June 2023

A Research Project at the Federal Institute for Vocational Education and Training (BIBB)

H2PRO

Hydrogen – a future-oriented topic for vocational education and training with regard to energy transition

Transformation in the chemical and refining industry: the training occupations fit!

To decarbonize the production chains in the chemical and refining industry using green hydrogren, substantial investments in research and development of products and processes are necessary, including the construction of new production facilities and changes of sites.

The professionals' work flows and processes, however, will not undergo considerable change because the technical innovations are within the scope of the common procedures of chemical engineering.

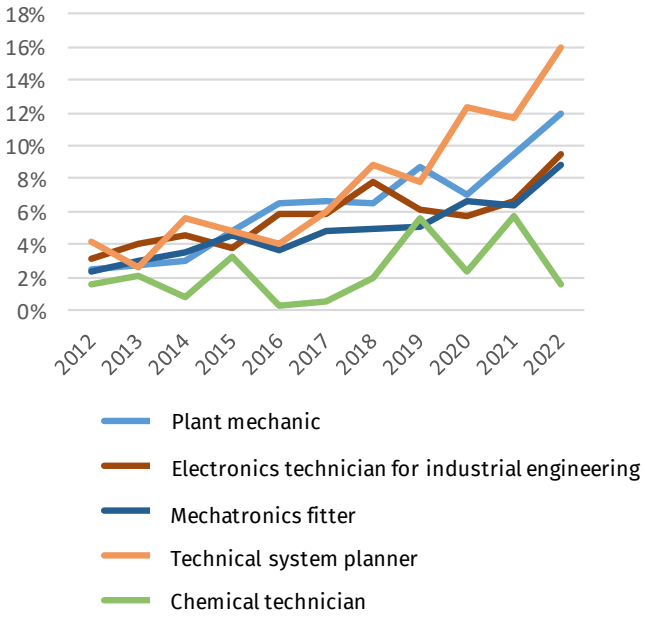
Hydrogen has been used in the chemical industry for over 100 years, for example for the production of ammonia by the Haber-Bosch method. Even the use of green hydrogen today does not require adjustments of training occupations and qualification strategies in this sector.

A new generation of skilled workers is critical for the transformation

Notwithstanding, the challenges imposed by the transformation of the chemical and refining industry reveal that industrial-technical training occupations are highly relevant for decarbonizing the German economy. They are indispensable for planning and developing, installing, monitoring and commissioning, operating, maintaining and safety monitoring of plants and infrastructure. The change towards green hydrogen can not succeed without them. Forward-looking personnel development and vocational training is particularly necessary for industrial sites that are new and growing.

Demographic change threatens to become an obstacle to the technological transformation of the chemical industry and refineries. The number of people who drop out of the labor market each year is significantly higher than the number of young people entering it. Training places in key professions remain vacant.

In this respect, teaching hydrogen-related topics in schools may emphasize the importance of industrial-technical professions for a transition of energy and raw materials towards sustainability and thus increase the attractiveness of apprenticeships trainings. The refining and chemical sector could benefit greatly from such a contribution to the urgently needed supply of skilled workers.



Unfilled training places for exemplary "hydrogen occupations" (BIBB survey as of September 30, 2022, (in German) own calculation)

Occupations in the chemical industry that have to do with hydrogen are for example: plant mechanic, electronics technician for industrial engineering, mechatronics fitter, technical system planner and chemical technician. Their areas of action make the complexity of future energy and raw material systems and the challenges of implementing decarbonization processes tangible

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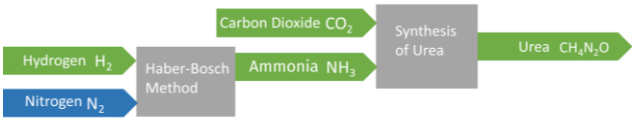
Decarbonization pathways using hydrogen in the chemical and refining industries

The chemical and refining industries are major emitters of CO_2. Here, crude oil and natural gas are not only energy sources, but also source materials for a wide range of products, so the reduction of CO_2 cannot be achieved through electrification alone. Replacing crude oil and natural gas with regeneratively produced (green) hydrogen is often the only solution and requires the adaptation of existing production processes as well as the development of new ones. Above all, hydrogen plays an important role in the synthesis of the basic substance ammonia (NH_3). Further, it can potentially replace fossil resources for the production of methanol (CH_4O) and synthetic naphtha (raw gasoline), relevant for chemical fertilizer, fuels and synthetic material (plastics).

Ammonia ($NH3$) is the basis for the production of urea and chemical fertilizers. If green hydrogen is used in ammonia synthesis instead of natural gas-based (gray) hydrogen, CO_2 emissions caused by the production and the use of ammonia can be avoided.



Synthesis of ammonia/Synthesis of urea using green hydrogen (simplified representation)

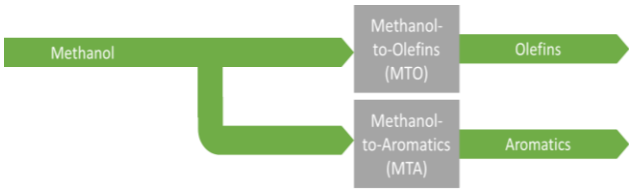
Methanol (CH_4O) is an important chemical raw material and can be used as energy source. In methanol synthesis green hydrogen can replace the fossil raw material, that are used conventionally such as heavy oil or natural gas. Methanol on the basis of green hydrogen can be applied for the production of synthetic material (plastics) and synthetic fuels.

Synthesis of methanol using green hydrogen (simplified representation)

Synthetic materials (plastics) are an important product group in the chemical industry. In plastics production, crude oil is first processed into naphtha which is then split into olefins and aromatics in so called steam crackers. Olefins and aromatics are chemical building blocks like for example the monomers ethene or propylene, from which the plastics (polymers) polyethylene and polypropylene are composed. Hydrogen and carbon monoxide (CO) can be processed into synthetic naphtha by Fischer-Tropsch synthesis which replaces crude oil as a source material.

Synthesis of olefins and aromatics by Fischer-Tropsch synthesis (simplified representation)

In order to replace fossil source material, **hydrogen-based methanol** can also be used instead of naphtha to produce olefins and aromatics. Procedures for this are methanol-to-olefin synthesis (MTO) or methanol-to-aromatics synthesis (MTA).



Synthesis of olefins and aromatics by the methanol route (simplified representation)

Synthetic fuels without fossil source material can be produced using synthetic naphtha or methanol. For this purpose, methanol is converted, for example into dimethyl ether (DME), gasoline or kerosene. Methanol can also be blended with conventional fuels and used in combustion engines. For this, adjustments to the engine are required.

BIBB Sector analysis "Chemical and Refining Industry" (PDF; in German)

More about H2PRO:
www.bibb.de/de/153294.php

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