LCRI LOW-CARBON RESOURCES INITIATIVE

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EXECUTIVE SUMMARY

Analyzing Decarbonization Pathways for Space Heating in Buildings

Development of Analytical Framework and Case Studies

Buildings consume fossil fuels, primarily natural gas but also propane (LPG) and heating fuel oil (diesel no. 2), for space heating, water heating, cooking and other end uses. As described in a forthcoming insight paper, space heating represents the primary driver of fuel consumption in buildings. There are several pathways to decarbonizing space heating in buildings, namely through full electrification, used of alternative energy carriers (AECs) such as hydrogen, or a hybrid approach. Yet each of these pathways can represent significant tradeoffs for the building owner/operator in terms of up-front cost and overall cost of ownership. These factors can be further complicated by which existing (baseline) equipment is in place, local climate, and many other factors (i.e., policy). As utility customers seek to decarbonize their buildings, there is a need to understand decarbonization pathways, to help guide future programs and the research and development activities needed to launch and support them.

Key findings of this report include:

- In the Low-Carbon Resources Initiative's Net-Zero 2050: U.S. Economy-Wide Deep Decarbonization Scenario Analysis "All Options" scenario, air-source heat pump with electric (resistive) backup heat was the lowest lifecycle heating cost in all scenarios except in the coldest climate zone modeled (Minneapolis, MN). In this location hybrid ASHP were lowest cost in single-family residential and small office applications, and the gas furnace was lowest cost in multi-family residential. Overall heating costs were found to increase the most for Minneapolis (67% increase) and the least in Atlanta (13%) under the "2050 All Options" scenario.
- The results of these case studies illustrate the significant increase in the total cost of space heating under the considered net-zero scenarios. Today, natural gas offers the lowest cost heating solution in nearly every scenario where it is available at the building. The price of fuels is modeled to increase significantly under the Net-Zero 2050: U.S. Economy-Wide Deep Decarbonization Scenario Analysis study, particularly for pipeline gas which includes natural gas and blended hydrogen, increasing heating costs by 38% on average across the modeled scenarios.

- These results point towards significant challenge to decarbonize heating in cold climates. Efforts to promote heating efficiency such as weatherization and building envelope enhancement (insulation, windows, sealing) may play a growing role as the price of delivered fuels increase. Note that this study did not model emerging technologies such as cold-climate heat pumps, ground-source (geothermal) heat pumps, or gas-driven heat pumps, which offer superior heating efficiency to the equipment considered here.
- Conversion from gas to electric space heating can require significant upgrades to electrical infrastructure (circuit breaker, wiring, service transformer, etc.), which were not included in this analysis. In these cases, hybrid (dual fuel) heat pumps can offer a cost-effective approach to decarbonize space heating without major infrastructure upgrades. For this reason, hybrid heat pumps are expected to play a growing role in existing building retrofits.

This report presents an approach for evaluating building decarbonization pathways, including full electrification, AEC, and hybrid, with particular focus on space conditioning in residential and light commercial (low-rise) buildings. The approach builds upon prior EPRI modeling and takes the perspective of building owners seeking to replace existing equipment. A series of case studies are used to illustrate the approach in several key applications, namely single-family residential, multi-family, and small office buildings, across a range of US climates. The results of this project are intended to inform researchers and managers of utility customer programs in developing programs and supporting research activities.

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.

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