

## EXECUTIVE SUMMARY

# Conversion of Existing Gas-Fired Commercial and Smaller Industrial Boilers to Hydrogen

### PRIMARY AUDIENCE

The primary audience are stakeholders directly involved in the manufacturing, operation, and regulation of commercial and industrial boiler systems. This includes boiler Original Equipment Manufacturers (OEMs), burner manufacturers, industrial facility operators, and engineers who are actively working to integrate or retrofit boilers for hydrogen use. These stakeholders are critical in advancing the adoption of hydrogen as a fuel for boilers, as their technical expertise and operational experience will determine the feasibility of hydrogen adoption in commercial and industrial settings. Policymakers and regulatory bodies also form part of the primary audience, as the development of standards and regulations will be essential for ensuring the safe and cost-effective deployment of hydrogen-based boilers.

### SECONDARY AUDIENCE

These include broader energy and climate policy advocates, environmental organizations, and academic researchers who are interested in the decarbonization of industrial processes and energy systems. Universities, research institutions, and sustainability-focused organizations with Environmental, Sustainability, and Governance (ESG) goals are also part of this group. Furthermore, energy utilities and infrastructure developers, particularly those focusing on hydrogen production, distribution, and blending with natural gas, will find the report's findings relevant as they explore future opportunities for hydrogen-based energy systems. This group is invested in the long-term impacts of transitioning to low-carbon energy and reducing greenhouse gas emissions from industrial operations.

## KEY RESEARCH QUESTION

The key research question addressed in this report revolves around the feasibility of converting existing natural gas-fired boilers in the 2.5 to 50 million BTU per hour (MMBtu/h) range to operate on hydrogen, either in blends or as 100% hydrogen-fueled systems. Specifically, the research aimed to evaluate the availability of hydrogen-fired boiler products, the technical challenges related to hydrogen combustion, and the regulatory and economic barriers to adoption. It also explored the extent to which hydrogen can replace natural gas in industrial boilers and what conditions would be required to make such a transition.

## RESEARCH OVERVIEW

This study undertook a comprehensive review of boilers in the 2.5 to 50 MMBtu/h range, focusing on their capacity to be adapted or retrofitted for hydrogen use. It involved an extensive review of boiler and burner OEM offerings, product availability, technical capabilities, and real-world hydrogen applications. Key industry stakeholders, including OEMs with experience in hydrogen firing, were interviewed to gauge the readiness of the market for hydrogen adoption. Additionally, technical concerns such as NO<sub>x</sub> emissions, operational safety, and regulatory uncertainties were assessed. Five different adoption scenarios ranging from maximum achievable energy efficiency using natural gas to full conversion to 100% hydrogen by 2040 were evaluated.

## KEY FINDINGS

The report highlights several critical findings, including:

- Few boiler OEMs currently offer hydrogen-fired equipment, primarily due to the lack of hydrogen availability and its high cost relative to natural gas. However, burner manufacturers with hydrogen-firing experience are confident that technical issues can be addressed.
- NO<sub>x</sub> emissions are generally higher in hydrogen combustion due to increased flame temperatures, and while some OEMs have tested solutions, further development is required.
- Regulatory uncertainty poses a major barrier to widespread adoption, with standards for non-refinery industrial applications still in development.
- Scenarios involving hydrogen blending (up to 100% by 2040) show promise in reducing CO<sub>2</sub>e emissions, but require policy, regulatory, and infrastructure support to become viable.

## WHY THIS MATTERS

This research is vital because it addresses one of the most significant sources of industrial greenhouse gas emissions—boilers that burn natural gas. As decarbonization becomes an urgent priority in achieving national and global climate goals, the industrial sector must transition to low-carbon fuel sources. Hydrogen represents a promising alternative due to its low carbon emissions when combusted. However, the challenges identified in this report, such as the high cost of hydrogen, technical hurdles, and regulatory uncertainty, highlight the complexity of this transition. The research underscores the need for coordinated efforts across industries, regulatory bodies, and energy providers to accelerate the adoption of hydrogen as a fuel.

## HOW TO APPLY RESULTS

The results of this report can be applied by various stakeholders to guide future planning, research, and investment in hydrogen-based boiler technology. Boiler OEMs and burner manufacturers can use the findings to focus on resolving technical challenges, particularly in mitigating NOx emissions, while preparing for future demand for hydrogen-ready systems. Policymakers and regulators can apply these results to develop standards that ensure safety and operational efficiency while supporting the gradual transition from natural gas to hydrogen. Industrial facility operators can explore retrofitting opportunities and prepare for future compliance with emerging hydrogen-based energy policies.

## LEARNING AND ENGAGEMENT OPPORTUNITIES

The findings offer multiple learning and engagement opportunities for the stakeholders involved. Manufacturers can benefit from demonstration projects and case studies that validate the technical performance of hydrogen boilers across different blends and industrial settings. These case studies could serve as training opportunities for operators and maintenance personnel. Additionally, regulatory bodies and policymakers can engage with industry experts to develop standards that ensure the safe and cost-effective adoption of hydrogen. Research institutions and universities can contribute to ongoing studies on NOx mitigation, hydrogen safety, and retrofit strategies, fostering collaboration between academia, industry, and government to advance decarbonization.



## THE LOW-CARBON RESOURCES INITIATIVE

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of EPRI and GTI Energy addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit [www.LowCarbonLCRI.com](http://www.LowCarbonLCRI.com).

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