Low-cost White Hydrogen as a pathway to a carbon-neutral and sustainable circular economy.

Delafield Pty Ltd is a Research & Development company based in Australia and established in 1987.
The company's focus is on low-emission technologies and Creates Carbon Neutral solutions.

We are inviting suggestions from companies interested in acquiring the White Hydrogen technology.

Abstract

Achieving a carbon-neutral economy looks like a daunting challenge; with the right approach, we can overcome these challenges and create opportunities that require us to act now and change how we live and use our resources. First, we must build a sustainable circular economy that can provide affordable and reliable energy for processes and transport. For example, Biodiesel has proven to be a viable renewable energy alternative for the transport sector, and its production has significantly increased over the last decade. Consequently, the volume of crude glycerol, a by-product of Biodiesel, has risen and has caused an oversupply in the glycerine market. It allowed us to develop an innovative carbon-neutral process for converting crude glycerol to renewable White Hydrogen at an exceptionally low cost, thereby providing a clear pathway to a renewable, carbon-neutral economy.

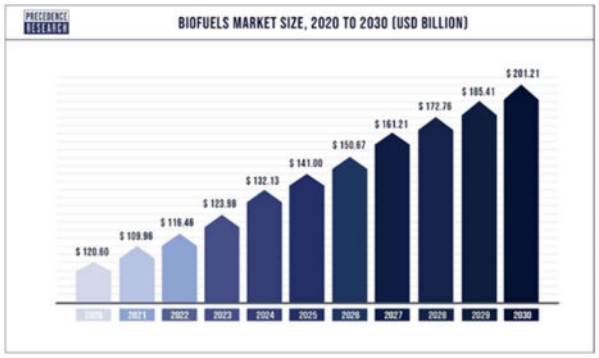
Climate change is an urgent concern we must deal with; hence more than 140 countries have joined an alliance aiming for net zero emissions by 2050. However, decarbonising our economies requires us to act now and change how we live and use our resources; we must eliminate or limit the use of fossil fuels in the mobility industry. We must strive towards a circular and sustainable economy without pollution.

Biofuels current challenges

The mobility industry is a significant source of emissions, and various new energy production processes have appeared in the past decades. Still, not all are green, environmentally sustainable, or cost-effective.

Biodiesel is a viable fuel alternative and is produced from vegetable oils, waste cooking oils, or animal fats and reduces life cycle emissions; the carbon dioxide released from biodiesel combustion is offset by the carbon dioxide absorbed from growing canola, soybeans or other feedstocks used to produce the biofuel. As a result, this fuel is a viable renewable alternative to fossil-based fuel; its production has significantly increased over the last decade. However, during biodiesel production, approximately 10% of the feedstock ends up as Crude glycerol, a by-product of the transesterification process. Causing an oversupply of the glycerol market. Furthermore, Crude glycerol is expensive to process to refine glycerine for use in food, cosmetics pharmaceutical, and this market is also at capacity. Resulting in a low market value of glycerol with prices continuing to fall. Currently, crude glycerol sells for $0.00 to $0.11 per kg.

Biodiesel producers must seek alternative use or recyclable methods for their waste Crude Glycerol.

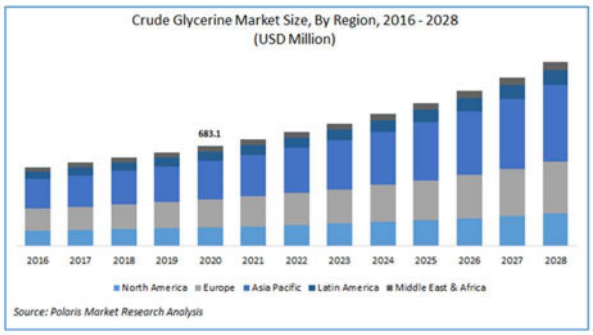


According to Precedence Research, the global biofuels market was valued at US$ 109.96 billion in 2021 and is predicted to reach US$ 201.21 billion by 2030, with a CAGR of 8.3% during the forecast period from 2021 to 2030.

According to Precedence Research, the biodiesel market compound annual growth rate forecast is 8.3%, from US$ 116.46 billion in 2022 to US$201.21 billion in 2030.

Various methods and utilisation have been attempted to create value-added products from crude glycerol, including combustion, composting, animal feeds, anaerobic digestion, biological/thermal conversions, and others. But unfortunately, found no feasible, sustainable solution to deal with oversupply and disposal. Still, it must be dealt with as it contains salt, free fatty acids, and methanol that could cause environmental problems.

Crude glycerol is a biodiesel waste product; we see this as a supply driver for clean hydrogen. Consequently, Delafield developed a sustainable carbon-neutral solution to deal with the complex composition of crude glycerol by converting this to renewable hydrogen.



The global crude glycerine market was valued at USD 683.1 million in 2020 and is anticipated to grow at a CAGR of 8.1% during the forecast period.

Polaris Market Research expects the crude glycerol market to grow at a CAGR of 8.1%, from US$683.1 million in 2020 to reach US$1260 million by 2028.

Hydrogen, the only fuel to produce water as a by-product, is an ideal energy carrier for our future energy needs. Green and White Hydrogen are critical to a net zero economy goal. The hydrogen market is expected to grow exponentially in the coming years due to the many applications in various industries and processes. Small hydrogen hubs, fuel cells and ammonia for the mobility industry are one of the applications where hydrogen will be used as a green alternative to fossil fuels. Even though hydrogen is a clean and ideal energy carrier with water as a by-product and is promoted under a variety of colours, we must be mindful that not all hydrogen production is emissions-free or produced from renewable and sustainable sources.

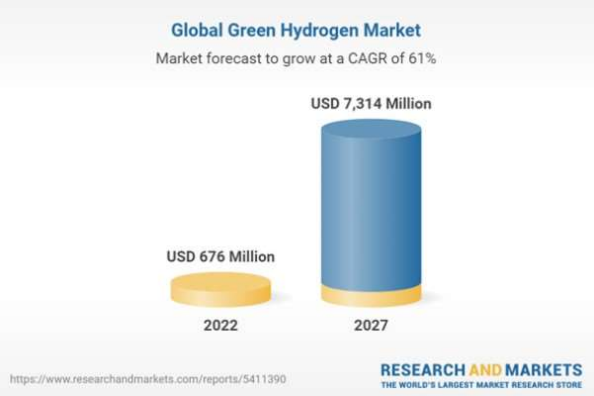
Green and White Hydrogen production methods are the only emission-free, carbon-neutral processes and key to a sustainable and carbon-neutral economy.

Clean hydrogen this term is increasingly used and is potentially misleading. Although it refers to hydrogen as a clean fuel, not a zero-emission production process, clean hydrogen production emits substantial amounts of CO_2 and other greenhouse gases.

A kaleidoscope of other colours is used to identify hydrogen and its production process. For example, on a large industrial scale, more than 96% of grey, black, brown, turquoise, and blue hydrogen is produced from natural gas, coal, and oil. These processes emit significant amounts of carbon dioxide (CO_2) into the atmosphere. As a result, these hydrogen production and distribution processes are not sustainable and not aiding to the net zero goal. Furthermore, the above colours of hydrogen are not immune to inflationary pressure; due to the rising cost of natural gas and electricity, the price of hydrogen has spiked to more than double its typical levels.

Green electrolytic hydrogen is produced in smaller and more expensive production systems using solar and wind power to generate the energy required for the electrolysers to spit hydrogen from water. However, besides the large area of land needed, solar and wind are not without

limitations and are not available 24/7 in all the countries aiming for net zero by 2050. Furthermore, look at a typical breakdown for green hydrogen production through electrolysis. In that case, it demands at least 55 kW of electricity and ≈60 litres of raw water (9 litres of purified water) per kg of hydrogen produced. If brackish, seawater or industrial wastewater is used, the kWe energy and volume of raw water will increase dramatically, and so will the disposal cost of wastewater/brine produced from water purification. Therefore, the primary disadvantage of green hydrogen is the cost; it is more expensive to produce than fossil-fuel-based hydrogen.



The market size in 2022 was around US$676 million, with a forecast to reach US$7,314 million by 2027, a compound annual growth rate of 61%.

White Hydrogen is produced in an innovative, proven processing plant, H2-XERONOX®, a thermo-chemical process where an abundant, low-cost organic waste by-product from biodiesel production, crude glycerol and reactant is converted to a hydrogen-rich gas.

H_2-XERONOX® is a patented processing plant for converting low-value feedstock to valuable hydrogen. The H_2-XERONOX pilot plant has been operating successfully with crude glycerol to produce a hydrogen-rich syngas stream with ≈80 vol% Hydrogen, approaching the theoretical maximum conversion rate. Further hydrogen purification to 99.999% purity can be conveniently achieved by existing separation technologies such as pressure swing adsorption or membrane separation.

The conversion of crude glycerol to hydrogen provides the most economical, sustainable, and cost-effective way to produce White Hydrogen (H_2).

The modular H_2-XERONOX® plant can be installed at the end user's sites. The hydrogen can then be used for a variety of processes, fuel cells, or stored in metal hydrides making transportation of hydrogen gas obsolete. On-site hydrogen production is widely seen as a promising alternative in the transition phase towards a fully renewable carbon-neutral hydrogen economy.

The Delafield H_2-XERONOX® is a fully self-sustaining thermo-chemical process for producing hydrogen-rich gas steam. When this gas steam is subsequently purified with pressure swing adsorption to quality 5.0, the off-gas from this purification process is recycled back to the reactor supplying the energy required to run the crude glycerol to the hydrogen conversion process.

Hydrogen storage in metal hydrides is ideal for hydrogen produced on-site. When hydrogen is needed, it can instantly be recovered as a gas or as electricity by adding heat. It is the most reliable and secure way for hydrogen storage at room temperatures and low pressure, the most loss-free and durable storage option.

Potential hydrogen applications

The applications of hydrogen from a renewable source are virtually unlimited and include industries involved, mobility, E-car charging, pharmaceuticals, ammonia fertilisers, waste management, fuel cells, power generation, transport, and many others.

According to S&P Global Commodity Insights, as of August 2022, green hydrogen costs US$5.50 – US$9.50 per kg.

H_2-XERONOX® Unique value proposition

- With the H_2-XERONOX® proven production process, a price of hydrogen below $1.00 per kg is achievable.
- The H_2-XERONOX® conversion of crude glycerol, a low-value waste by-product of Biodiesel, to valuable hydrogen is low-cost,

safe, sustainable, and environmentally responsible.

- A process that ticks all the boxes for sustainable, carbon-neutral hydrogen production.
- In this self-sustaining H_2-XERONOX® process, the energy required for the conversion of crude glycerol to hydrogen comes from the process itself; a small percentage of the product gas stream is recycled back and provides the energy needed for the process.
- H_2-XERONOX® is scalable. However, due to hydrogen handling and transport complexity, we believe this technology is most suitable for small to medium-high-efficiency on-site hydrogen production and storage. Hydrogen can be used in fuel cells when demand requires this.
- H_2-XERONOX® hydrogen plant is a modular system with a small footprint.
- H_2-XERONOX® hydrogen production process is suitable for remote locations, apartment buildings, industry or hydrogen refuelling stations and has virtually unlimited applications possibilities.
- H_2-XERONOX® sustainable White Hydrogen sets a benchmark and provides a pathway to a carbon-neutral and sustainable future.

Sustainability is the ingenuity to exist without damaging the ecosystems or depleting natural resources. Hence, we must all do our utmost to find new solutions to reducing carbon emissions and providing a sustainable circular economy.

In summary,

- ✓ H_2-XERONOX®, the White Hydrogen production process, is low-cost and ticks all the boxes for a Carbon Neutral and Sustainable Circular Economy.
- ✓ H_2-XERONOX® a proven process to produce hydrogen-rich gas streams of ≈80vol% hydrogen. (The pilot plant has been operating on crude glycerol). An alternative carbon-based feedstock is feasible.
- ✓ Production of Hydrogen-rich syngas for direct application in Solid Oxide fuel cells or PSA purification to quality 5.0 (99.999% purity)
- ✓ The H_2-XERONOX® White Hydrogen production technology provides added value to the biodiesel industry and potentially reduces the cost of Biodiesel.
- ✓ White Hydrogen, with an achievable cost below $1.00, offers a high-value solution to the low-value crude glycerol by-product.
- ✓ H_2-XERONOX®, a safe and renewable White Hydrogen production method at end users' sites or locations, combined with fuel cell technology (SOFC) or PSA, will avoid expensive hydrogen transport and storage.

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