Press Release

thyssenkrupp

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Expansion to 5 gigawatts of annual production capacity: thyssenkrupp represented in all three BMBF hydrogen lead projects

- **H_2Giga: thyssenkrupp is driving forward the industrialization of alkaline water electrolysis through automated series production**
- **H_2Mare: thyssenkrupp tests the offshore production of green methanol and ammonia**
- **TransHyDE: thyssenkrupp tests ammonia cracking**

With the hydrogen lead projects – its largest research initiative to date on the topic of energy transition, the German Federal Ministry of Education and Research (BMBF) is supporting Germany's entry into the hydrogen economy. thyssenkrupp is involved in all three hydrogen lead projects and is testing the industrial production, use and system integration of green hydrogen. Within four years up to 2025 thyssenkrupp will therefore be further expanding its technology leadership along the entire green chemicals value chain. This involves the series manufacturing of large-scale water electrolyzers (H_2Giga), the production of synthetic fuels, green ammonia, green methanol and synthetic methane at sea (H_2Mare), as well as hydrogen transport and conversion technologies such as ammonia cracking (TransHyDE). These flagship projects will bundle the expertise for hydrogen technologies in science, industry and civil society throughout Germany, thereby providing the initial spark for the development, conception and implementation of hydrogen solutions on an industrial scale.

"With its comprehensive technology portfolio for both completely green value chains and the recycling of emissions in closed-loop systems, thyssenkrupp can represent the entire value chain for green chemicals," explains Martina Merz, Chairwoman of the Executive Board of thyssenkrupp AG. "Bringing together this strength of our innovation-driven long-standing company with scientific research in the hydrogen flagship projects is the recipe for success for the implementation of the National Hydrogen Strategy and for keeping Germany's technology leadership competitive internationally."

Upscaling of water electrolysis to automated gigawatt series production
thyssenkrupp will be receiving almost 8.5 million euros in subsidies for the research and development of the large-scale production of alkaline water electrolysis (AWE). The aim on the one hand is to take advantage of scaling effects and thereby be able to reduce the manufacturing costs. On the other hand, an expansion of the existing supply chain of 1 gigawatt (GW) of electrolysis cells enables larger project volumes to be implemented, so that several gigawatt projects can be implemented at the same time each year.

Martina Merz emphasizes the need for this research initiative: "We have seen a significant shift in the project sizes towards several hundred megawatts to gigawatts in recent months,

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so that large-volume and automated series production is already in line with market demand today. For these orders of magnitude, simple upscaling is not feasible, but disruptive approaches have to be applied, which are being developed, tested and optimized in individual steps within the framework of this project." So, on the one hand, completely new stack and cell development work is being carried out in order to develop the next technology generation of alkaline electrolysis. Furthermore, we are striving to implement the supply chain optimization process required for industrial series production. Through the use of robotics and automation, both the manufacturing and assembly processes are being optimized.

The thyssenkrupp-led H_2Giga project "INSTALL AWE" focuses on the industrialization of AWE, which is today the furthest developed market-ready technology and used above all for large-scale industrial applications. The modular and standardized 20 MW module from thyssenkrupp is also advantageous in terms of economic aspects and climate protection. In contrast to the compact construction of PEM electrolyzers, the single-element technology used for AWE enables selective maintenance work to be carried out on individual cells instead of having to replace the entire stack. This conserves resources and reduces the operating costs. Essential for this ramp-up to series production is the core relationship with the Joint Venture partner Industrie De Nora, a globally renowned specialist in electrochemistry and high-quality supplier for cell manufacturing and coatings. The fully integrated workflow between thyssenkrupp and De Nora, their proven set-up gigawatt supply chain for water electrolysis cells and global service workshops is the strong basis for this next development step. For this purpose, thyssenkrupp will be working together with its long-standing partners like De Nora and Hoedtke GmbH & Co. KG, as well as scientific partners, but will also be building on new collaborations. In the H_2Giga innovation pool with institutions, universities and small specialized companies offering scientific and technical skills with respect to the subject of series production, investigations of broader research and development topics are being carried out which are also intended to further drive forward thyssenkrupp's own development.

Offshore ammonia for direct shipment

The H_2Mare flagship project is aimed at developing the production of hydrogen and downstream products such as synthetic fuels, methanol, ammonia and synthetic methane on the high seas. The power-to-X processes being worked on by thyssenkrupp comprise all three of the last-named products. The company will receive funding of 780,000 euros in the H_2Mare "PtX-Wind" project for the development of the fundamentals up to the engineering stage.

As a specialist in chemical plant engineering and construction, thyssenkrupp can offer various integrated green value chains based on its water electrolysis technology. These include, for example, processes for the production of sustainable ammonia, methanol and synthetic natural gas (SNG). In addition, the company can contribute its extensive knowledge of process optimization, technology scale-up, modularization and experience from over 2500 projects. The holistic consideration of the selected plant and process concepts comprises all relevant research questions from material evaluations and operating modes to safety and environmental concepts.

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As offshore wind turbines supply significantly greater quantities and more regular power than their onshore counterparts, the direct generation of hydrogen and other power-to-X products holds great potential, since the CO_2 and nitrogen required in addition to water can be extracted directly from the air on site. The production of green ammonia in particular can be decisive here, as its high energy density and simpler storage technology make ammonia the cheaper option in some applications compared to hydrogen, for example as a fuel for ships. In countries with a high potential for the production of hydrogen due to good supply of solar and wind power, for example Australia or Chile, green ammonia is superior to green hydrogen as an energy carrier that is destined for export. Since ammonia is transported by ship, transportation routes – and therefore costs – would be saved through direct offshore generation by coupling wind turbines with electrolyzers. Moreover, the offshore wind farm sizes make larger production volumes possible, which in turn reduces the selling prices and makes green ammonia more competitive as an energy carrier.

Research on hydrogen transport solutions

thyssenkrupp is also involved in the third flagship project TransHyDE and is considering the potential of the ammonia cracking process as an associated partner. Over long distances in particular, the transportation of ammonia as a hydrogen carrier is more profitable. After the transportation of green ammonia and its conversion back from liquid ammonia into its constituents hydrogen and nitrogen at locations where hydrogen is required, the hydrogen produced in this way can be put to direct use. Potential applications include, for example, its use in steelworks, as a green feed for chemical plants, or in fuel cells in order to be converted into electrical energy. With Uhde's extensive expertise in the field of ammonia synthesis, the research into the binding of green hydrogen in ammonia for transportation and its subsequent release demonstrates the innovative spirit and future viability of the established technology portfolio elements.

About the hydrogen lead projects:

Funded by the German Federal Ministry of Education and Research. Over 240 partners from science and industry are working together in the hydrogen lead projects. This spring, the projects were launched on the basis of non-binding funding prospects. The funding will amount to around 740 million euros in total. More information is available at wasserstoff-leitprojekte.de.

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About us:

thyssenkrupp Uhde Chlorine Engineers offers world-leading technologies for high-efficiency electrolysis plants. The company, a Joint Venture with Industrie De Nora, has already successfully installed more than 600 projects and electrochemical plants worldwide with a total capacity of over 10 gigawatts. With its water electrolysis technology to produce green hydrogen, it offers an innovative solution on an industrial scale. **thyssenkrupp Uhde** has unique technology expertise and decades of global know-how in the field of chemical plant construction at its disposal – from planning and construction to a comprehensive service. Among other things, the portfolio comprises leading technologies for the production of basic chemicals, fertilizers and plastics, as well as complete value chains for green chemicals. In this way thyssenkrupp's business areas cover the entire value chain for green chemicals – from hydrogen, ammonia and methanol to synthetic natural gas – a major step towards a climate-neutral industry.