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REPORT #E21-323

Variable Speed Heat Pump Smart Thermostat Findings

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MEMO

TO: Tamara Anderson, NEEA
FROM: Nick O'Neil, Energy 350
SUBJECT: Variable Capacity Heat Pump Smart Thermostat Findings Summary[1]
DATE: August 17, 2021

1. Introduction and Research Goal

As part of NEEA's research into savings from smart thermostats on conventional heat pumps, a separate research scope was undertaken to understand the potential for savings from smart thermostats on variable capacity heat pumps (VCHP). This research included a market scan of available thermostats that were both capable of controlling ducted VCHPs and were likely to save energy over a viable baseline model. This memo includes the findings of that market scan.

Unlike single stage heat pumps, VCHPs have control logic built into the heat pump itself to determine how and when to vary fan speed and compressor loading. The VCHP thermostat serves as an input and are called "Communicating" thermostats by the manufacturers. Instead of containing multiple wires to convey a call for first or second stage heating or cooling, communicating thermostats utilize four wires: One for heating, one for cooling and two that provide power and allow the heat pump and the thermostat to "communicate." As such, the heat pump and associated sensors send information to the thermostat, and the thermostat responds by sending a signal back to the unit to control the amount of heating or air conditioning that is required. Each component in the heat pump has an electronic address, so the thermostat knows where the data is coming from and can send the necessary data back to that component to control its operation.

This memo describes the inventory of available thermostats along with key features such as meeting the ENERGY STAR Screening criteria for a smart thermostat, the potential market share, whether the communication was proprietary or open-source, and what energy saving features the thermostat possessed. The sub-advisory committee requested the research to focus solely on ducted systems, and that thermostat solutions should be packaged devices, not a built-up system of various components. The committee requested documentation of comparable baseline products for VCHP systems to understand the potential for energy savings.

2. Research Approach

[1] NEEA is currently using the term Variable Speed Heat Pump to describe this technology. At the time of the research and in this report, we used the term Variable Capacity Heat Pumps to refer to the same technology.

To build the inventory we began conducting secondary research online and through our contacts in the market. Based on research and conversations with several regional distributors, we determined that only proprietary thermostats (i.e. thermostats and the heat pump are from the same OEM) would accurately control VCHP systems the way they were intended to. This is because VCHP systems rely on the data wires found with communicating thermostats to determine compressor loading and fan speed which are absent in both conventional and 3rd party smart thermostats. Furthermore, while there were past efforts to develop a 3rd party communication protocol, those efforts had stalled and there were no future plans to develop open-source communication protocols.

Since the inventory would be limited to matching communicating thermostats with VCHP manufacturers, we focused on determining which parent companies had the largest market share and therefore likely a suite of available thermostats that could incorporate smart features. We analyzed heat pump unit data from AHRI to understand how many units are available by manufacturer and grouped them by the parent company. The results are shown in the table below:

Parent Company	Model Count	Communicating Thermostat Brand Name
Trane	7,072	Comfortlink
Carrier	5,734	Infinity
Daikin	4,051	ComfortNet
Lennox	3,943	iComfort
Coleman	3,810	Echelon

As expected, this high-level market share assessment tracks with general market share as well as common stocking at regional distributors. Focusing on these manufacturers began to assemble characteristics data for all thermostats from each manufacturer capable of controlling VCHP systems.

3. Findings

In summary and described more below, we found that few VCHP products exist in the market, the products that do exist are proprietary to the specific OEM, and that manufacturers do not currently have plans to open the communication up to 3rd party suppliers. We found that only 3 out of the 5 major manufacturers offer more than one communicating thermostat that is compatible with a VCHP. (Daikin, Lennox, and Coleman). Furthermore, there is very little variety among the multiple thermostats offered by each OEM, with common differentiators being larger touch screens, integration with home assistants, and in some cases geofencing. The following is a breakdown of findings by each manufacturer, and a more detailed summary of the findings is shown in the table below for reference.

3.1 Daikin (Includes Goodman, Franklin, Amana)

The Daikin line of communicating thermostats includes the CTK04, and the new Daikin One+. Although the CTK04 has been the only communicating thermostat for VCHP systems, the One+ is a new product that is beginning to be included with new systems. It is not sold as a standalone thermostat at this time. The CTK04 will still be used on inverter-based heat pumps going forward, and all other product lines will continue to have entry levels controls offered as well as the Daikin One+ as an upgrade.

While Daikin has a baseline communicating thermostat, the features of the Daikin One+ are limited compared to the CTK04. The only potential energy saving features we noted were the ability to integrate with home assistants, and the inclusion of geofencing. The incremental cost between the CTK04 and the Daikin One+ was estimated to be around $50 based on internet research and discussions with regional representatives.

3.2 Lennox (Including Armstrong Air)

Lennox has multiple Wi-Fi thermostats available for its products, and two communicating thermostats for inverter-driven heat pumps. The baseline iComfortWiFi and the premium iComfort S30 Ultra both offer a range of potential energy saving features such as One-Touch away mode, remote monitoring, and smooth setback. However the S30 has a suite of additional energy saving features including geofencing, behavior learning mode, IFTTT logic, a "feels like" temperature mode, and monthly energy reporting. These features are clearly additions for a premium product and marked as such on Lennox's website. The incremental cost between the iComfort WiFi and the iComfort S30 Ultra was estimated to be around $125 based on internet research and discussions with regional representatives.

3.3 Coleman (Including York, Luxaire)

Similar to Daikin, Coleman has several communicating thermostats offered. The Echelon (also labeled as York Affinity) is the base model and is capable of controlling inverter heat pump technology.

The Hx and Hx3 are two premium WiFi thermostats offered by Coleman with the primary difference between the two being a larger touchscreen on the Hx3. However similar to the Daikin, the only energy saving features found were the ability to integrate with home assistants, and the inclusion of geofencing. The incremental cost between the Echelon and the Hx3 was estimated to be around $230 (or $160 between the Echelon and the Hx) based on internet research and discussions with regional representatives.

3.4 Carrier (Including Bryant, Tempstar, Comfortmaker)

Carrier has only one communicating thermostat offered at this time, the Infinity WiFi thermostat. While this product has energy saving features such as occupancy sensing, DR integration, real-time energy tracking, and advanced smart setback, there is not a baseline thermostat to compare to. Therefore all Carrier VCHP systems must include this thermostat to take advantage of the inverter-based heat pumps. As such, there is no true incremental

cost (though this thermostat has a full cost of $450), and no premium energy savings features compared to the baseline model.

3.5 Trane (Including American Standard)

Trane also had several products offered for VCHP systems, all sold as ComfortLink II XL. The 850, 950, and 1050 series all have similar feature-sets however with the primary difference between them being a larger touchscreen. Although they have potential for energy saving through self-guided scheduling (An interview is given to detect common occupancy patterns rather than programming a daily schedule) and integration with home assistants, these features appeared on all models in the XL series. As such, there are no energy saving features of the premium model over the baseline communicating thermostat. The incremental cost between the lowest communicating model (XL850) and the most premium (XL1050) was estimated at $125 based on internet research.

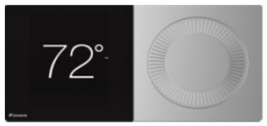
4. Key Findings and Recommendations

We found that few products exist in the market, that the products that do exist are proprietary to the specific OEM, and that manufacturers do not currently have plans to open the communication up to 3rd party suppliers. Therefore, we did not find a viable path for utilities at this time to test the savings potential of these products in a lab or field demonstration. Although the Lennox iComfort S30 is promising with the number of energy saving features offered by its premium product, a field test would need to be done on only a Lennox system to test the features of this product.

Possible next steps and future research for the Northwest to pursue to further understand VCHP smart thermostats could include:

- Coordinating closely with ENERGY STAR as it explores the development of a variable capacity heat pump thermostat specification.
- Conducting in-depth interviews with manufacturers and regional distributors regarding sales of VCHP systems and more in-depth knowledge of premium communicating thermostat features.
- Conducting targeted discussions with major OEMs regarding incorporating energy saving features into their communicating thermostat line and to understand whether new communicating thermostats may be coming to market, or if proprietary communication may be opened up to allow more 3rd party products to control inverter-based heat pumps.

About: **Communicating thermostats for ducted VCHP systems and comparison of features and energy saving features over base model.**

Manufacturer	Daikin/Goodman	Lennox	Coleman/York	Carrier/Bryant	Trane/American Standard
					
Premium Communicating Model	Daikon One+	iComfort S30	Hx3	Infinity	Comfortlink II XL1050
Base Communicating Model	CTK04 Comfortnet	iComfort WiFi	Echelon/Affinity	N/A	Comfortlink II XL850
Premium Product Features	- Works with Alexa, Google - WiFi-capable with Venstra Skyport Wi-Fi key - High resolution touchscreen - Geofencing capabilities	- Works with Alexa, Google, Apple watch - IFTTT logic - Geofencing (Smart Away) - Learns behavior mode (Schedule IQ) - Has "feels like" temperature mode - Energy reporting (monthly run hours) - Smooth setback recovery - One-touch away mode (override) - Allergen Defender (fan cycling) - Remote control via iComfort app - Perfect Temp control - Dual Fuel capability	- Works with Alexa, Apple watch - Geofencing capabilities - Preset modes - Remote access - CFM percentage setting	- Occupancy sensing - DR capable - Real-time energy tracking - Remote access - Manages airflow to each zone - Advanced smart setback	- Works with Amazon Alexa - Daily weather forecasts (Info only) - Allergy Clean (fan cycling) - Self-guided Scheduling
Premium Model Energy Saving Features (over base model)	- Works with Alexa, Google - Geofencing capabilities	- Works with Alexa, Google, Apple watch - IFTTT logic - Geofencing (Smart Away) - Learns behavior mode (Schedule IQ) - Has "feels like" temperature mode - Energy reporting (monthly run hours)	- Works with Alexa, Apple watch - Geofencing capabilities	- N/A	- Works with Amazon Alexa
Compatible Heat Pump Models	- DZ20VC, DZ18VC, DZ18TC, DZ16TC	- XP25/XP21/SL18XP1/XP20	- All Johnson Controls HPs	- All Infinity Series HPs	- XV20/XV18
Incremental Cost (over base model)		$125	$230	$475	$125
Asessment	Relatively new product with no known installations in the PNW. Energy savings over the base model would primarily be from geofencing capabilities.	A slew of potential energy saving features are available in the iComfort model compared to the other 2 base models.	Both Hx and Hx3 models have geofencing compared to baseline t'stat, but no other energy saving features were noted.	Infinity t'stat has many energy saving features, however it is the only model that works with VCHP, therefore no market to incentivize	Few (if any) energy saving features, even though 3 products available for communicating equipment.

About:	Product features for manufacturer thermostats. Orange higlights indicate possible energy saving features

Daikin, Goodman, Franklin, Amana

https://www.goodmanmfg.com/products/controls

Goodman Model	Heating Stages	Cooling Stages	WIFI	Communicating	Programmable
CTK04 ComfortNet™	4	2	OPTIONAL	YES	YES
TSTATG4271GT	4	2	YES	NO	YES
TSTATG4272GT	4	2	YES	NO	YES

Daikin Thermostat Models	Price
Daikin/Goodman CTK04 ComfortNet	$460-$515
Goodman TSTATG4271GT	$185-$225
Goodman TSTATG4272GT	$185-$225
Daikin One+	

Equivalents

Daikin One+ communicating https://daikincomfort.com/products/thermostats-controls/daikin-one

Notes

Goodman builds just three thermostats. One supports Goodman communicating systems and two are universal thermostats that will work with most HVAC brand non-communicating systems.
Goodman communicating components ONLY work with a Goodman communicating thermostat
Compatible Goodman communicating equipment: DSZC18/DSZC16 Heat Pumps
The ComfortNet thermostat is not programmable in the traditional sense. Instead, it "interviews" you with display questions such as "when does the first person wake up in the morning?"
When you answer the series of questions, the thermostat will automatically program its schedule.
All units are WiFi-capable but only with the inclusion of a Venstra Skyport Wi-Fi key that costs about $70.
CTK04 Accessories: The ComfortNet CTK04 thermostat works with several accessories to optimize performance.
They include the RedLINK Internet Gateway for wireless control, a wireless indoor sensor to provide data for balanced temperatures, wireless humidity control and a portable comfort control remote.
Daikin One+ works with Daikin heat pumps: DZ20VC, DZ18VC, DZ18TC, DZ16TC

Features (from Daikin website)

The high-resolution color touch screen display is protected by the same toughened glass used in smart phones.
The anodized aluminum bezel and dial are precision manufactured.
The surfaces have a fine bead blast with a warm hued anodized finish.
The dial rotation is extraordinarily smooth because it rests on a bearing assembly typically found in precision instruments.
A switch behind the dial enables users to return to the home screen from any menu with a single tap.
An integrated WiFi radio connects to the internet (via a home router) to the cloud and on to the homeowner mobile application
A thin LED light bar sits flush within the bottom surface and runs from edge to edge delicately illuminating the wall beneath. The light bar indicates the current system mode: red-orange for heating and blue for cooling.
A number of screen savers are available including an analog clock.
Built-in bubble level aids professional installation.

About: **Product features for manufacturer thermostats. Orange higlights indicate possible energy saving features**

Lennox, Armstong Air
https://www.lennox.com/products/comfort-controls/thermostats

Feature	iComfort® S30 Ultra Smart Thermostat	iComfort® Wi-Fi Smart Thermostat	iComfort® E30 Smart Thermostat	iComfort® M30 Smart Thermostat
System Compatibility	Works with premium Lennox® communicating equipment only	Works with premium Lennox® communicating equipment only.	Universal thermostat that works with non-iComfort-enabled and non-Lennox® products	Universal thermostat that works with non-iComfort-enabled and non-Lennox® products
Amazon Alexa Allows you to voice control your HVAC system through Amazon Alexa-enabled devices	X		X	X
Google Assistant Allows you to voice control your HVAC system through Google Assistant-compatible devices	X		X	X
Apple HomeKit Allows you to voice control your HVAC system through Apple HomeKit-enabled devices	X		X	
If This, Then That (IFTTT) Creates chains of conditional statements, called applets, that activate a system to respond to specific scenarios	X		X	X
Programmable Versatile programming options offer custom comfort and energy savings	X	X	X	X
Smooth Setback Recovery Senses extreme temperature changes and begins the temperature recovery process up to 2 hours before the programmed time	X	X		X
Smart Away™ Uses the GPS in your smartphone to detect when you're leaving, and automatically changes the temperature to a more energy-efficient setting	X		X	X
Schedule IQ™ Allows you to only program your thermostat once. Whenever there's a change in your routine, the thermostat adapts heating and cooling to match	X		X	X
One-Touch Away Mode Overrides your regular programming schedule when you're away and automatically turns down heating or cooling to save energy	X	X	X	X
Allergen Defender Monitors the air quality and pollen levels of your local zip code and automatically turns the fan on to clean your home's air when outdoor levels are high	X		X	
Feels Like™ Similar to the "Feels Like" temperature in a weather report, this feature takes into account temperature and humidity to create a comfortable environment	X		X	X
Perfect Temp Works with your system to heat or cool as needed to preserve your temperature in any weather, year-round	X		X	
Filter Reminder Reminds you when its time to change the filter	X	X	X	X
Customizable Reminders Allow you to set a series of service and parts replacement reminders which display on the home screen	X	X	X	
Auto Changeover Decides between heating and cooling operation, depending on indoor temperature	X	X	X	X
Touchscreen Features a large, easy-to-use display with adjustable brightness	X	X	X	X
Photo Display Allows you to display a personal photo as the screensaver of your thermostat	X		X	
Weather Screen Savers Themed screen savers on the 7" HD color touchscreen are designed with graphics that tell you what weather conditions are like outside	X		X	
Dual-Fuel Capability Increases the efficiency of dual-fuel heating systems by automatically alternating between gas and electric operation	X	X	X	X
Energy Reports Show how often and how long the heating or cooling system has run for the month	X		X	X
Humidity Control Works with the whole-house humidity-control systems to adjust the home's humidity level	X	X	X	
Remote Capability Monitor and adjust temperatures and schedules from anywhere in the world using the iComfort App and your smartphone, tablet or other web-enabled device	X	X	X	X
Weather-On-Demand Air quality conditions are offered for your local area, so you always know what's happening outside	X	X	X	
Precise Comfort® Plus Holds your home's temperature to within 0.5 degree or less when used with premium Lennox® equipment	X	X	X	
Climate IQ® Technology Monitors humidity levels, and removes excess moisture for healthier, more comfortable air	X	X	X	
Emailed Alerts Provides detailed diagnostics and reminds your Dealer when service is needed	X	X	X	X
Remote Monitoring Allows Lennox dealers to analyze your system from anywhere via their computer or mobile device	X	X	X	X
Remote Troubleshooting Makes it possible for dealers to use their mobile device to adjust system parameters to fix problems, without ever making a trip to your home	X		X	X
Warranty	5-Year Limited Warranty	5-Year Limited Warranty	5-Year Limited Warranty	5-Year Limited Warranty

Notes
The iComfort S30 and iComfort Wi-Fi thermostats are strictly communicating, so can only serve a Lennox brand communicating HVAC system.

Eligible Heat Pumps: XP25/XP21/SL18XP1/XP20
The iComfort E30 and all ComfortSense thermostats are universal, non-communicating models, so work with Lennox and other brands of non-communicating HVAC systen

Lennox Thermostat Models	Price
Lennox ICOMFORT S30	$525-$550
Lennox ICOMFORT E30	$430-$450
Lennox ICOMFORT WI-FI	$385-$425
Lennox COMFORTSENSE 7500	$195-$215
Lennox COMFORTSENSE 5500	$165-$190
Lennox COMFORTSENSE 3000	$65-$75

About: **Product features for manufacturer thermostats. Orange higlights indicate possible energy saving features**

Coleman, York, Luxaire

http://www.colemanac.com/residential/Thermostats-Controls

Feature	Coleman® Echelon™ Hx3 Smart Thermostat	Coleman® Echelon™ Hx Smart Thermostat	Also called York Affinity Coleman® Echelon™ Residential Communicating Control	Coleman® CTS Series Thermostat
Power	Wi-Fi® capable	Wi-Fi® capable		
Efficiency Rating	Offers voice control using Amazon Alexa	Offers voice control using Amazon Alexa		
Capacity	Compatible with Apple Watch®	Compatible with Apple Watch®	Control up to six zones	Up to 4-heat and 2-cool stages
Phase	Up to 4-heat and 2-cool stages	Up to 4-heat and 2-cool stages		
Refrigerant				
Technical Feature (Compressor/Blower)				
Technical Feature	4.3" Touchscreen	2.8" Touchscreen		
Configuration				
Compressor Warranty	ENERGY STAR® Most Efficient performance when connected to select Coleman® HVAC home comfort systems	ENERGY STAR® Most Efficient performance when connected to select Coleman® HVAC home comfort systems		
Electric Heat Warranty				
Heat Exchanger Warranty				
Parts Warranty	5-year Limited Warranty*	5-year Limited Warranty*	5-year limited warranty	5-year limited warranty

* /** Warranty terms vary based on product registration and model details.

Coleman Thermostat Models	Price
Coleman® Echelon™ Hx3 Smart Thermostat	$425
Coleman® Echelon™ Hx Smart Thermostat	$355
Coleman® Echelon™ Residential Communicating Control	
Coleman® CTS Series Thermostat	$195

About: **Product features for manufacturer thermostats. Orange higlights indicate possible energy saving features**

Carrier, Bryant, Tempstar, Comfortmaker

https://www.carrier.com/residential/en/us/products/thermostats/wifi-thermostats/

Characteristics	Infinity	Côr Wi-Fi	Côr 5C Wi-Fi	Côr 7C Wi-Fi
Compatible With Communicating And Variable Speed Systems	X	-	-	-
Touchscreen	7" full color	4.3" full color	4.3" black & white	4.3" black & white
Programmable (Days/Schedules Per Day)	7/4	7/4	7/4	7/4
Heat/Cool Stages	5/2	5/2	4/2	4/2
Adjust Home Temperature Remotely	X	X	X	X

Bryant Equivalents	**Housewise**	**-**	**Côr 5C Wi-Fi**	**Côr 7C Wi-Fi**
Comfortmaker Equivalents	**Ion**	**Observer**		

Carrier Thermostat Models	Price
Carrier INFINITY CONTROL	$475-$600
Carrier INFINITY REMOTE ACCESS W/O ROUTER:	$340-$400
Carrier INFINITY REMOTE ACCESS W/ ROUTER	$425-$475
Carrier CÔR	$135-$195
Carrier CÔR 7C/7	$225-$260
Carrier CÔR 5C/5	$185-$200
Carrier COMFORT WI-FI	$135-$225
Carrier INFINITY TOUCH CONTROL	$385-$450
Carrier PERFORMANCE EDGE–6 MODELS	$185-$265
Carrier COMFORT — 6 MODELS	$115-$170
Carrier PERFORMANCE COMFORTZONE II ZONED SYSTEM — 3 MODELS	$1,100-$1,350

Notes

Carrier Infinity communicating components ONLY work with a Carrier communicating thermostat
Compatible Carrier communicating equipment: All Carrier Infinity Series Heat Pumps
No energy saving features discovered over base communicating model, as Infinity is only communicating model available

INFINITY STANDARD FEATURES
Full-color touch screen with photo upload capability
Intuitive, on-screen prompts
Local weather 5-day forecast
Occupancy sensing to automatically select comfort or energy saving system settings
Remote access via Internet as well as Apple® and Android™ smartphone or tablet devices[1]
Real-time energy use tracking
Ideal Humidity System® management capable for exacting comfort
Hybrid Heat® system management capable
Intelligent, heating- and cooling-comfort staging capable
Auto changeover between heating and cooling
Controls indoor air quality products
ComfortFan™ technology capable with four levels of "constant ON" fan speeds
Ventilation management capable
Measures and manages airflow to each zone and adjusts for quiet comfort
Measures percentage of airflow to each zone for best operation
Day-at-a-glance 7-day (wake, away, home, sleep) programming
Advanced smart setback for best energy savings during "away" and ramp up periods
One-button Touch-N-Go® quick-settings-change feature
Simple vacation programming controls temperature and humidity
Up to 8-zone capability with custom naming feature
Choice of TrueSense™ dirty filter detection or fixed-schedule based filter replacement reminders
System maintenance reminders
10-year parts limited warranty upon timely registration[2]

OPTIONAL FEATURES
Purchase of dedicated wireless router (SYSTXXXGWR01)
Home automation compatible with system access module (SAM)
Separate purchase of up to 8 smart sensors for zoning applications
Application of remote sensor to feed information to the main control from a different location
The wall control is available in black or white which can be mounted on an accessory trim plate in Silver, Black, Gray or White.

[1] When connected to a Wi-Fi network with an existing or optional dedicated wireless router. Wi-Fi® is a registered trademark of the Wi-Fi Alliance Corporation.

EFFICIENCY
Hybrid Heat® system management capable
Utility curtailment compatible
Occupancy sensing allows automatic activity changes to save energy when space is unoccupied

PERFORMANCE
Manages up to 8 zones
Precise temperature management with intelligent system staging[1]
Occupancy sensing allows automatic activity changes to provide comfort when space is occupied
Load matching performance with Greenspeed® intelligence system for greatest comfort and efficiency
Ideal Humidity System® cooling dehumidification control capable
Manages humidification products
Ventilation management capable
Controls system airflow
Permanent system settings and 9-hour clock setting retention in case of power failure

TECHNOLOGY
Touch screen, intuitive control
Advanced smart setback
Real-time energy use tracking[2]
Manages airflow to each zone
Self-configuration aids system setup
Advanced programming includes Touch-N-Go feature
Wi-Fi® enabled remote access[3]
Advanced communicating system diagnostic intelligence
Window protection feature eliminates frost inside windows from over humidification
Home automation compatible (with SAM option, Infinity OpenAPI, or Amazon Alexa connection)

REQUIREMENTS
Battery free
Powered by connection to major system components
Four wire connection to indoor unit

AESTHETICS
Large, full-color, LCD display
Dimensions: 4.5"H x 5.5"W x 1.25"D

About: **Product features for manufacturer thermostats. Orange higlights indicate possible energy saving features**

Trane, American Standard

https://www.trane.com/residential/en/products/thermostats-and-controls/connected-controls/

Characteristics	Comfortlink ™ II XL1050	Comfortlink™ II XL950	Comfortlink™ II XL850	XL824	XR724	XL624
Nexia™ Remote Climate Access	X	X	X	X	X	X
Nexia™ Connectivity	Wi-Fi or Ethernet	Wi-Fi or Ethernet	Wi-Fi or Ethernet	Wi-Fi or Ethernet	Wi-Fi or Ethernet	Z-Wave®
Nexia™ Bridge	Built-In	Built-In	Built-In	Built-In	Purchased Separately	Purchased Separately
Compatible With Communicating And Variable Speed Systems	X	X	X	-	-	-
Touchscreen	7" full color	7" full color	4.3" full color	4.3" full color	4.3" black & white	4.3" black & white
Programmable (Days/Schedules Per Day)	7/4	7/4	7/4	7/4	7/4	7/4
Heat/Cool Stages	5/2	5/2	5/2	5/2	4/2	4/2
Adjust Home Temperature Remotely	X	X	X	X	X	X
Upgradable Software	X	X	X	X	X	X
Nexia™ Diagnostics	X	X	X	X	X	-
American Standard Equivalents	**Platinum 1050**	**Platinum 950**	**Platinum 850**	**Gold 824**	**Silver 724**	**Silver 624**

Trane Thermostat Models	Price
Trane ComfortLink II XL1050	$565-$600
Trane ComfortLink II XL950	$525-$550
Trane ComfortLink II XL850	$435-$475
Trane XL824	$195-$235
Trane XL624	$150-$170
Trane XL803	$245-$300
Trane XL802	$185-$240
Trane XL800	$170-$195
Trane XL602	$160-$190
Trane XL600	$115-$145
Trane XR402	$75-$110
Trane XR401	$65-$100
Trane XB200	less than $100

Notes

Compatible Trane communicating equipment: XV20/XV18 Heat Pumps
Trane communicating thermostats only work with Trane communicating HVAC equipment, not with any other brand.
Communicating stats include Nexia smart home automation system that also controls lighting, locks, the garage door, your home's security system and more.

Key Features

Wi-Fi or Ethernet Connectivity
Large Color Touchscreen
Built-in Nexia Bridge
Program up to 4 schedules a day, 7 days a week
Trane Confortlink™ II zoning compatible
Allergy cleaning
Self-guided scheduling
Amazon Alexa compatible

About:	Various name brands and which parent company they fall under to understand volume of sales

AHRI HP Manufacturers (split systems)

Manufacturer	Count
TRANE	4312
AMERICAN STANDARD	2760
LENNOX	1847
COLEMAN	1298
LUXAIRE	1275
CARRIER	1273
YORK	1237
GOODMAN	1111
CONCORD	1090
BRYANT HEATING AND COOLING SYSTEMS	1047
FRANKLIN	1015
ARMSTRONG AIR	1006
TEMPSTAR	973
AMANA DISTINCTIONS	972
JANITROL	953
ONE HOUR AIR CONDITIONING AND HEATING	945
ENERGI AIR	945
CHAMPION HEATING AND COOLING	900
HEIL	851
DAY & NIGHT	812
ARCOAIRE	781
COMFORTMAKER	778
KEEPRITE	764
KENMORE	760
AIRQUEST	757
FRASER-JOHNSTON	744
AMANA	726
DUCANE	668
AIREASE	606

Rank (avail. models)	
Trane	7072
Carrier	5734
Daikin	4051
Lennox	3943
Coleman	3810

Communicating Thermostat Brand Names

Amana, Goodman and Daikin ***ComfortNet***

Armstrong Air ***Comfort Sync***

Bryant ***Evolution***

Carrier ***Infinity (or Greenspeed)***

Coleman ***Echelon***

Heil, Comfortmaker, Keep Rite and others ***Observer***

Lennox ***iComfort***

Luxaire ***Acclimate***

Maytag, Tappan, Westinghouse, Nu-Tone or Broan ***iQ Drive***

Rheem and Ruud ***Comfort Control System***

Trane and American Standard ***ComfortLink II***

York ***Affinity***

About: **Notes from various sources referencing smtart thermotats for VCHP systems.**

Cadeo Market Transformation memo

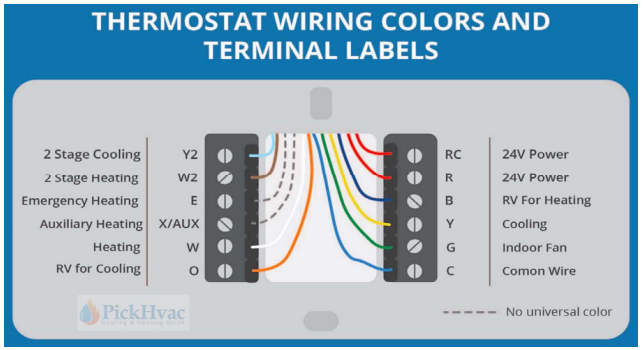
Variable speed heat pumps: Variable speed (inverter driven) heat pumps require specialized control sequences to operate properly. Currently, smart thermostats are unable to control these units. The market barrier here is likely the proprietary nature of the manufacturer's control sequence. There may also be limitations within the smart/advanced smart thermostat as to the complexity of control sequences the device can handle. Some manufacturers are developing workarounds to allow for smart, third party, thermostat controls (LG Electronics 2018, Turpin 2015). Some equipment manufacturers have their own, proprietary controls to handle variable speed heat pumps, but so far, none of these have emerged in the literature as smart.
Ductless heat pumps: Currently, manufacturers of ductless heat pumps have not configured their units to be compatible with smart or advanced smart thermostats, which represents a market barrier on the manufacturer side, although Carrier claims their Cor thermostats are compatible with Carrier DHPs. Additionally, smart/advanced smart thermostats are currently unable to talk to each other, which is a requirement for proper control of multi-head DHP installations (installation of multiple indoor DHP units with a common outdoor condenser). Again, this represents a market barrier that could likely be overcome if the thermostat manufacturers allocated resources and effort to the issue. Some workarounds may exist but with reduced functionality and increased expense (Zitko 2018).

Variable Speed Thermostat Operation

Rather than having wires that give direct signals for first or second stage heating or cooling and wires for other performance features, communicating thermostats are built with just four wires: A single wire for heating, a single wire for cooling and two wires that provide power and allow the components and the thermostat to "communicate." This means the components and temperature sensors send information to the thermostat, and the thermostat responds by controlling precisely how much heating or air conditioning is required to keep the home at the temperature desired with little variation.

Communicating HVAC Basics

Used with some two-stage and all variable-capacity HVAC systems
Require just four wires – two power wires for heating and cooling and two for communication between components
When communicating equipment is installed, the thermostat searches for the components in similar fashion to how your smartphone searches for a Bluetooth speaker you want it to pair with
Once the thermostat and components are paired, the components communicate to the thermostat what their capabilities are in terms of heating and cooling capacity and, for blower motors, how much air they can move through the system, which allows the thermostat to set up optimal performance
Each component has an electronic address, so the thermostat knows where the data is coming from and can send data back to that component to control its operation
A computerized serial network allows each component to send ongoing performance data that refines performance
Indoor and outdoor sensors allow the thermostat control to determine and communicate exactly how much heating or cooling, dehumidification or humidification and air flow are required to keep the home optimally comfortable



General Notes

The terms 'communicating' and 'smart' share many features but are not synonymous

NEEA Sub-advisory committee meeting notes

- Need to establish baseline communicating thermostat specified/installed with variable speed systems
- Interested in interfaces with smart thermostats in addition to proprietary brands
- Determine common variable speed thermostat installs with AHR and distributor conversations
- 3rd party tstats dumb down operation (Ecobee field trial proved conversion to 2-speed operation)

About: **Notes to inform possible future IDI scope**

Possible Interview Questions

Future support for 3rd party t'stats (why/why not)?
Does t'stat continue functionality upon loss of WiFi signal?
Possible integration with 3rd party apps (ex. Whisker Labs)?
Future communicating t'stat enhancements (such as occ sensors, DR capability, etc.) forthcoming?
Market knowledge: Incentives for premium (occupancy) vs basic, Future of controls, priority of energy savings, etc.

Feedback from Abi at Energy Star regarding value of testing

For ductless, in reality don't modulate down as far as suppoesd to in light loaded conditions. Be interesting to compare similar ducted units in similar homes using own recommended controller to units that ramp down appropiately or not
Do some do better than others at low levels?
Trying to develop metric for whether controls take into account running time, and could look at power to determine runtimes
Do some manufacturers do a better job than others at reducing cycling losses
Test different scenarios and see how systems respond
Do advanced controllers do better controls algorithms?
Some ducted manufacturers feel like they stand above ductless controllers
Should include TRANE

Calls to local HVAC shops to ask about market for communicating thermostats sold with VCHP systems

Manufactuers	Local rep	Location	T'stats sold
Daikin/Goodman	Columbia He	Portland	Haven't sold a Daikin One+ yet
Lennox	Garoken	Beaverton	Mix of premium vs base level products
Coleman/York	NW HVAC Se	Portland	Mix of HX products, mostly HX or Honeywell home/Echelon
Carrier/Bryant	Evergreen G	Sherwood	Infinity line only
Trane/American Standard	ComfortAir	Vancouver	Comfortlink II only

Notes on research from Energy Star call

Proximity sensor available on several models, just controls backlight
Carrier/Bryant infinity model has occ sensor linked to comfort control, just no differentiating thermostat that is communicating
Trane Comfortlink can add motion or window/door sensors as part of Nexia bridge
check off against energy star metrics
ask about studies they have done to establish energy savings features