Advancing Dual-Fuel Residential HVAC to Achieve a Reliable, Resilient and Affordable Energy Future

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Introduction

North America's energy system stands at a pivotal juncture, necessitating innovative and multifaceted approaches to support future resilience and reliability. Integrating natural gas and electricity can be a flexible and resilient solution to meeting the growing needs of our energy system. Dual-fuel residential heating and cooling (HVAC) systems, with their ability to optimize infrastructure utilization and balance peak loads, present a viable path forward. These systems have the potential to enhance energy efficiency, reduce demand during peak events and optimize consumer preferences for comfort and affordability.

In this paper, GTI Energy (GTI) and the Northwest Energy Efficiency Alliance (NEEA) propose a vision to achieve the goals of reliability, resiliency, and affordability using evolved versions of dual-fuel technologies and leveraging the most valuable characteristics of both systems. While this paper focuses on residential dual-fuel systems, there is a broad range of applications in both residential and commercial settings. GTI brings in-depth experience and understanding of building thermal loads to analyze how advanced controls can be integrated into dual-fuel systems, to develop a cost-effective foundation for future technological advancement. The technical work GTI explored helps provide guidance for successful control strategies to realize the maximum potential of residential dual-fuel systems. In collaboration with GTI, NEEA brings comprehensive market research findings that help explain how existing consumer and contractor behaviors present barriers and opportunities to accelerate market adoption of dual-fuel systems. Together, this system-level Market Transformation approach will empower a robust energy-efficient, dual-fuel market that improves grid resilience and increases consumer comfort and savings.

Existing Technology Landscape

Over half of North America's residential heating load is served by natural gas. Based on the Residential Energy Consumption Survey (RECS) 2020 data,[1] approximately 16 million homes in the U.S. use electric heat pumps and around 53 million use natural gas furnaces. Condensing furnaces are standard market practice at 95+% efficiency. Dual-fuel systems can potentially achieve a seasonal efficiency of 200% or more while minimizing cost to homeowners and greenhouse gas emissions relative to single fuel-based systems.

To optimize dual-fuel systems that pair gas furnaces with heat pumps, there are several installation requirements for energy and cost savings that are critical and often overlooked. Early research indicates that these dual-fuel systems often operate far below their achievable, seasonal dual-fuel COP metric. This is typically due to suboptimal choices in equipment sizing and set up, control settings, and misalignment of when to use the electric heat pump versus the natural gas furnace for heating.

Control settings: Most dual-fuel systems available today lack customization, flexibility and broad controllability. These are also sold as a packaged system. A packaged system is controlled with a proprietary thermostat that can be set at one fixed switchover temperature. This switchover temperature is key as it dictates the outdoor temperature where the system switches from the heat pump to the furnace to provide heating. For example, setting a switchover temperature as high as 45 or 50 degrees will minimize the use of the heat pump in heating mode and cause the heat pump to operate as an air conditioner by primarily operating in cooling mode during warmer seasons. Systems are set up in this way primarily to address consumer comfort complaints resulting from the perception of cooler air coming from a heat pump when compared to their gas furnace.[2] This may result in a missed opportunity to realize the most energy and cost savings. However, when installed and configured with a switchover temperature balancing cost-effectiveness and comfort, dual-fuel systems can provide households more affordable options by shifting space heating loads and reducing operating costs by as much as 50% or more.[3]

Equipment sizing: Proper sizing of heat pumps is critical to a home's overall efficiency, along with other building factors including duct work configuration. Air Source Heat Pumps (ASHPs) and cold climate Air Source Heat Pumps (ccASHPs) are increasingly being promoted as solutions for reducing energy waste associated with residential heating; however, these technologies are limited to homes with peak heating capacities of 5 tons, which is under the capacity for majority of residential homes in the U.S. An under-sized heat pump risks insufficient cooling and would require electric resistance back up or other means to adequately heat a home during the coldest temperatures. A dual-fuel system can aid in rightsizing equipment for heating and cooling loads and reduce inefficiencies on both the electric and natural gas systems. For dual-fuel systems, it is even more crucial that the correct design practices are applied to ensure optimal combined efficiency.

Misaligned motivation: In sum, dual-fuel system efficiency is generally compromised when the gas furnace is used during times when the heat pump could more efficiently meet some, or all, of the heating load or when the heat pump is utilized when the furnace is more efficient. Compounding this problem are the fluctuations in the cost of gas and electricity. The distinction between getting higher efficiency and lowering energy bills, and how these components are subject to change, is difficult to convey to consumers and contractors. Consequently, neither consumers or contractors are strongly motivated to choose more efficient solutions.

[1] *U.S. Energy Information Administration, Office of Energy Demand and Integrated Statistics, Form EIA-457A of the 2020 Residential Energy Consumption Survey. March 2023.*
[2] *ANSI/ASHRAE, Standard 55, Thermal Environmental Conditions for Human Occupancy. ASHRAE, 2023.*
[3] *Kumar, Navin, PhD, et al., Hybrid Heat Pump System's Control Optimization for Annual Heating Operating Cost and Emissions Minimization. ASHRAE, 2024.*

An Overview of Dual-Fuel Systems[4]

The North American market offers many dual-fuel systems with various hardware and control combinations. All dual-fuel systems operate differently. The thermostat, typically the brain of the dual-fuel system, controls the furnace and ASHP and their modulation as a function of the logic input variables (i.e., utility rates, setpoint, outdoor air temperature time-of-use, and demand response calls). The control strategies for dual-fuel systems can be grouped into the following three approaches:

1

Two-stage heating: In a simple two-stage heating strategy, the ASHP is the primary heating source, and the furnace is the auxiliary heating source. The auxiliary heating source turns on when the ASHP cannot meet the thermostat setpoint. The auxiliary heating is typically activated by 1 to 2 °F below the setpoint target temperature when the ASHP cannot meet the setpoint. The ASHP runs until the auxiliary heating is activated. The two-stage heating approach is optimized for homeowner comfort, with limitations on optimizing for operating cost and grid emissions.

2

Outdoor Air Temperature (OAT) reset: The outdoor air temperature (OAT) reset approach is the most common hybrid heating strategy. To achieve economic benefits, the switchover temperature is mostly selected based on fixed utility rates and manufacturer component efficiencies. This temperature is typically set by the installer when the system is initially installed. Home occupants rarely adjust the temperature setting. Using a condenser's onboard sensor, cloud measurements, or a third-party outdoor sensor, the thermostat can switch between the heat pump and the furnace, depending on the pre-selected switchover set point. OAT switchover temperature could be implemented in both non-communicating (24 Volts) and communicating thermostats. Like the two-stage hybrid heating approach, the OAT reset strategy has limited capability to optimize time-of-use rates.

3

Smart dual-fuel switching: Unlike the two above-mentioned dual-fuel control strategies, smart dual-fuel switching can be optimized to achieve the lowest operating cost or greenhouse gas emission for heating with advanced thermostats or controls with grid-interactive capabilities. The thermostat or additional controls optimize the operation based on component efficiencies, hourly utility rates (fixed or dynamic), outdoor air temperature, and source greenhouse gas emission (i.e., WattTime, Electricity Maps) while maintaining comfort.

Dual-fuel systems are widely available among major manufacturers in the North American market and are especially popular in cold climates where heat pumps require backup heat on the coldest days. Natural gas backup tends to offer more economical operating costs than electric resistance backup heat. These systems are also common in moderate climates because of the perceived comfort, reliability, and lower operating costs on the coldest days. Dual-fuel systems with smart controls are a promising solution to provide an efficient solution for space heating to potentially reduce operating costs and manage peak loads. Still, much research and development is needed to foster the adoption of this technology.

[4] Kumar, Navin, PhD, et al., Market Landscape of Residential Hybrid Systems. GTI Energy, 2023.

Benefits of Dual-Fuel Systems

With increased interest in efficiency and reducing costs in the building energy sector, dual-fuel system research and development has become a priority for manufacturers of HVAC equipment and Internet of Things (IoT) technology developers.[5] These entities have begun realizing the potential to build on an existing and robust value stream in the residential sector by expanding partnerships with utilities. These new relationships can unlock additional utility values including resource adequacy, grid resilience and demand management. Successful realization of both consumer and utility value streams depends on successfully leveraging the benefits on both sides of these streams, as detailed below.

CONSUMER BENEFITS: Increased comfort, convenience, resilience and energy savings

Consumers indicate an appreciation for the comfort provided by the "set and forget" functionality of a dual-fuel system. With one control, they can select their preferred indoor temperature, and the system automatically adjusts between fuels/equipment to ensure the preferred temperature is maintained.[6] As discussed later in this paper, this ability to adjust between fuels and/or equipment can also enhance resilience by being able to adapt to energy distribution system issues without the consumers comfort being impacted.

Dual-fuel systems with smart controls can provide energy savings and even modest consumer utility bill reductions compared to a gas furnace with air conditioning, though this varies with climate, equipment efficiency, rates for fuel, switchover temperature, and other considerations (Tudawe 2023). However, energy savings are not guaranteed by simply installing a dual-fuel system with the technology and installation practices of the market today. It is influenced by several variables, including appropriate selection of dual-fuel equipment hardware and its capacity, controls employed, local utility pricing, and consumer comfort needs (Kumar et al. 2024). Energy savings of existing dual-fuel equipment is also strongly determined by occupant behaviors.

UTILITY BENEFITS: Resource adequacy, grid resilience and demand management

Recent research completed by GTI demonstrates that even in very cold outdoor temperatures dual-fuel HVAC systems that integrate a heat pump with an existing or new gas furnace and a smart controller are an underutilized tool for managing grid capacity while achieving efficiency (as measured by system coefficient of performance).[7]

By design, dual-fuel systems rely on gas when outdoor temperatures cross a preset threshold or setpoint as described above. In peak heating times, dual-fuel HVAC systems with grid responsive controls could also switch to gas at electric grid capacity constrained times enabling utility demand response communication like other smart electric appliances (i.e., heat pump water heaters). When paired with variable speed equipment, these systems can dial back energy use while still delivering heating or cooling. While such dynamic controllers are not yet broadly available for residential space heating, they are common for adjacent systems such as residential water heaters and commercial HVAC equipment.

With many policies moving towards increased use of electricity, efficient use of natural gas can provide significant value as grid infrastructure improvement remains slow, and utilities are capacity constrained during peak heating and cooling days. Through controlled use of dual-fuel systems paired with smart controls, gas utilities can provide grid resiliency, ensure consumer comfort and reduce electric utility carbon emissions during peak periods. Several utilities in North America have begun to explore and implement innovative collaborations facilitating achievement of carbon reduction requirements through concerted usage of both gas and electricity.

[5] *Kumar, Navin, PhD, et al., Market Landscape of Residential Hybrid Systems. GTI Energy, 2023.*
[6] *NEEA, Dual Fuel and Gas Heat Pump Market Research, 2023.*
[7] *Kumar, Navin, PhD, et al., Market Landscape of Residential Hybrid Systems. GTI Energy, 2023.*

For example, in 2021, Canadian utilities Hydro-Québec and Énergir announced an innovative partnership with a dual-fuel energy solution that combines electricity and natural gas to offset winter peak periods. Heating buildings with electricity puts significant pressure on Hydro-Québec's system during winter peak periods. Dual energy is an excellent way of maximizing the use of electricity in the heating of buildings while limiting the impact on peak periods.

In concrete terms, the partnership replaces heating systems fueled solely by natural gas with dual-energy systems meaning buildings can be heated with electricity most of the time, with natural gas being used only in very cold weather.

Québec is fortunate in that it can count on renewable electricity—low-cost hydropower. However, completely electrifying the economy comes with certain challenges in terms of cost and time and is a major issue during winter peaks.

Dual fuel energy solutions will help Québec society avoid significant costs. By 2030, it will result in savings of $1.5 billion compared with fully electrifying those markets currently fueled by natural gas.[8] That amount would have led to a rate increase for the customers of both energy providers.

Hydro-Québec saw the dual energy solution as an excellent way of maximizing electricity use in heating buildings while limiting the impact on peak periods. "This partnership with Hydro-Québec perfectly symbolizes the concept of the right energy in the right place, at the right time and at the best possible price," said Stéphanie Trudeau, Énergir's Executive Vice President, Québec.[9]

The most significant advantage of dual-fuel systems may be the potential avoided costs on the electric grid, from transmission and distribution to generation. While the costs and benefits for consumers have been explored, the societal costs of adopting a dual-fuel approach versus full electrification requires more research.

Successfully realizing all the benefits above requires innovative collaboration across the supply chain, involving utilities, manufacturers, contractors, and consumers of dual-fuel technologies. By reimagining the interplay between electric and natural gas systems, we can achieve several goals more rapidly and effectively, supporting a robust and adaptable energy infrastructure.

[8] *Hydro-Québec and Énergir, An Unprecedented Partnership to Reduce Greenhouse Gas Emissions. 2021.*
[9] *Ibid.*

Technologies on The Horizon

Internet-enabled communications for HVAC systems are an emerging trend. When cloud-connected capability is added to a dual-fuel system, there is the potential to create a grid-enabled, interactive system. Some of the benefits of a grid-enabled system include the ability to apply real-time electrical pricing. This would enable the HVAC system to determine the appropriate energy source to meet the heating load at a given time at the lowest cost. A barrier to fully leveraging this capability is the proprietary “locked-down” nature of many controls, through either a manufacturer-specific thermostat or a smart thermostat controlled by a third party who restricts access.

In collaboration with Clark Public Utilities and NW Natural, NEEA is currently demonstrating a dual-fuel system that shows what the future could look like with an efficient, flexible and controllable HVAC system that provides value to consumers, the market and utilities.

“Clark Public Utilities sees value in better understanding potential ways to reduce energy waste and maintain energy efficiency with new and adapted technologies,” explains Matt Babbitts, Clean Energy Program Manager,” Clark Public Utilities. “Partnering with NEEA and NW Natural on this residential dual-fuel heating system pilot is part of our ongoing effort to identify and evaluate viable alternatives for our customers.”

In the demonstration project, the innovative controller allows remote setpoint adjustment and simultaneous use of both fuels to provide true fuel flexibility and dynamic, automated management. The demonstration aims to assess energy efficiency, user experiences, and the system’s capability to transition between gas and electricity for load flexibility.

“These newly emerging dual-fuel systems provide a stellar opportunity for regional utilities to collaborate and address resource challenges while building solutions that benefit our customers,” said Holly Braun, Business Development Manager / Geothermal Lead at NW Natural. “We are invigorated to be working with Clark PUD and NEEA on this pilot and optimistic about the system wide benefit it could demonstrate.”

The demonstration project pairs an air source heat pump operating in parallel with a tankless gas water heater and hydronic air handler, which is similar in function to a furnace. The demonstration will evaluate the individual component energy use and efficiency compared to a selected baseline along with the overall space heating and water heating efficiency. Furthermore, the system’s ability to respond to remote signals will be evaluated during scenarios developed by the team. These scenarios will assess potential impacts to peak demand constraints, response time, fuel switching dynamics, and simultaneous use of both electricity and gas to provide heating.

This data, along with qualitative results of occupant comfort and ease of installation, will allow NEEA to identify barriers to more sustained market adoption. Results of this demonstration will be published in 2026 and 2027.

Conclusion

Dual-fuel systems are a promising, efficient solution for residential space conditioning to potentially increase consumer comfort while reducing operating costs and electric peak load. Dual-fuel systems are available among major manufacturers in the North American market, but the market demand for dual-fuel technology is modest. Only recently, with the support and incentives of utilities, local, and federal governments has this technology been adopted more rapidly.

Next steps to support increased market adoption of dual-fuel systems in North America include:

- Comparing these technologies and evaluating their performance against the current market practice to develop competitive performance data;
- Evaluating and modeling to accelerate the development of a standard test method for rating existing dual-fuel systems;
- Developing design guidelines for field implementation based on climate and power generation mix; and
- Developing standards and testing methods to help build consumer confidence when comparing one system to another and inform energy efficiency program development.

Dual-fuel systems present a significant, immediate opportunity for natural gas and electricity to be used in concert, adapting and responding to an evolving grid. Dual-fuel systems can help achieve state and regional policy goals, provide the market opportunities to innovate, and support consumer preferences of comfortable, affordable heating and cooling. However, driving greater market adoption requires innovative, collaborative approaches across the supply chain.

Transforming markets through dual-fuel technologies requires a commitment to reimagining how electric and natural gas systems work together to achieve a wide spectrum of goals faster and with greater utility, manufacturer, contractor, and consumer support. Pairing this reimagined collaboration with evolved systems will provide a balance between consumer satisfaction, market needs and policy drivers.

For more information on NEEA's dual-fuel strategies and other Market Transformation efforts, visit **neea.org/market-transformation-portfolio.**