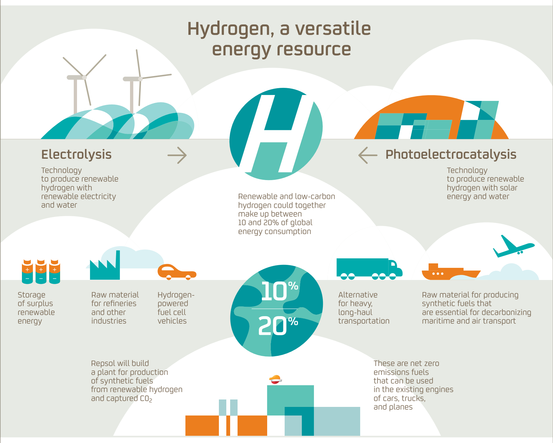

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Renewable and low-carbon hydrogen can become high-potential energy vectors with uses in industry, mobility, or the electrical system, as long as there is an appropriate regulatory framework in place that permits the development of these types of projects and allows for them to be profitable. Repsol is working on different technological options to generate these forms of hydrogen in a competitive way.

"It is estimated that once they are developed in all their potential applications, renewable and low-carbon hydrogen could together make up 10 to 20% of the global energy consumption," explains Elena Verdú, Senior Process Development Scientist at Repsol's Technology Lab. This is why, "in our commitment to the energy transition, we have a clear focus on developing these production technologies."

Renewable and low-carbon hydrogen could together make up between 10 and 20% of global energy consumption

Among the advantages of renewable and low-carbon hydrogen is the versatility of their energy uses. They constitute a more sustainable alternative to the traditional hydrogen that is used in industrial processes, mainly in the production of ammonia and oil refining. In Repsol's case, renewable hydrogen will serve as a raw material for the production of synthetic fuels with net zero emissions at the plant that Repsol is planning to build in the port of Bilbao.

Renewable and low-carbon hydrogen can also be used at a large scale to store all the excess renewable energy that will be produced as the market share of these types of energy increases. The costs of renewable electricity will, predictably, be very low when generation exceeds demand, and this could be used to generate hydrogen at a competitive price.

In the area of mobility, the hydrogen-powered fuel cell vehicle is one of the options to decarbonize mainly heavy road transport.

At present, Repsol is both the leading producer and the main consumer of hydrogen in Spain at the company's industrial complexes that are among the most important in the country. Hydrogen is a key component in its refining processes. It is used in desulfurization and hydrocracking treatments that improve the performance and the environmental quality of the refined fuels.

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Low-carbon hydrogen with CO_2 capture

Renewable hydrogen and CO2 will be the raw materials of the synthetic fuels that Repsol will produce in Bilbao

Today, the most frequently used production technology for traditional hydrogen is natural gas steam reforming. The search for solutions to reduce the carbon intensity of the production of this hydrogen is one of the priorities of Repsol's Technology Area.

A potential way of reducing it is low-carbon hydrogen, produced by reforming steam using fossil raw materials, but including systems to capture the CO_2 associated with the process.

It is expected that this process can become competitive before other alternatives. "The development of the different applications of low-carbon hydrogen would make it possible for the infrastructures and the market to be more mature and consolidated when renewable hydrogen reaches competitiveness," explains Elena Verdú.

Renewable hydrogen: water-based electrolysis and renewable energy

One of the technologies to produce renewable hydrogen is water-based electrolysis, "which consists in the splitting of the water molecule into hydrogen and oxygen through the application of electrical energy. Whenever this electricity comes from a renewable energy source, the hydrogen produced has zero CO_2 emissions," continues Verdú.

Electrolysis with renewable electrical energy will be applied to produce the renewable hydrogen that will be used along with captured CO_2 to create the synthetic fuels with net zero emissions that Repsol will produce at the future plant in Bilbao.

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Other methods to produce renewable hydrogen

Synthetic fuels produced with renewable hydrogen will be essential for decarbonizing sectors that are difficult to electrify, such as maritime or air transportation

Another alternative that Repsol is considering is to produce renewable hydrogen through the traditional process, but swapping the fossil raw material for material from a biological source, like biomethane. This biomethane is obtained from the treatment of biological waste, sewage sludge, domestic organic waste, and industrial or biomass waste. This option makes it possible to continue using the existing plants.

There is also progress in production systems through photoelectrocatalysis which involves direct conversion of solar energy and water to produce renewable hydrogen. "Using this system, we could obtain a renewable hydrogen that is competitive and uses less energy," because its main advantage compared to electrolysis "is that no electricity is used, and it, therefore, does not depend on the electricity price. This results in a significant operational cost reduction".

Repsol is developing its own photoelectrocatalysis technology to produce hydrogen from solar energy. This project is being conducted together with Enagás, and several leading research centers - such as the Catalan Institute for Energy Research, the University of Alicante, and the Aragon Hydrogen Foundation - also participate in the initiative.

Mobility and electricity generation

The expansion of the uses of renewable and low-carbon hydrogen can also contribute to the decarbonization of road mobility. Here these applications could meet the demand of hydrogen powered fuel cell vehicles, a technology that, once fully developed, "is expected to be complementary to battery electric vehicles, especially in heavy-goods and long-distance transportation." Additionally, synthetic fuels produced with renewable hydrogen "will be essential to decarbonizing sectors that are difficult to electrify, such as maritime or air transportation," notes Elena Verdú.

Hydrogen is also an ally of renewable electricity generation, as energy storage at times when generation exceeds demand. This excess energy can be transformed into renewable hydrogen through electrolysis and stored.

Furthermore, the stored energy can be used to generate electricity again (power to power), but it can also be destined to industrial uses, to the generation of both electricity and heat in the domestic sector or used as fuel for mobility.

An appropriate regulatory framework

Among the challenges for renewable hydrogen to take off are the production costs that are currently higher than those of traditional hydrogen. "In the case of electrolysis production, the most decisive factor is the price of electricity," which makes up 70-75% of the costs, explains Verdú. The expected development of the electrolysis techniques will "reduce the investment and increase their efficiency."

Repsol is developing its own technology to produce renewable hydrogen from water and solar energy

Even so, to ensure that the hydrogen-based solutions can become truly competitive, one of the key conditions will be the development of an appropriate regulatory framework. Building on the Roadmap approved by the Spanish Government Cabinet on October 6 this year, the framework should facilitate the development of these types of projects and allow them to reach the necessary thresholds of profitability. "Only this way can a true expansion of these technologies take place," concludes Elena Verdú.

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