Nicor Gas | Energy Efficiency Program

Emerging Technology Program

#1166: Residential Heating, Ventilation and Air Conditioning (HVAC) Telemetry Solution - Public Laboratory Evaluation Report

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The results within this report relate only to the items tested.

Executive Summary

Introduction

As part of the Nicor Gas Energy Efficiency Program, the Emerging Technology Program (ETP) assesses new technologies that have the potential to realize natural gas savings for the 2.3 million Nicor Gas customers in Northern Illinois. GTI Energy provides program implementation services for Nicor Gas ETP. This report summarizes the results of lab verification of Residential Heating, Ventilation and Air Conditioning (HVAC) Telemetry Solution from an HVAC controls manufacturer, Manufacturer 1, and its potential to improve furnace and condensing unit performance and operational life.

Background

An Illinois Baseline & Potential Study conducted by GDS Associates on behalf of Illinois utilities found that natural gas furnaces are the primary heating source for both single-family and multifamily homes across all income levels.[1] Residential HVAC units (Figure 1) play an important role in occupants' comfort by maintaining indoor temperatures and air quality throughout the year. It is important to maintain uninterrupted operation of the furnace and condenser/heat pump unit especially when peak/design day conditions occur. A furnace unit has a median lifetime of 18 years[2] if maintained well, with average maintenance costs between $75 to $100 per year. A homeowner can typically respond to minor issues such as dirty filters, low battery alert on thermostats, incorrect thermostat settings such as "Fan Mode [air circulation mode only]" during a heating and cooling season, clogged drain lines, etc., without a HVAC contractor. However, critical issues such as gas valve faults, mechanical wear and tear, fault in evaporator and condenser coils, etc., are typically resolved through an HVAC contractor, which may involve high service, labor, and material costs. A typical homeowner rarely monitors the performance of their HVAC units. A periodic maintenance plan could detect minor faults, reduce overall maintenance costs, lower utility costs, and prolong equipment operational life. The Residential HVAC Telemetry Solution from Manufacturer 1 aims to improve a homeowner's equipment maintenance process by continuously monitoring the HVAC unit's performance to proactively detect and notify a homeowner of potential issues that may arise.

[1] 2023-2024-Illinois-Energy-Efficiency-Potential-Study_FINAL_12-13-2024_with-App-A-and-App-B_v2.pdf
[2] https://www.naturalhandyman.com/iip/infhvac/ASHRAE_Chart_HVAC_Life_Expectancy.pdf

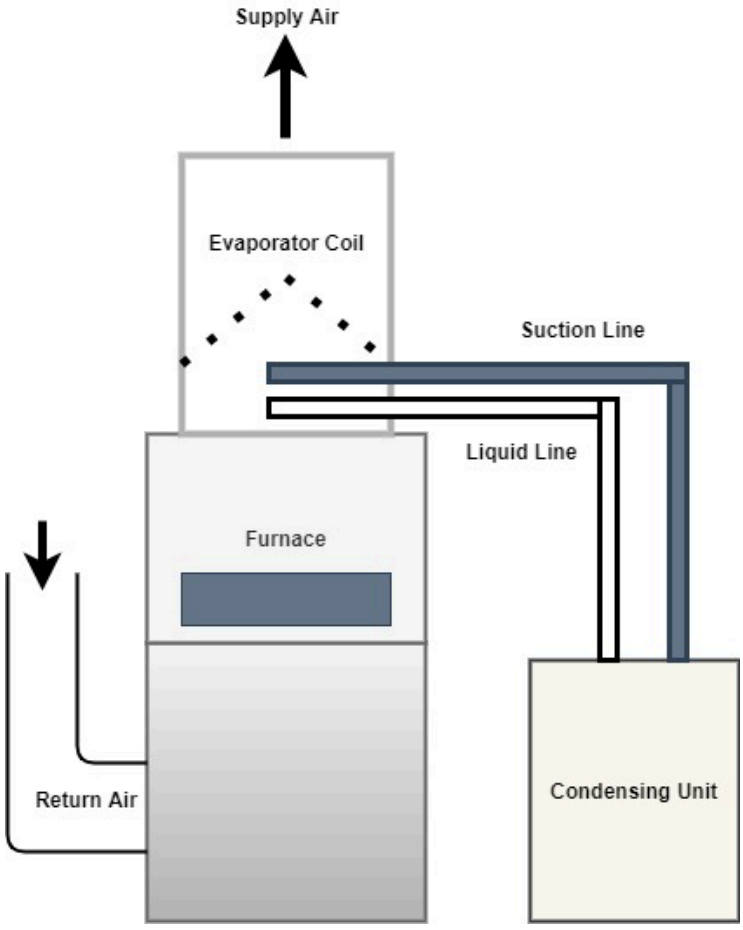

Figure 1: Typical Residential HVAC Unit

The Residential HVAC Telemetry Solution Platform is a remote data monitoring system that claims to predict operational faults of furnace and condenser/heat pump units and to provide its clients with uninterrupted and hassle-free indoor thermal comfort. The platform uses nine (9) sensors as shown in Figure 2 to predict performance issues or faults in the HVAC unit. These sensors monitor supply and return air temperatures, refrigerant suction and liquid line temperatures, indoor/outdoor equipment voltages and currents, and include an optional condensate monitor. The name of the furnace and condenser system manufacturer and model number, capacities, dates of install, number of stages, etc., must be manually entered into the interactive website. The system processes data through a Data Hub and communicates to the Cloud Platform via the homeowner's Wi-Fi network or through an optional cellular router provided by Manufacturer 1. When a performance issue or fault is detected, the Residential HVAC Telemetry Solution platform generates an alert via email that provides recorded data of the conditions under which the fault has occurred.

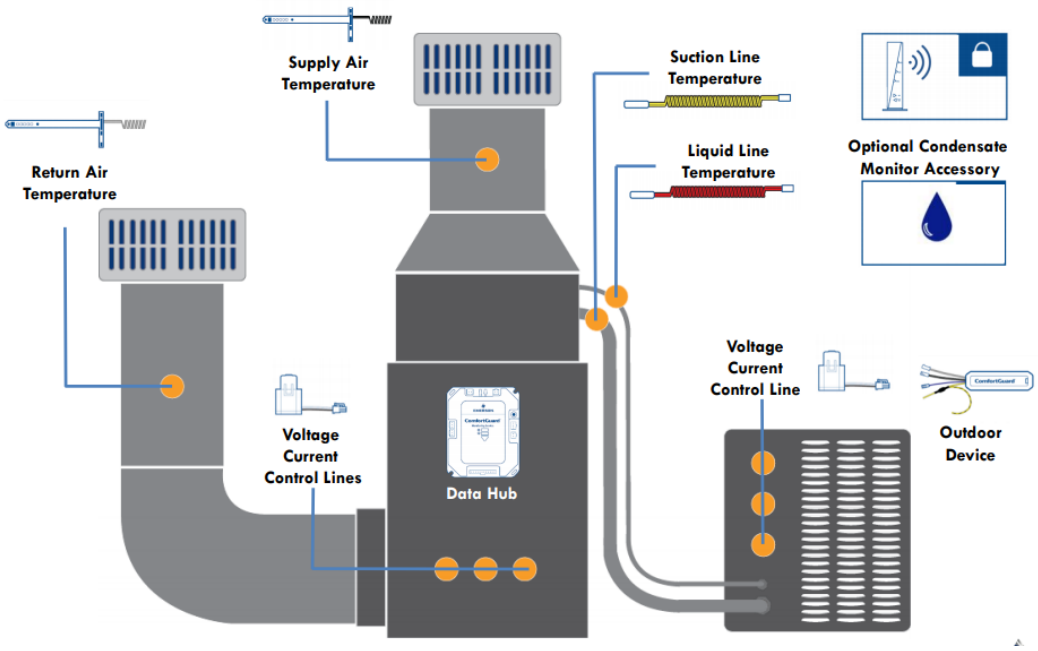

Figure 2: Residential HVAC Telemetry Solution by Manufacturer 1 - Data Acquisition Sensors

Table 1 summarizes the Residential HVAC Telemetry Solution platform alert codes, along with descriptions. Alert notifications generated by the platform list the fault code and provide a graph of the system parameters before and after the fault occurred.

Table 1: Residential HVAC Telemetry Solution Fault Log

Fault Code	Description
40	Frozen AC coil likely due to low indoor airflow or low refrigerant charge
88	Condensate drainage issue likely caused by a blockage in the condensate drain
204	Capacitor alert which means we've detected that the capacitor has lost capacitance significantly below the acceptable design range
258	Compressor trip likely caused by excess refrigerant charge, capacitor failure, contactor failure, or outdoor wiring issue.
403	Poor AC temperature drop likely caused by low refrigerant or high indoor airflow
405	Poor heat pump temperature drop likely caused by low refrigerant or high indoor airflow
902	Furnace not starting likely due to failing igniter, dirty flame probe, faulty pressure switch, or failing ignition control board

Results

A 100,000 Btu/hour Furnace and a 5-ton AC/Heat Pump unit were retrofitted with the Residential HVAC Telemetry Solution for lab verification at GTI Energy. Below are the results of functional tests that were performed to determine the Residential HVAC Telemetry Solution Platform's ability to detect fault conditions:

Table 2: Simulated System Faults

Test #	Simulated System Faults	Expected Fault Code	Alert Fault Code	Pass / Fail
1	Simulate a Frozen Coil Alert with Airflow	40	40 & 403	Pass
2	Simulate a Clogged filter Alert	40	40	Pass
3	Simulate a Refrigerant Pressure Loss Alert	403	403	Pass
4	Simulate a Furnace Start Fault with manual gas valve closed	902	None	Fail
5	Simulate a Furnace Start Fault with Igniter Power Disconnected	902	None	Fail
6	Simulate a Poor Furnace Temp Rise Alert	902	902	Pass
7	Simulate a Compressor Trip Alert	258	403	Fail
8	Simulate a Fan Not Operational Alert	40 / 403	None	Fail
9	Simulate a Condensate Level Trip Switch Alert	88	88	Pass

Manufacturer 1's Residential HVAC Telemetry Solution platform was successful in identifying typical fault conditions that impact performance of an HVAC unit, and it provided an intuitive visualization of system performance. Although it was unable to detect and correctly diagnose certain simulated faults that occurred in extreme conditions, it is recommended that this platform be deployed in a representative subset of households in Northern Illinois along with adequate training and support for first-time users to gather additional information. Deployment of this platform may provide additional information on parameters that could influence successful adoption such as:

1. Issues with integration of the Residential HVAC Telemetry Solution Sensors and the Hub with new or existing residential HVAC equipment
2. Type of faults that occur in a household, along with their frequency
3. Resolution times and costs incurred (if any) by homeowners for typical faults
4. Maintenance and/or replacement costs (if any) offset by early detection of faults
5. Natural gas (therms) savings achieved (if any) throughout heating season operation – through undersized or oversized units. However, the lab study is unable to detect whether the given load matches the operation. This feature is best left for field study.

Data collected through site deployment efforts can be used to determine if additional HVAC parameters can be monitored as part of the Residential HVAC Telemetry Solution platform. In addition, this data can be used to advise homeowners on future energy efficiency upgrades.