Dispan, 2013; Fraunhofer IAO, 2019). Even though the production of fuel cells and tank systems for FCEV holds additional potential for employment and value creation, it won´t balance out the expected job reduction connected to the change in production towards electric drive systems in Germany (NPM, 2021).

5 Occupational changes and qualification requirements in electromobility

Since FCEV are also electric vehicles, qualifications for high-voltage drive systems are a basic requirement for professional practice in the hydrogen mobility. Therefore, it is worth taking a look at previous changes for automotive professionals in the rapidly developing field of electromobility. Electric drive systems operate with voltages up to 1000 volts, whereas ICEV are only equipped with 12 or 48-volt electrical systems. Working on electrical drive systems requires basic knowledge of electrical measurement technology, knowledge of potential hazards and their avoidance, skills such as conducting analyses, error diagnosis and measurements, as well as the evaluation of measurement results and the installation and removal of high-voltage system components (Becker, 2018b; Kohl, 2018a). Kohl summarizes that compared to a previously more "mechanical and visually controlled way of working" in automotive professions, electromobility represents a "significantly more abstract area of work" that "requires a new electrical way of thinking and working” (2018b, S. 26). In 2013, the basic qualifications for working on high-voltage drive systems were integrated into the basic training for the occupation of "automotive mechatronics service technician" with the last adjustment of regulatory instruments. In addition, apprentices have the option to specialize in electromobility (BIBB, 2013). To ensure that all apprentices receive basic qualifications for high-voltage drive systems, regardless of whether their training company works with electric vehicles, a standardized course for inter-company training has been introduced (Syha, 2016).

6 Additional training needs for workshop personnel in the hydrogen mobility using the example of automotive mechatronics technicians.

Fuel cells have not yet been integrated into the training of automotive professionals. However, working with fuel cell drives requires qualifications in high-voltage and gas systems. Workshop personnel working on fuel cell systems typically perform tasks such as conducting leakage, tightness, and functional tests on the gas system, flushing the gas system, diagnostic procedures, as well as removal and installation of components. It is essential to consider safety aspects when working with hydrogen vehicles. Hydrogen has a broad explosive range and requires lower ignition energy than other fuels. Besides that, risk of injury exists due to high gas pressures. In the case of liquid hydrogen, the cryogenic temperature of -253 degrees Celsius poses an additional risk. Additional skills for working with fuel cell and tank systems include safe handling of high-pressure system components, knowledge of substance behaviour and hazard avoidance, system understanding for performing diagnostics and analyses, and application of tools and work equipment. In addition to new skills requirements, the workplace also changes, for example, because hydrogen workshops require explosion protection devices such as sensors and ventilation systems, as well as overhead workstations and cranes, for example, because in hydrogen buses, the fuel cell and tanks are mounted on the roof.

As the example of automotive mechatronics shows, the training occupation provides a very good basis for working in hydrogen mobility, especially since qualifications for electric drives are already anchored in the basic training. To qualify skilled workers for work in hydrogen workshops, demand-oriented further training is necessary. In the further course of the H2PRO project it will be necessary to examine based on the overall needs whether it makes sense to include hydrogen-related training and teaching content as mandatory in the basic training for automotive mechatronics technicians.

7 Initial findings: No need for a hydrogen-related training occupation and the role of regional skills ecosystems

At this point in research, it is assumed that there is no need for a specific hydrogen-related training occupation such as a "hydrogen technician" in Germany. Many technical occupations have broad skills profiles that provide a good foundation for working in different fields of the hydrogen economy. However, there is a need for tailored training and education programs to provide specific qualifications for working with hydrogen that should be provided in time to avoid qualification bottlenecks during the ramp-up of hydrogen technologies.

Initial findings from the H2PRO project also show that training needs are currently covered by what can be characterised as regional skills ecosystems. According to Buchanan et al. (2017), skills ecosystems refer to “regional or sectoral social formations in which human capability is developed and deployed for productive purposes”. The concept is of great benefit in this case because it offers a lens through which the evolvement of qualification structures for skills that are yet not covered by training regulations or school curricula can be analysed on a regional basis. The hydrogen economy will develop from individual regions and networks, where different qualification needs exist depending on the local sectors and hydrogen technologies. Currently, these needs are met through individual training programs and certificates designed and offered through cooperation of local actors such as chambers, training providers or research institutes. In some regions, analyses are conducted initially to determine what qualification needs exist and what potentials are available to set up specific training programs (e.g. H2Skills, 2022).

In the further course of the project, it is necessary to further examine for individual training occupations where qualification gaps exist for working with hydrogen. Furthermore, it will be examined how training companies and vocational schools can be supported in teaching hydrogen-related content and skills. As mentioned before, qualified professionals are essential for the successful establishment of a hydrogen economy and for the green transformation as a whole. Other sectors have already shown that a shortage of skilled workers can slow down the expansion of green technologies. Therefore, it is even more important to identify potential qualification and skilled worker shortages in the hydrogen economy at an early stage in order to prevent similar effects.

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