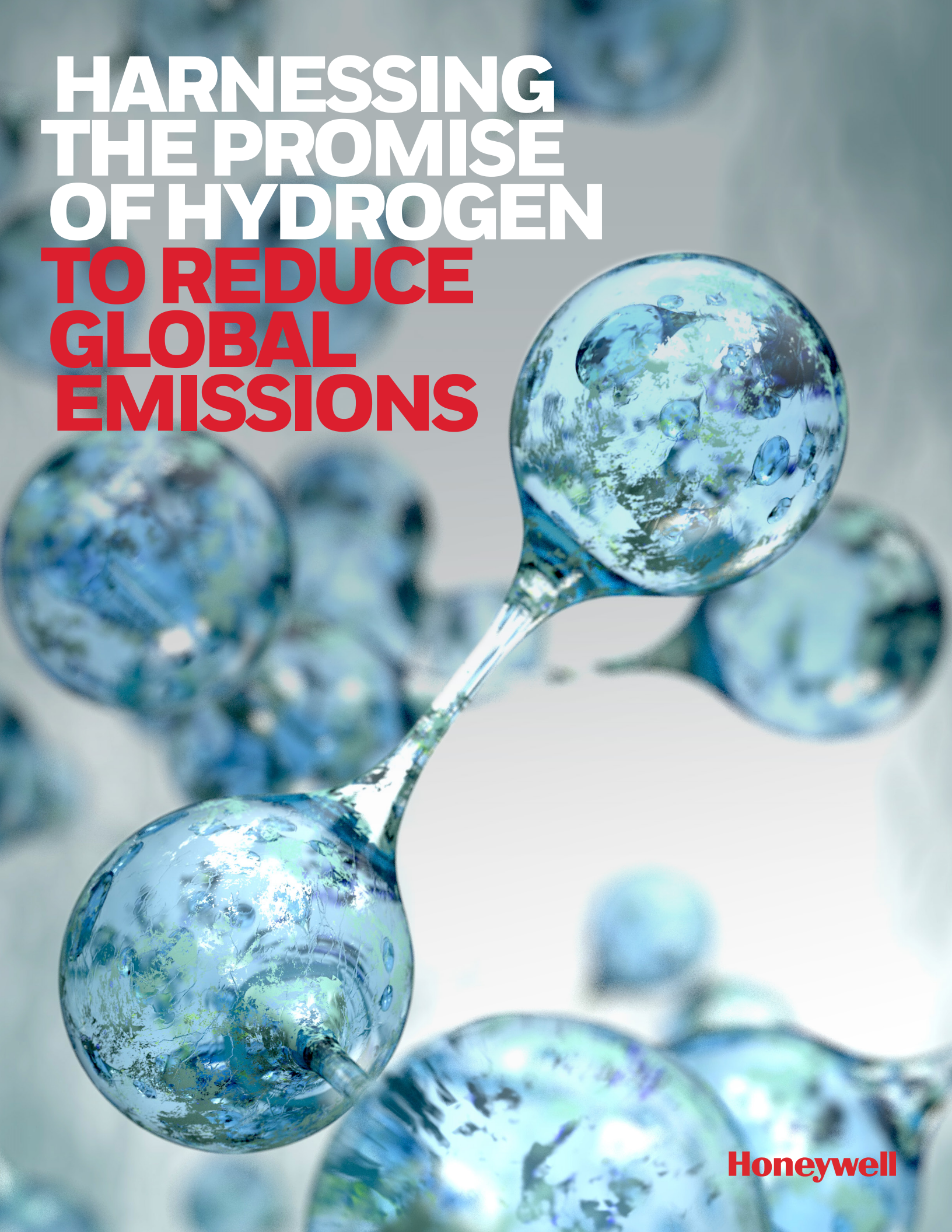
HARNESSING THE PROMISE OF HYDROGEN TO REDUCE GLOBAL EMISSIONS



Honeywell

THE PROMISE OF HYDROGEN ENERGY

> The most abundant element in the universe, hydrogen offers significant potential to reduce carbon emissions around the world and create a greener, safer future for us all.

That's because when it is produced using renewable energy, hydrogen emits no greenhouse gases, which lends it to playing a central role in next-generation, clean energy networks. Furthermore, hydrogen's ubiquity in industrial processes and its suitability as a fuel for a wide range of applications makes it ideal for widespread adoption.

However, for hydrogen to make an impact globally, it needs to overcome a number of challenges, including a lack of infrastructure, limited production capabilities and high costs.

Fortunately, several factors are tipping the balance toward a hydrogen-propelled future.

The cost of hydrogen, for example, is anticipated to fall sharply over the next decade, and by 2030 hydrogen is expected to be price-competitive with other low-carbon alternatives and some conventional energy sources.[1]

Infrastructure-wise, existing natural gas grid networks around the world can be adapted to accommodate hydrogen at minimal cost. Europe, for instance, has a well-developed grid that could be converted relatively quickly. In fact, to meet long-term obligations under the United Nations' COP21 Paris Climate Agreement, hydrogen is expected to be blended with natural gas to comprise 25% of the energy in EU gas grids by 2050.[2] This will help the EU realize key COP21 objectives including virtually carbon-free power generation, increased energy efficiency and the deep decarbonization of transport, buildings and industry. Meanwhile, separate initiatives are underway in the region to create 100% hydrogen-powered energy grids.

The final barrier to mainstream adoption is the availability of solutions that harness hydrogen for the manufacturing of goods – specifically, via thermal appliances in which heat is required. Here, Honeywell Thermal Solutions is rapidly expanding its portfolio of hydrogen-ready burners that can fire up to 100% hydrogen with no burner modification required; and hydrogen-capable burners that can fire up to 100% hydrogen or a mix of hydrogen, with a slight burner modification required. Let's look at these offerings in more detail.

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[1] *Hydrogen Council report, January 2020*

[2] *Hydrogen Roadmap, Fuel Cells and Hydrogen Joint Undertaking, 2019*

HONEYWELL'S RESPONSE TO DEMAND

> Honeywell Thermal Solutions has built its reputation on helping industrial and commercial thermal process customers reduce NOx combustion emissions, achieve energy efficient operations and enhance safety through cutting-edge thermal equipment.

In recent years, Honeywell has conducted extensive lab-based computational fluid dynamics simulations between natural gas-fired burners and hydrogen-fired burners, and studies on how to best adapt burners for hydrogen firing. Additionally, the company is applying learnings from application testing with customers, and development best practices from its deep experience with thermal process applications.

All of this expertise is being channeled into a portfolio of hydrogen-ready and hydrogen-capable burners that, when combined with Honeywell hydrogen-ready fuel supply products and controls, provides customers with a complete solution for hydrogen combustion. No other vendor can match the breadth and depth of Honeywell's offering across different applications, markets and verticals.

Honeywell's number one priority when designing fuel fired thermal appliances is safety. Every Honeywell burner undergoes a technical risk assessment at both proposal phase and execution phase to ensure it meets application safety requirements. In addition, the burners are designed to comply with local safety codes and standards, and to meet customer specifications.

Given hydrogen's large flammability range, high flame speed and low ignition temperature, precautions are taken in applying proper electrical wiring application principles, as well as to the design of purging, ratio-control, temperature protection and burner management functions. Additionally, leak testing and functional testing is performed during manufacturing and further testing and inspection is undertaken during commissioning.

Although Honeywell today offers a vast selection of hydrogen-ready and hydrogen-capable solutions, it will continue to convert more of its range for hydrogen firing over the coming years and bring additional innovations to market.

HYDROGEN BURNERS FOR VIRTUALLY ANY APPLICATION

Honeywell's burner portfolio includes both hydrogen-ready and hydrogen-capable burners designed for a wide range of markets and applications, including:

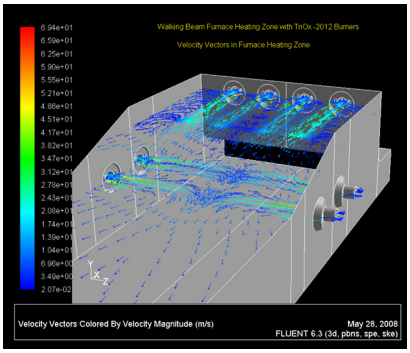
- **Automotive:** incinerators, paint cabin air supply units and paint bake ovens
- **Food:** baking ovens, coffee roasters, counterflow dryers and spray dryers
- **Paper:** paper-edge dryers, TADs and Yankee hoods
- **Chemical:** process air heaters and thermal oxidizers
- **Glass:** high temperature oxygen burners for glass melting ovens
- **Printing:** drying units for industrial printing machines
- **Environmental:** flue gas treatment, sludge dryers and solid waste incinerators
- **Metal:** ladle preheaters, metal melting and thermal treatment
- **Textiles:** pre-dryers and tenter frames
- **Construction:** bake ovens for bricks, cement and sand dryers, gypsum board dryers and insulation fabrication
- **Oil & Gas:** gas treatment, glycol reboilers, shut off valves and vaporizers for LNG production
- **Power Generation:** boilers, heat and power cogeneration systems and steam generation systems

COMPLETE SOLUTIONS FOR HYDROGEN COMBUSTION

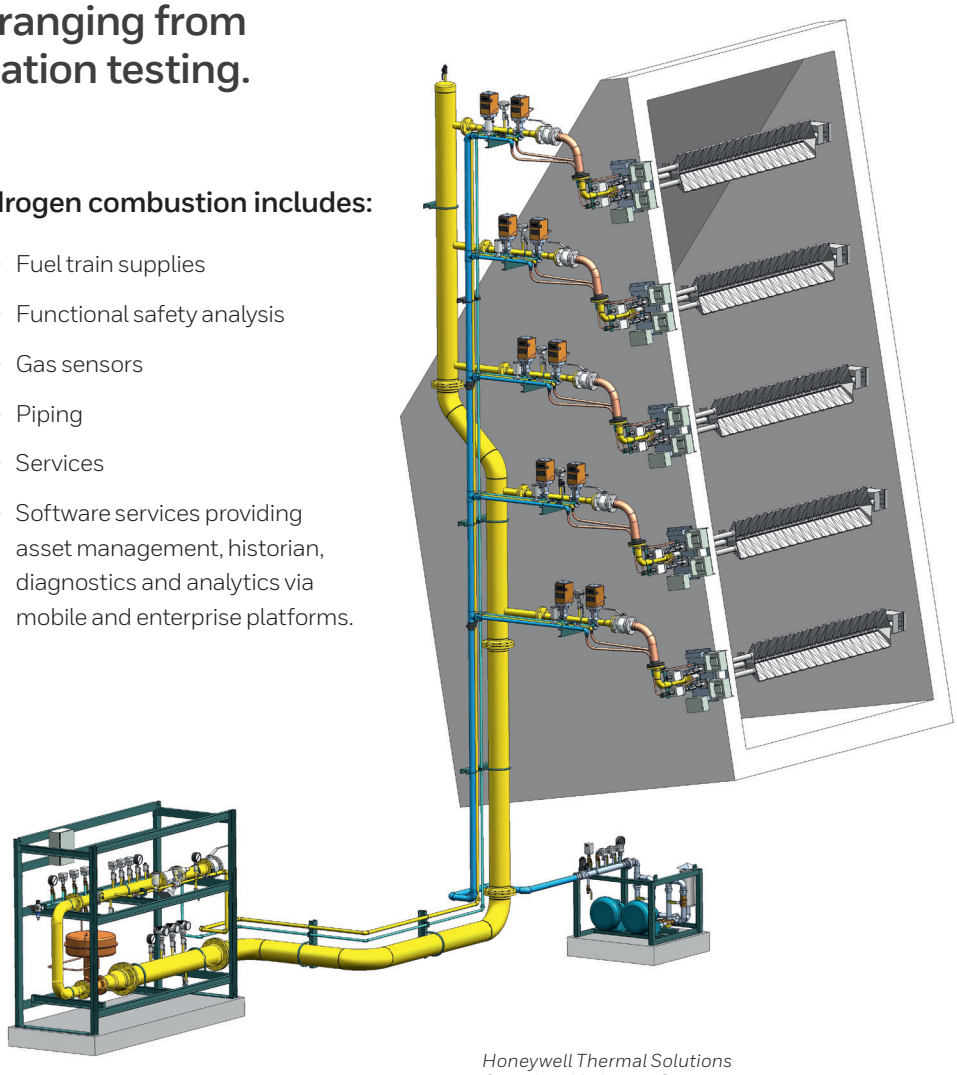
In addition to burners, Honeywell provides customers with everything they need for hydrogen combustion, from products such as fuel train supplies, piping and burner management systems, to software solutions such as Thermal IQ™, which turns thermal process data into actionable information that enables users to optimize their thermal process systems. Honeywell also delivers a wide range of services ranging from commissioning to application testing.

Honeywell's complete solution for hydrogen combustion includes:

- Blending (mixing) systems
- Burner control panels
- Burner management systems
- CFD analysis
- Combustion chambers
- Flame monitoring systems designed for multi-flame supervision
- Fuel/air adaptive control systems
- Fuel train supplies
- Functional safety analysis
- Gas sensors
- Piping
- Services
- Software services providing asset management, historian, diagnostics and analytics via mobile and enterprise platforms.



Honeywell CFD Computational Fluid Dynamics.



Honeywell Thermal Solutions Complete Hydrogen System.

Honeywell reduces cogeneration plant emissions by switching to hydrogen fuel

When a global chemical customer wanted to refit its longstanding gas turbine and steam boiler cogeneration system to run on hydrogen power, it turned to Honeywell for assistance.

The conversion opportunity arose when the customer was approached to purchase an ongoing supply of hydrogen at low cost. Spotting an opportunity to achieve cleaner operations and reduce carbon footprint, an agreement was soon reached.

However, there was a challenge: the hydrogen supply wasn't constant. During peak production, the supply could be sufficient to run the entire installation on hydrogen, but equally, there could be periods when no hydrogen was available.

The solution? To build flexibility into the system by allowing it to run on 100% natural gas, 100% hydrogen, or any mixture of the two. At the same time, the customer wanted the conversion performed with little or no system re-adjustments, mechanical changes or safety setting changes.

Honeywell—which helped to design the original cogeneration system—was brought back in to manage the conversion. It began by implementing an additional fuel train to safeguard the hydrogen supply. Among other control equipment, Honeywell Maxon safety shut off valves were used to connect the hydrogen supply and mix it with the natural gas line upstream of the burners. Finally, Maxon Series HC AIRFLO® low NOx burners were deployed to seamlessly accommodate both natural gas and hydrogen, with no changes required to the gas nozzles or mixing plates.

With the project objectives thus achieved, today the chemical customer is realizing the environmental, performance, and cost benefits of its hydrogen energy supply.

HYDROGEN CAPABLE THERMAL PROCESS

Whether you're looking to reduce your emissions footprint, drive operational efficiency, achieve compliance or enhance safety, Honeywell Thermal Solutions is ready to meet all your hydrogen-related needs today and into the future.

Our offering spans the hydrogen lifecycle, from helping you take your first steps along the journey, to providing you with complete solutions for hydrogen combustion.

For more information

The Honeywell Thermal Solutions family of products includes Honeywell Combustion Controls, Honeywell Combustion Safety, Honeywell Combustion Service, Eclipse, Exothermics, Hauck, Kromschroder and Maxon.

To learn more about our hydrogen capable thermal process solutions, visit ThermalSolutions.Honeywell.com/ZeroCarbon or contact your Honeywell Sales Engineer.

Honeywell Process Solutions

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