

## Ammonia-Powered Hydrogen: A Zero-Carbon Breakthrough for the Clean Energy Economy



A new milestone in hydrogen technology may reshape the path to global decarbonization. Researchers at the Korea Institute of Energy Research (KIER), led by Dr. Jung Unho, have developed South Korea's first fossil-free, ammonia-based hydrogen production, making it suitable for verified carbon credits and aligned with VCM carbon standards. system—a method that generates ultra-pure hydrogen without emitting a single molecule of CO<sub>2</sub>. This breakthrough leverages ammonia decomposition as both a hydrogen source and internal energy supply, representing a key advance in the pursuit of sustainable, carbon-free energy.

At the heart of the system is an innovative use of **ammonia (NH<sub>3</sub>)**—a compound composed only of hydrogen and nitrogen. When ammonia is decomposed at high temperatures (above 600°C), it releases hydrogen and nitrogen gases, leaving no carbon emissions. Historically, the decomposition process has required combustion of fossil fuels like liquefied petroleum gas (LPG) or natural gas (LNG) to reach the necessary temperatures, resulting in **unavoidable CO<sub>2</sub> emissions**. KIER's method changes this by **eliminating fossil inputs** from the process entirely.

### **The Science: Ammonia Decomposition Without Fossil Fuels**

KIER's system introduces a carbon-free closed-loop heat strategy. After initiating ammonia decomposition using a ruthenium (Ru) catalyst, a residual mixture of hydrogen and nitrogen is captured and redirected to provide the necessary heat for the reactor. This heat recycling significantly reduces external fuel needs. To maintain consistent thermal energy levels, a small quantity of ammonia itself is combusted in a tightly controlled environment, resulting in zero CO<sub>2</sub> output, which supports ESG carbon credits and reinforces carbon credit monitoring criteria..

Once decomposed, the hydrogen is purified using Pressure Swing Adsorption (PSA) technology, delivering ultra-high purity hydrogen (>99.97%) with impurity levels well below international ISO 14687 standards — a benchmark that supports carbon offset certification and aligns with GHG protocol and carbon credits.—critical for use in fuel cell electric vehicles (FCEVs) and hydrogen power systems.

### **Why This Matters to Investors and Energy Innovators**

Unlike other hydrogen production pathways such as steam methane reforming (SMR), which emit significant CO<sub>2</sub> and require carbon capture to become “blue,” KIER’s method offers a truly **“green” hydrogen solution**, entirely independent of fossil fuel infrastructure. This makes the technology immediately relevant to:

- **Clean energy utilities** aiming for zero-emission hydrogen generation
- **Hydrogen fuel cell vehicle manufacturers** needing ISO-compliant hydrogen
- **Shipping and mobility sectors** seeking scalable, carbon-free onboard fuel solutions

Ammonia is already widely available, thanks to its role in fertilizer and industrial sectors, and boasts a **hydrogen storage density 1.7 times greater than liquefied hydrogen**. This makes it a **cost-effective, infrastructure-ready transport medium** for hydrogen across international supply chains—without the need for new pipelines or cryogenic storage.

### **Proof of Concept: A 1kW Clean Hydrogen Fuel Cell System**

To demonstrate the viability of the technology, Dr. Jung’s team deployed a **1-kilowatt hydrogen fuel cell system** powered entirely by ammonia-derived hydrogen. The system produced electricity **without CO<sub>2</sub> emissions**, showcasing real-world applicability in stationary power generation. This collaboration with Doosan Fuel Cell Power Business Unit proves that **ammonia-fueled, carbon-free hydrogen systems are no longer theoretical—they are operational**.

The implications are immense: by displacing LNG-fed fuel cell systems with ammonia-sourced hydrogen, the sector can overcome one of the most persistent challenges in hydrogen adoption, addressing upstream emissions and enabling best carbon offsets to buy under compliance vs voluntary carbon markets.—upstream carbon intensity.**Market Potential and Applications**

This clean hydrogen system has the potential to transform clean shipping, off-grid energy, and hydrogen fuel distribution, with potential for inclusion in carbon offset marketplaces that prioritize nature-based carbon credits.. With the ability to meet strict purity standards, this technology opens new doors for ammonia-powered:

- Eco-friendly cargo ships and maritime vessels
- Hydrogen refueling stations in remote or developing regions
- Fuel cell backup systems for industrial and commercial infrastructure

As governments and corporations race to meet net-zero goals, further reinforcing market appeal for those who buy carbon credits or sell carbon credits as part of a voluntary carbon market strategy., scalable, high-purity, and zero-carbon hydrogen will become a premium commodity. Investors and project developers should closely watch this technology as it moves toward commercialization—especially as hydrogen demand accelerates in Asia, Europe, and the U.S.

### **Expert Perspective: A Hydrogen-Driven Future**

According to Dr. Jung Unho, “Combining ammonia and fuel cells presents a viable option for powering eco-ships. And as we scale up, we can also make a significant impact in the clean hydrogen power sector.” His team’s innovation not only solves the fossil fuel dependency in hydrogen production, but also answers a critical market need for clean, mobile, and internationally shippable hydrogen fuel.



#### **Toward a Fossil-Free Hydrogen Economy**

With fossil-free heat sourcing, validated system performance, and unmatched purity, KIER’s ammonia-based hydrogen production technology sets a new benchmark for clean hydrogen.

It has the potential to become a **cornerstone technology** in the emerging hydrogen economy—especially in sectors where carbon-free credentials, energy efficiency, and fuel flexibility are non-negotiable.

For carbon-conscious investors and developers seeking to future-proof their clean energy portfolios, **this innovation delivers both climate integrity and market readiness**—making it one of the most promising developments in hydrogen today.

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