On-Site, On-Demand H_2 in the Artificial Diamond Industry

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HYDGEN

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Introduction

Hydrogen is an essential element in the manufacturing of artificial diamonds using the Chemical Vapour Decomposition (CVD) process. In a typical CVD setup, the plasma environment which is required for the growth of the diamonds comprises a mixture of 1% methane and 99% hydrogen. This process demands high purity of hydrogen, even traces of contaminants like oxygen or water vapour can compromise crystal structure, introduce lattice defects, and significantly affect the optical clarity of the final gemstone. As a result, maintaining consistent hydrogen quality is critical not just for achieving high-quality end product, but also for ensuring stable operations and accurate process control throughout the diamond growth.

HYDGEN offers a decentralized, on-site hydrogen production solution using modular electrolyzers that generate ultra-pure hydrogen (99.97+%) on demand. For artificial diamond manufacturers around the world, especially in industrial clusters with constrained infrastructure or limited hydrogen delivery options, this model enables lower-cost, more reliable hydrogen access while eliminating the emissions, delays, and supply chain risks associated with centralized delivery models.

Today, most manufacturers rely on centralized production facilities that use fossil fuel-based methods and high-pressure gas cylinders to store and transport hydrogen to manufacturing sites. This model can result in:

- High per-kg costs (often $8–$20/kg depending on region and logistics)
- Inconsistent supply and delivery delays
- Safety and storage challenges
- Minimal transparency into hydrogen purity or emissions footprint

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However this approach is rapidly becoming unsustainable as industries face tightening regulations, carbon pricing mechanisms, and growing supply chain disruptions, the need for transitioning to on-site hydrogen generation is more pressing than ever.

This paper explores the case of decentralized hydrogen production in the artificial diamonds industry and why it is becoming a strategic necessity for businesses looking to stay competitive.

Hydrogen Use Cases in the Industry

Hydrogen is not merely a process gas, it's a critical enabler of both plasma generation and impurity control in the CVD method.

Plasma Creation

Hydrogen is required to initiate and sustain the microwave or hot filament plasma used to break down methane and deposit carbon atoms onto a seed crystal. These carbon atoms form the sp^3-bonded lattice that makes up a diamond.

Surface Purification

Hydrogen plays a key role in etching away non-diamond carbon (sp^2), ensuring the resulting crystal maintains its diamond structure and clarity. It helps maintain the proper bonding environment and prevents the formation of graphite-like defects during growth.

For manufacturers using Microwave Plasma-Enhanced CVD (MPCVD), hydrogen purity is non-negotiable. Hydrogen used in this process often requires 99.999% purity (6.0 grade) to avoid contamination and ensure layer consistency.

Current & Projected Demand for H_2

The demand for hydrogen in the artificial diamond industry is expected to grow steadily as CVD production scales and quality standards become more stringent. Unlike large industrial uses, diamond manufacturing requires smaller but extremely pure and consistent hydrogen supplies making it an ideal candidate for on-site hydrogen generation.

Current H_2 demand in the industry

There's a growing push for more sustainable practices in lab-grown diamond production. Using **green** sources of hydrogen, like **water electrolysis powered by renewable energy**, can significantly reduce the carbon footprint of diamond manufacturing.

Projected H_2 demand by 2030

The growth of the lab-grown diamond market points to a corresponding rise in hydrogen consumption. As the industry scales and prioritizes sustainability, the demand for high-purity hydrogen especially green hydrogen is expected to increase significantly.

CO_2 emissions impact

Every tonne of grey hydrogen used results in roughly 10 tonnes of CO_2 emissions. Given the industry's current reliance on grey hydrogen, total emissions from hydrogen usage in this sector amount to approximately 30 million tonnes of CO_2 per year.

Supply Chain Challenges in the Status Quo

Purity Inconsistencies

By definition, grey hydrogen will include impurities not found in green hydrogen electrolysis processes. And even among certified vendors, hydrogen purity can degrade during transport or cylinder refilling, introducing variability and increasing rejection rates in diamond manufacturing lines.

Limited Supplier Ecosystem

Only a small number of gas companies are certified to deliver ultra-high purity hydrogen and methane for CVD use. This creates a fragile supply chain, where regional access is limited and redundancy is nearly non-existent.

Price Volatility

During the 2022 energy crisis, European natural gas price spikes led to a 22% increase in methane prices and drove up hydrogen-related operating costs by 15–25% in some industrial clusters. This volatility threatens operating margins and limits long-term cost planning.

High Hydrogen Delivery Costs

Transporting high-pressure hydrogen cylinders adds significant cost. Hydrogen logistics can contribute up to 70% of total hydrogen cost, especially in regions far from production hubs.

Safety, Compliance, & Waste

On-site cylinder storage increases safety risks, compliance burdens, and on-site labor requirements. Additionally, end-users often lack transparency into the actual purity of delivered gas, putting product quality at risk.

Why On-Site, On-Demand Hydrogen is the Future

The challenges associated with grey hydrogen supply are pushing manufacturers toward a new solution: on-site, on-demand hydrogen production. By generating hydrogen as needed, companies can take control of their supply, eliminating transportation risks and reducing exposure to market volatility.

Just as importantly, producing hydrogen locally allows companies to transition away from fossil-based hydrogen and cut their carbon footprint without relying on expensive offsets.

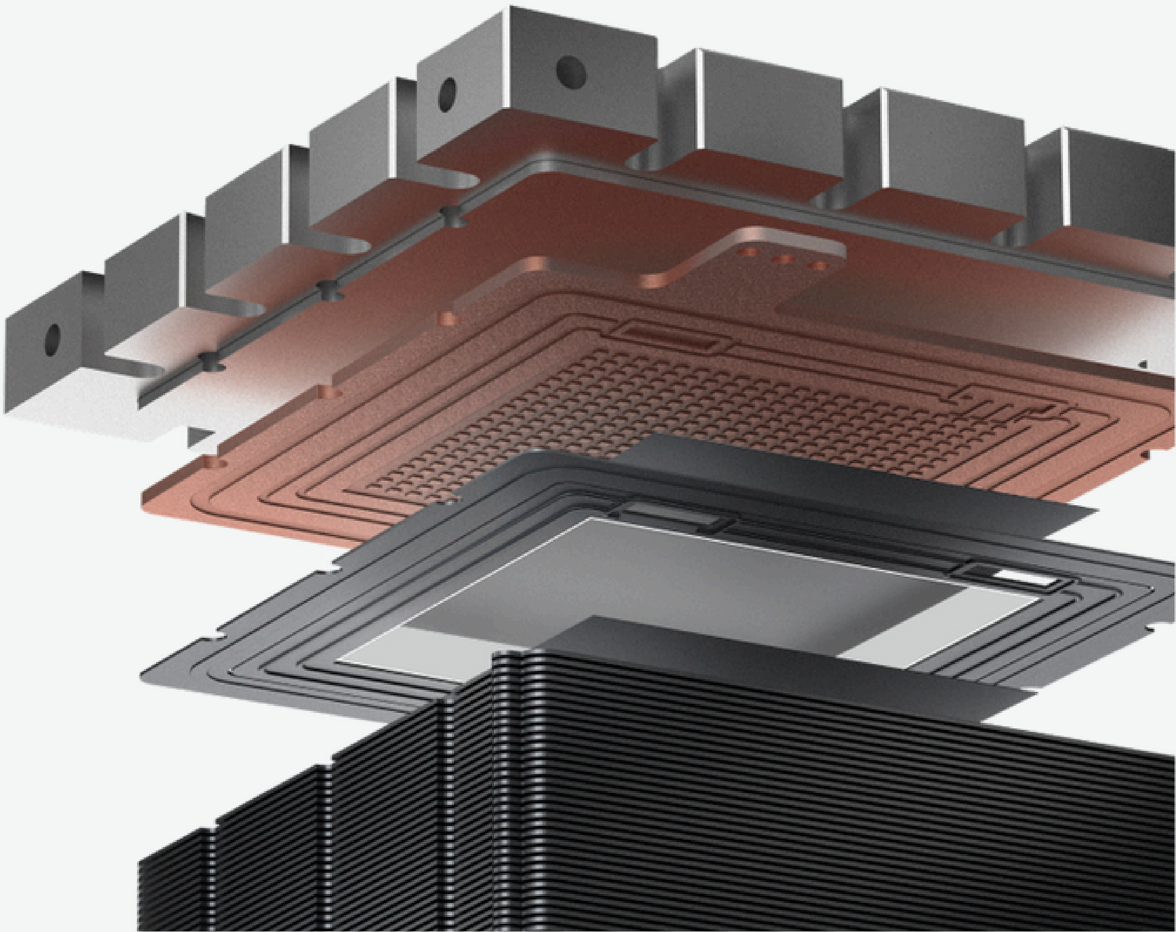
With on-site production, costs become more predictable. Instead of fluctuating with market conditions, hydrogen costs are tied to electricity prices—an increasingly favorable dynamic as renewable energy sources such as solar and wind become more affordable. For manufacturers with existing renewable energy capacity, integrating electrolysis into their operations can create a self-sustaining hydrogen supply, further enhancing cost efficiency.

Operational flexibility is another advantage. Hydrogen production can be adjusted based on real-time demand, reducing waste and improving efficiency. This level of control is particularly valuable for manufacturers dealing with batch production processes or fluctuating order volumes.

The Shift Towards Localized Hydrogen Production

HYDGEN's decentralized, modular hydrogen generators offer a new model tailored to the precision and continuity needs of synthetic diamond manufacturing:

Ultra-Pure Output	Electrolyzer stacks produce hydrogen with ≥99.97% purity (optionally upgradable to 99.999% with polishing stages), directly from water and electricity, no fossil fuels or bulk delivery required.
On-Demand Operation	Hydrogen is generated and consumed on-site, reducing the need for high-pressure storage, and eliminating exposure to delivery schedules or truck-related delays.
Real-Time Monitoring	HYDGEN's control systems offer live purity readings, flow rate management, and leak detection, delivering full transparency and process assurance.

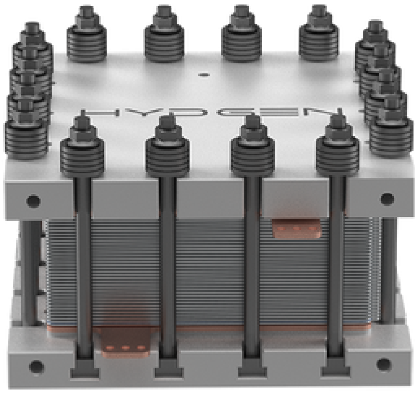


A Strategic Fit for Modern Manufacturers

Artificial diamond production is scaling rapidly, driven by demand in electronics, optics, quantum computing, and high-end jewelry. As production scales, so does hydrogen demand.

A centralized model quickly becomes a bottleneck:

	Centralized Supply	HYDGEN On-Site
Purity Control	Low	High
Delivery Risk	High	None
Cost Predicability	Low	High
ESG Transparency	Low	High
Scalability	Limited	Modular
Safety & Compliance	High Burden	Automated & Built-In



Quantifying the Benefits

For a facility using 1,000 kg of hydrogen per year, this transition could result in $60,000–$90,000 annual savings, improved uptime, and reduced rejection rates due to purity inconsistencies.

	Delivered H_2	On-Site H_2
Base H_2 Cost	$5.50/kg	$3.90/kg
Transport & Logistics	$3.00	$0.00
Cylinder Handling & Testing	$2.50	$0.00
Total Cost	$11.00	$3.90-$5.20

Prices vary by region and electricity source

The HYDGEN Technology Stack

Built for performance, scalability, and safety in precision manufacturing environments.

- **Anion Exchange Membrane (AEM) & Proton Exchange Membrane (PEM)** electrolyzer stacks
- **Purity Output:** ≥99.97% out-of-stack hydrogen; upgradable to ≥99.999% with polishing
- **Production Rate:** Configurable over 50 Nm^3/h
- **Modular Skid Design:** $2m^2$ footprint per stack; stackable for increased output
- **Smart Control & Safety:** Built-in sensors, remote monitoring, and leak detection
- **Power Integration:** Compatible with solar, hybrid, or 3-phase grid electricity
- **Digital Interface:** Cloud-based dashboard for monitoring, control, and maintenance planning

Conclusion

For manufacturers in the artificial diamond industries, the shift to on-site hydrogen isn't just a sustainability decision—it's a strategic move to enhance operational resilience, reduce costs, and stay ahead of evolving regulatory requirements.

As the economic landscape changes, companies that continue to rely on grey hydrogen may find themselves at a competitive disadvantage, while those that embrace on-site, on-demand production will be better positioned to navigate future challenges.

The transition to decentralized hydrogen production is no longer a theoretical concept—it is a viable and necessary step toward a more stable and sustainable supply chain.

Transform Your Production with HYDGEN

For more details on implementation and feasibility, please contact our team to explore how on-site hydrogen can work for your specific processes.

Contact Us Today:
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