LCRI LOW-CARBON RESOURCES INITIATIVE

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EXECUTIVE SUMMARY

LOW-CARBON FUEL PATHWAYS FOR COMBUSTION-BASED BOILER AND HEAT RECOVERY STEAM GENERATOR APPLICATIONS

Boilers and combined-cycle gas turbines (CCGTs) with heat recovery steam generators (HRSGs) for power generation and industrial applications comprise the largest stationary source consumers of fossil fuels. Accordingly, the potential conversion of the existing fleet of fossil-fired boilers and CCGTs to low-carbon alternative fuels, either fully or even partially, represents a tremendous decarbonization opportunity. In addition to power generation, key industries where conversion to low-carbon fuels would yield the greatest impact include chemicals, petroleum, paper, food/beverage, and iron/steel production.

This report focuses on low-carbon fuel conversion pathways for existing boilers and HRSGs with duct burners. The report covers the major categories of larger fossil-fired boilers and HRSGs, including electric power generators, large industrial units, water tube and fire tube package boilers. As most of these units currently fire coal, oil, and/or natural gas, the report considers the technical hurdles that must be overcome for low-carbon fuel conversion. The report includes a general description of existing boiler and HRSG types within the power generation and industrial sectors. A summary of combustion, heat transfer, and emissions-related system components is also included. However, the level of detail has been limited to not go beyond the primary objectives.

Key insights from the full report include:

- The use of hydrogen as a low-carbon fuel has been proven on multiple industrial applications, albeit where the boiler or HRSG duct burner was originally designed for hydrogen firing. The challenge to the industry entails retrofitting a unit designed for fossil fuel to hydrogen firing, in a manner that minimizes negative impacts to performance, reliability, and emissions. A key issue associated with fossil fuel conversion to hydrogen firing is NOx control, due to its increased flame temperature over natural gas and other fossil fuels.
- Ammonia combustion is in earlier stages of development, and all potential issues are not fully understood. In the shorter term, this may limit its use. However, the advantages of deploying ammonia, such as relative ease of transport and storage (addressed in other Low-Carbon Resources Initiative [LCRI] Technical Subcommittee groups), may make ammonia utilization attractive as a longer-term solution. Combustion issues associated with ammonia that would need to be addressed include fuel NOx conversion as well as ammonia's lower limits of flammability.
- Under the heading of "biofuels" is a wide assortment of biogas, bioliquid, and solid fuels (often referred to as *biomass*). Accordingly, in determining challenges and benefits, specific properties of the biofuel must be considered. Bioliquids and solids (for example, biomass) have been successfully co-fired in numerous boiler applications. Biogases such as landfill and digester gases are of significantly lower heating value than natural gases, which makes full load fuel conversion problematic, although renewable natural gas may minimize or mitigate this issue. One commonality among all biofuels, however, is the limitation in supply, which may restrict most applications to co-firing as opposed to full conversions.

- For all boiler types, hydrogen co-firing with the base fossil fuel may be an intermediate strategy that would better assess the severity of the key challenges, while simultaneously take a significant step toward reducing fossil emissions. There have been numerous successful demonstrations of co-firing natural gas on utility boilers designed to fire 100% coal. One proposed strategy would be to conduct a demonstration whereby the co-fired natural gas is partially or fully substituted with hydrogen (which in turn would be co-fired with the base coal). As an initial step, a computational model could be used to gain insights into anticipated issues at incremental increases in the percent of hydrogen deployed.

The Low-Carbon Resources Initiative

This executive summary was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the Electric Power Research Institute (EPRI) and Gas Technology Institute (GTI) 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.

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3002023231 December 2021

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