Cold Climate Heat Pump Sizing Support Tools

User Guide

FEBRUARY 2024

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

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Cold Climate Heat Pump Sizing Support Tools

The cold climate heat pump sizing support tools help users to select cold climate air source heat pump (ccASHP) products that are sized to best match the peak and annual heating needs of a home or heating zone. The tools, functioning within the NEEP ccASHP Product List website, include a search function and a product-level analysis. The search function helps view multiple products based on search criteria and select products for further analysis or comparison. The product view displays system and load-matching data, providing a visual for how a specific heat pump's capacity matches the heating and cooling loads across the home's seasonal temperatures.

Considerations

This tool is for preliminary product selection planning only. It is necessary to conduct full engineering capacity assessments that take line-length, multi-head impacts, and other factors into consideration. Use manufacturer's data and tools to finalize product sizing and selection determinations.

This tool is designed for use in heating-dominated climates. The tool and user guide presume the reader has a basic understanding of heat pump terminology and home heating and cooling load concepts. If designing for regions that also have high humidity and summer cooling loads, the sizing decision needs to carefully balance heating, cooling, and humidity control needs.* In these climates, it is highly recommended to compare sensible cooling capacity to sensible load at the cooling design temperature and then select the equipment and system configuration that supports the higher of the heating or cooling loads. Then, if supplemental dehumidification or heat is needed, install as necessary. This tool can provide information about the heating and sensible cooling aspects of those systems, but it is insufficient for the ultimate system selection.

**Note:* *If cooling load or humidity control require a system that can provide over 140 percent of the heating load at design temperatures, consider other heat pump products or consider additional non-heat-pump equipment such as energy recovery ventilators and dehumidifiers.*

Views

This tool has multiple views and features designed to support the user's needs.

1. A **search result list view**, where a user can compare multiple products to each other based on search criteria. In this view, the tool limits users to viewing 500 products due to calculation speeds of the underlying data
2. A single **product view**, which displays key data regarding how that product fulfills a home or zone's heating and cooling loads
3. Alternate views and other features, which allow a user to simultaneously evaluate multiple products, build a system with multiple compressors, or view only the basic information

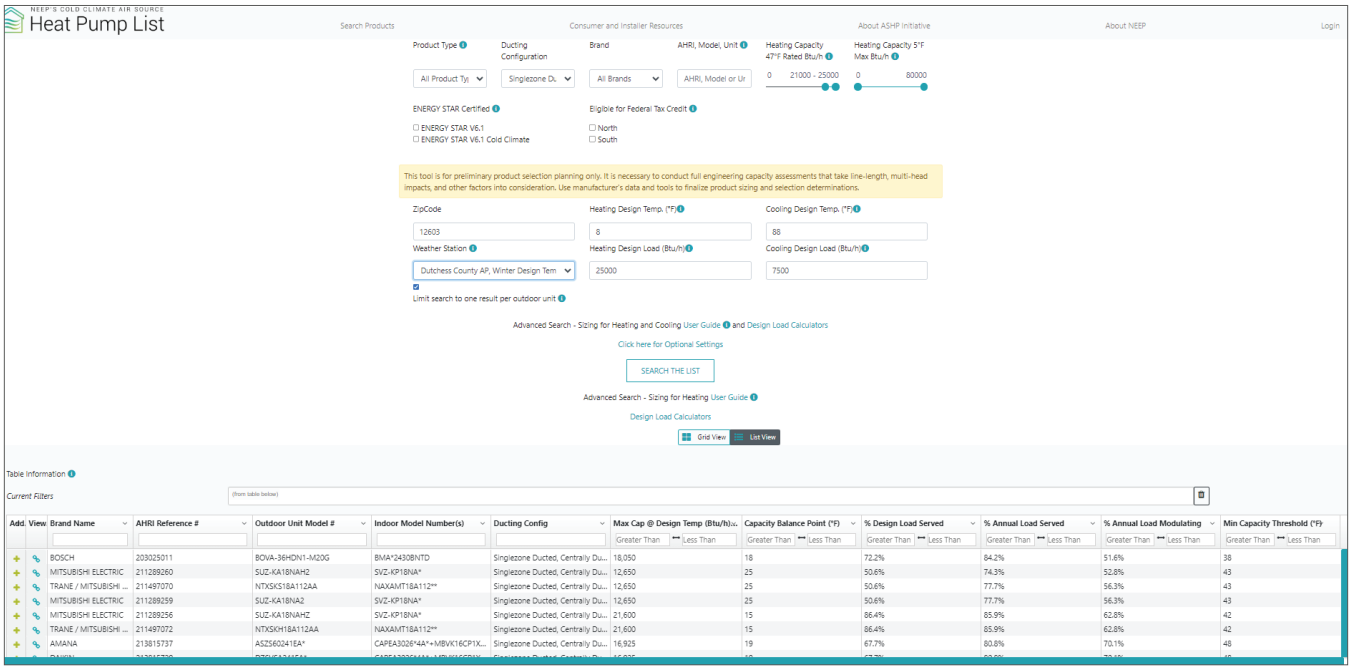
Search Result List View Instructions

For the **search result list view,** from the main page click the *Advanced Search - Sizing for Heating and Cooling* button. This will open extra data fields to allow product listing relative to load-matching. Complete any known standard search data fields before entering the sizing data fields.

- **Complete the following data fields:** *Zip Code, Weather Station*, *Heating Design Load (Btu/h),* optional: *Cooling Design Load (Btu/h)*
    - The tool will assign the *Heating Design Temperature* and *Cooling Design Temperature* based on the selected weather station using American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) data. The user can adjust this value to meet the specifics of the location.
- After entering data, click the *Run Advanced Sizing for Heating Search* button.
    - Returns from the advanced search will be available in both List View and Grid View. Within List View, the user can sort results for any column in either ascending or descending order or filter columns to only show products that meet the entered conditions. Grid View will present products in the same order as sorted and filtered in the List View. From either view, the user can navigate to a specific heat pump's Product View for additional data visualization. Add products to the selection bar to compare or create a multi-product system.

Note: *Some ccASHP products in the database may not include performance data below 5°F. If searching for a weather station where the design temperature is below 5°F, this tool will not display design-load related data for such products. In these cases, the user has the option to self-enter a low-temperature maximum capacity rating on the product view.*

Figure 1: ***List View Results Example***



To run the calculations, the user must apply filters to reduce the search returns to 500 results or fewer. If a search is over the limit, use a combination of the following filters:

1. Brand
2. Ducting Configuration
3. Heating Capacity ranges (either/both @47°F and @5°F)
4. Limit search to one result per unique outdoor unit checkbox*
5. AHRI, Model, Unit

Note:* Some manufacturers, particularly those with ducted systems, have listed many relatively similar heat pump systems in the database. Each individual listing is its own AHRI certificate number representing a unique combination of outdoor unit, indoor unit, and in some cases paired indoor gas-furnace. For the heat pump's heating capacity variations, the dominant variable is the outdoor unit. Selecting the **Limit search to one result per unique outdoor unit checkbox sets the search to pick the first instance of each outdoor unit as representative, significantly reducing the product count in the search results. This is checked by default when a user starts a new search.*

*Once chosen, users can list-view other systems that have the same outdoor unit by entering the selected outdoor unit number into the **AHRI, Model, Unit** input box and de-selecting the **Limit search to one result per unique outdoor unit** checkbox.*

Apply Compressor Lock-Out Temperature

If the user intends to apply a compressor lock-out or backup system switchover temperature, they can see the impact of that decision by using the optional *Apply Compressor Lock-Out Temperature field. This temperature setting should be set based on the installer's experience or manufacturer guidance. The tool will zero out the heat pump's capacity for all hours that occur below the indicated temperature threshold, thus changing some of the load-fulfillment data.*

This tool does not presume what the backup, supplemental, or auxiliary heating system may be. The tool's default display assumption is that the heat pump continues to run at its full capacity even below the capacity balance point, with a supplemental heating system providing the remainder of the heat load. Use the compressor lock-out temperature option if a system's controls will stop the heat pump operation below a certain temperature, reverting entirely to the secondary heating system.

Manually Set Low Temperature Capacity Rating

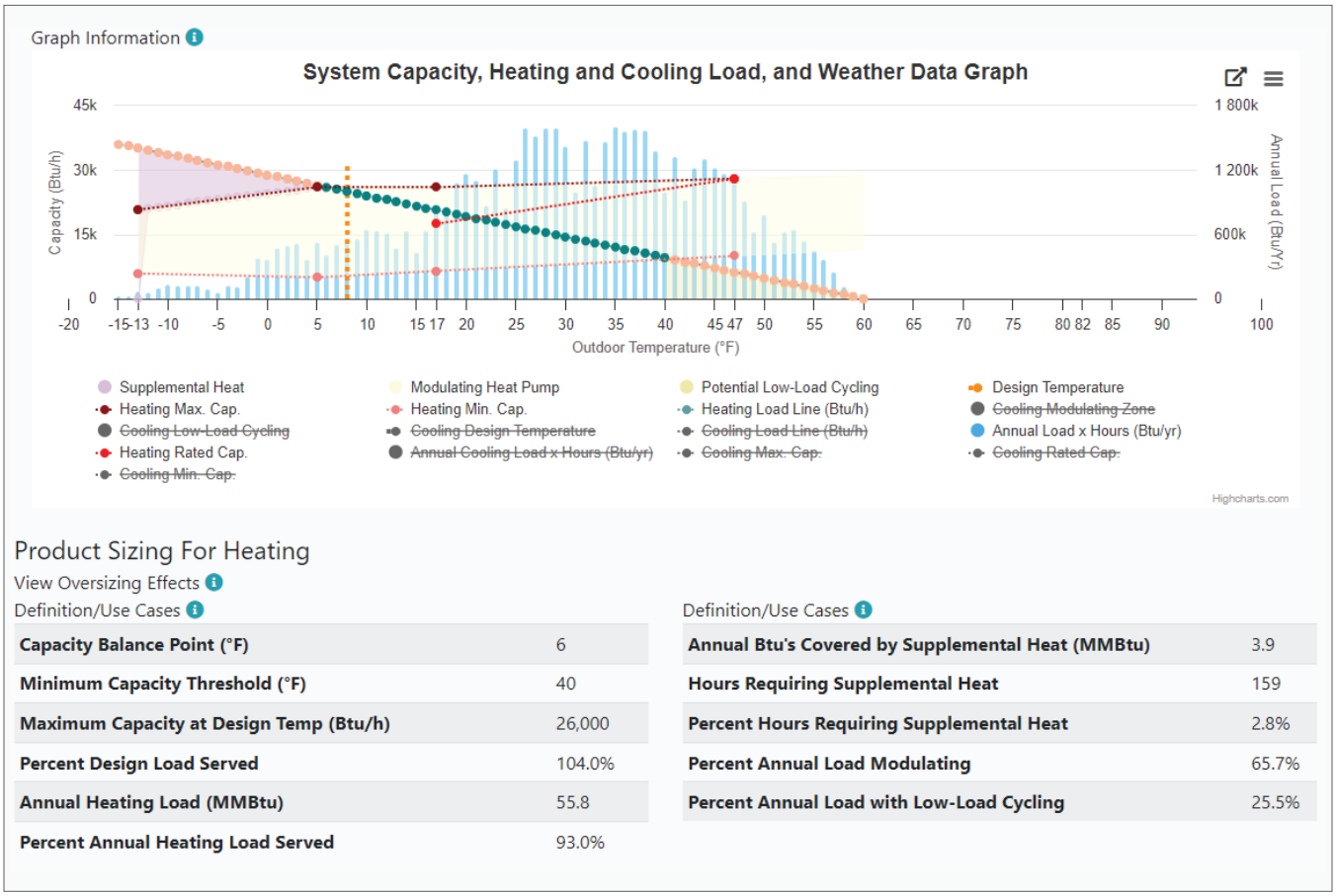
Some ccASHP products in the database do not include performance data below 5°F. If viewing a product for a particularly cold climate, where the design temperature is below 5°F, this tool will display a warning text below the graph to state that the tool assumes zero capacity below 5°F *even though ccASHPs will operate below 5°F. In these cases, the user has the option to self-enter a low-temperature maximum capacity rating to complete the data set. Please reference the manufacturer's expanded performance data to determine this input.*

Product View Instructions

For the **product view**, navigate to a specific product in the database and select the *Advanced Data - Sizing for Heating* button to open extra data fields:

- **Complete the following data fields:** *Zip Code*, *Weather Station*, *Heating Design Load (Btu/h),* optional: *Cooling Design Load (Btu/h)*
    - The tool will assign Heating Design Temperature and Cooling Design Temperature based on the selected weather station as per ASHRAE data. This value can be edited to the specific heating design temperature of the home.
    - Optionally: Complete the *Apply Lockout Temperature*, and *Manually Set Low Temperature Capacity Rating* data fields.
- After entering data, click the *Run Sizing for Heating Data* button.
    - Data and a graphic visualization of how the selected system's capacity matches the annual heating needs will display. More details about the graphic and the data points are below.

Figure 2: ***Product View Results Example***



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	6
Minimum Capacity Threshold (°F)	40
Maximum Capacity at Design Temp (Btu/h)	26,000
Percent Design Load Served	104.0%
Annual Heating Load (MMBtu)	55.8
Percent Annual Heating Load Served	93.0%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	3.9
Hours Requiring Supplemental Heat	159
Percent Hours Requiring Supplemental Heat	2.8%
Percent Annual Load Modulating	65.7%
Percent Annual Load with Low-Load Cycling	25.5%

Manage the Product View Visualization Chart

Clicking on any element in the chart's key will toggle it between being displayed or hidden. The user can remove the load x hours histogram and view cooling capacities on the chart at their discretion.

Note: *The annual load x hours histogram is only indirectly related to the system capacity and load lines. It is on its own scale shown on the right axis. The largest bars represent temperatures with the highest overall impact on the heat pump's annual performance. Selecting a heat pump that will be modulating with particularly high efficiency at those temperature points will lead to lower energy bills and best performance.*

Product View Quick-Guide

The product view visualization and associated data provide a wealth of useful information to help the user determine if this heat pump is a good fit for the load. A detailed description of each data point and visual element is provided later in this user guide. For a quick assessment, here are the most important aspects to consider:

1. Look at the heat pump's max capacity at the design condition. Does it match the user's intentions?
    a. If planning for the heat pump to provide heating without backup, check that *Percent Design Load Served* is between 90 percent and 120 percent. Avoid oversizing.
    b. If planning for the heat pump to provide partial load, recognize the need for supplemental heat to cover the difference. Is that being provided by a separate heating system?

2. Maximize time spent modulating. Will this heat pump spend its run-hours efficiently providing heat?
    a. Look at Percent Annual *Load Modulating* and pick a product that maximizes this value.
    b. Observe the overlap between the load x hours histogram, the load line, and the modulating zone. Pick a product with the load line passing through the heat pump's modulating zone coincident with the weather station's highest load x hours. These are the conditions with best operational efficiency, providing the home's full heating need. The load line is represented by teal markers when inside the modulating zone and orange markers when outside of the modulating zone.

    > ***Example:*** *The majority of load x hours in Figure 2 are within the range of 18°F to 50°F. The modulating zone of the heat pump for the entered load ranges from 6°F to 40°F. A better sized heat pump for this load at this location would modulate to 50°F or above to operate efficiently for the majority of the load x hours.*

    c. Confirm that the Minimum *Capacity Threshold* is not too low of a temperature. The ideal unit should only be at risk of low-load compressor cycling for particularly mild days, with low overall load.

Maximize the user's annual use of heat pump heating. View the *Percent Annual Heating Load Served* to gauge how much of the home's heating need is provided by the heat pump. It is common and appropriate for a small percent of the annual load to not be fully covered below the design temperature.

Alternate Views and Features

Basic View

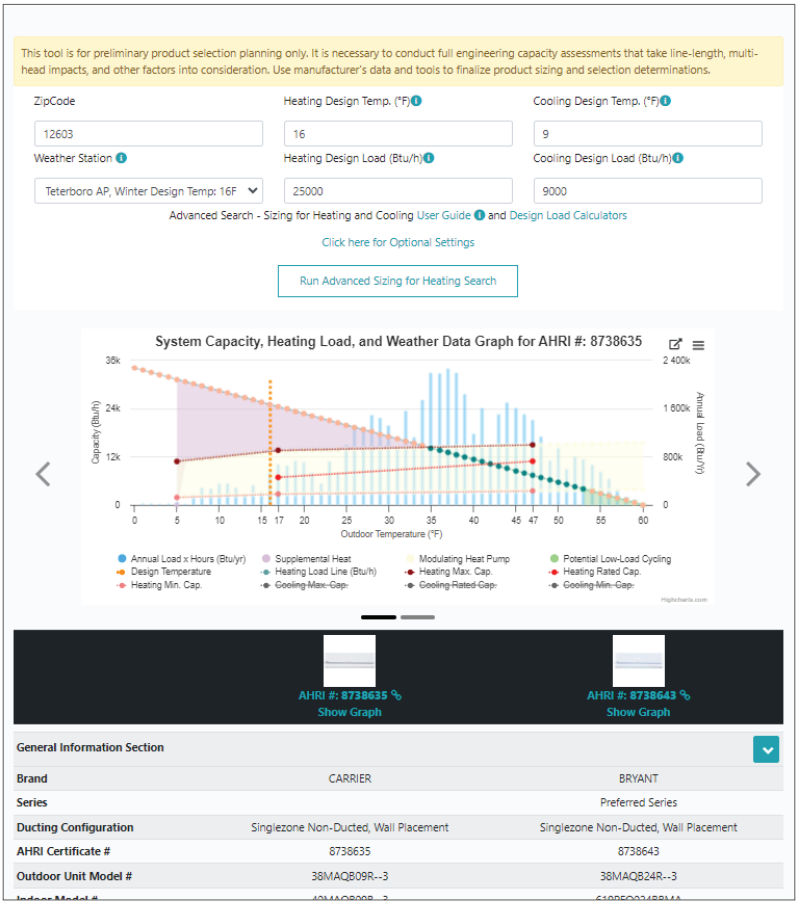
The *Basic View* button displays a view of the product page that reduces the information displayed to only the basics of the heat pump specs and sizing. The graph no longer shows the load x hours, and there is no product sizing data. This feature can be used for a user that only wants the basic heat pump performance data. Select *Classic View* to return to the original page showing the complete graph and sizing data.

Compare Products View

To access the compare products view, run an *Advanced Sizing for Heating Search* and add products to the selection bar using the Add button to the left of the product. The user can select up to five products from multiple brands or ducting configurations. Once all the products to compare have been selected, click *Compare Products* on the selection bar. If a single product is added more than once to the selection bar, the *Compare Product*s button will be hidden. To compare the products, reduce the count of each product to one by clicking the "-" for the products with a count greater than one.

This feature allows the user to compare the product graphs, general information, and sizing data of multiple heat pumps. All data for each selected product is shown in a single column making it easy to compare between products. Move between graphs by clicking the arrows, swiping (mobile), or selecting *Show Graph* below the product. Open a heat pump's product page in a new tab to view without the other products by selecting the AHRI number shown below the product.

Figure 3: *Compare Products View Example*



Multi-Product System View

This view lets the user visualize how the use of multiple heat pump compressor products add up, or stack, to support the building's full load. Scenarios where this feature may be useful would be one ducted heat pump compressor supporting the upstairs and a second supporting the downstairs or an open floorplan supported by multiple mini-splits. To access the stack products feature, run an *Advanced Sizing for Heating Search* and add products to the selection tab using the *Add* button to the left of the product. Select up to five different products from multiple brands or ducting configurations. Users can select multiples of a single product. Once all products have been selected, click Stack Products on the selection bar.

Note: *Each zone of the home should be analyzed independently to confirm the heat pump tasked with heating and cooling the zone is sized correctly. It is possible for a multi-product system to be sized properly to the home's total load but for each compressor to be sized improperly to the zone it is intended to heat and cool.*

Failing to size a heat pump to the zone it heats and cools can result in poor comfort, inefficient operation, and high bills.

The multi-product system is compared against the heating and cooling design loads as entered. The heating and cooling produced by each compressor will interact with the others because the compressors that comprise the system heat and cool mutual space. This causes some features of the graph and product sizing data to change:

Multi-System Graph Features	Definition/Importance
Total Max Cap (Btu/h)	The sum of all products' maximum capacities. This is the stacked-system's total capacity if all heat pumps are operating at their highest possible outputs.
Total System Min Cap (Btu/h)	The sum of all products' minimum capacities. This is the stacked-system's minimum capacity if all heat pumps are operating. However, at loads below this line, it is likely that the heat pumps will minimize compressor low-load cycling by not operating simultaneously.
Single System Min Cap (Btu/h)	The minimum capacity of the heat pump with the lowest heating capacity.
Modulating Single System	In this zone, the heating load is below the total system minimum capacity but above the single system minimum capacity. At conditions within this zone, one heat pump should operate normally while the other heat pump(s) remains off as the operating heat pump alone has the minimum capacity necessary to heat the space without low-load cycling. The product sizing for heating refers to this area of the primary cycling zone.
Single System Low-Load Cycling	The area where the load is less than the single system minimum capacity. At conditions in this zone, all heat pumps may experience low-load cycling.

Detailed Descriptions for Data Fields and Calculation Methods and Sources

Weather Station*: This selection will auto populate the *Heating Design Temperature* field from the 99-percent dry-bulb heating design temperature listed in the 2021 ASHRAE Handbook of Fundamentals.

> ****Note:** The tool does not have weather data for all weather stations. If a user does not see theirs, they should select the closest. Be sure to consider stations in neighboring states if near a state border.*

Heating Design Load*: The general use of this tool only shows results for a single heat pump. If a user's home will use multiple heat pumps to fulfill a home's total load, add multiple products to the selection bar and use the *Stack Products* function or enter a zonal design load and repeat for each zone. For the heating and cooling design loads, use the user's preferred method. This could be by Air Conditioning Contractors of America (ACCA) Manual J software, block-load calculators, or historic-fuel use load estimators. An accurate design load is critical to proper sizing. Resist adding in extraneous safety factors to avoid oversizing.

> ****Note:** A home's load is principally determined by outdoor air temperature relative to thermal envelope quality. But it is also impacted by solar gains, internal gains, and wind. Design load calculations assume no solar gains, moderate internal gains, and moderate wind impacts.*
>
> *This tool applies a linear load line from the designated heating design load at design temperature, to zero load at 60°F. In reality, the load at any given temperature is impacted by other variables, particularly solar gains that will reduce load. The Annual Heating Load and related calculations have been derated 10 percent to reflect this. The graph's load line has not been derated and can therefore be considered conservative.*

> ***Note:** For particularly cold climates, there will be some load hours at temperatures for which there is no manufacturer's capacity data. In these cases, the tool will use a capacity of 0 Btu/h for those hours. This calculation approach only has a small impact on annual load-served results.*

List Search Data Fields Definitions

Figure 4: ***Data Fields for List Search***

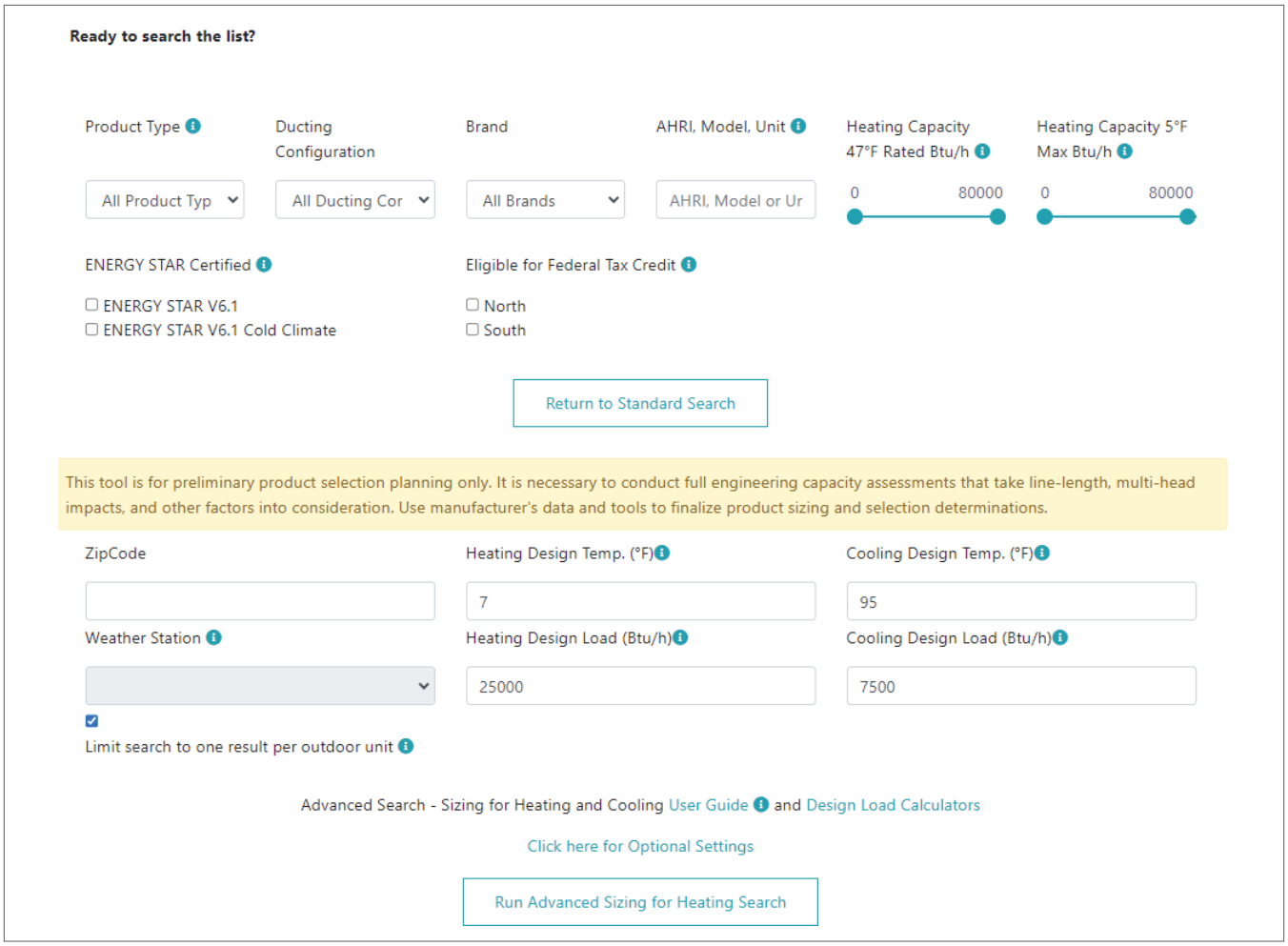
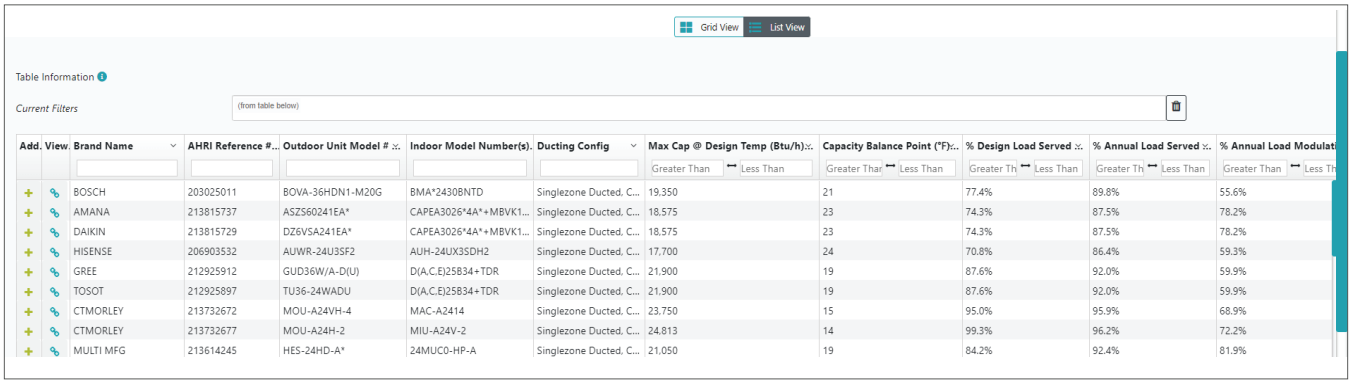


Table: List Search Data Fields Definitions

Filters/Data Points	Definition/Use Case
Brand	The product's manufacturer as listed within the NEEP database. This field can be used to limit search results. Note, some manufacturers list products using a variety of tradenames.
AHRI, Model, Unit	Identifiers used to label equipment. AHRI tests and certifies equipment ratings. This field can be used to limit search results.
Ducting Configuration	A drop-down of different system configurations as listed by the manufacturer within NEEP's database. This field can be used to limit search results.
Heating Capacity @47oF	Often listed as the *rated capacity*. Unlike *max capacity* @5°F, this is a standardized capacity at 47°F used for standard comparison amongst all heat pumps.
Heating Capacity @5oF	Often listed as the maximum heating capacity @ 5°F, this is the amount of Btu/h the device is capable of producing at the outdoor temperature.
Weather Station	Location that collects weather data. The design temperature and temperature-bin climate information used by the tool calculations are specific to the weather station's data. This tool only has temperature bin data for a subset of all weather stations listed in the ASHRAE Handbook of Fundamentals or used by ACCA Manual J 8th Edition Version 2.5.
Heating Design Temp	This is also referred to as the *winter design temperature*. This tool follows best practices and assigns the 99% heating dry-bulb temperature as listed by the 2021 ASHRAE Handbook of Fundamentals for the selected weather station. For heating, 99% of the region's hours are above this temperature.
Heating Design Load	This is the heating need of the home (or zone), at the heating design temperature, to maintain a 70°F indoor air temperature.
Limit Search to One Result per Outdoor Unit	Some manufacturers, particularly those with ducted systems, have listed many relatively similar heat pump systems in the database. Each individual listing is its own AHRI certificate number representing a unique combination of outdoor unit, indoor unit, and in some cases paired indoor gas-furnace. For the heat pump's heating capacity variations, the dominant variable is the outdoor unit. Selecting this checkbox sets the search to pick the first instance of each outdoor unit as representative, significantly reducing the search results. This is checked by default when the user starts a new search.

List Results Data Fields Definitions

Figure 5: ***List View from Advanced Search - Sizing for Heating***

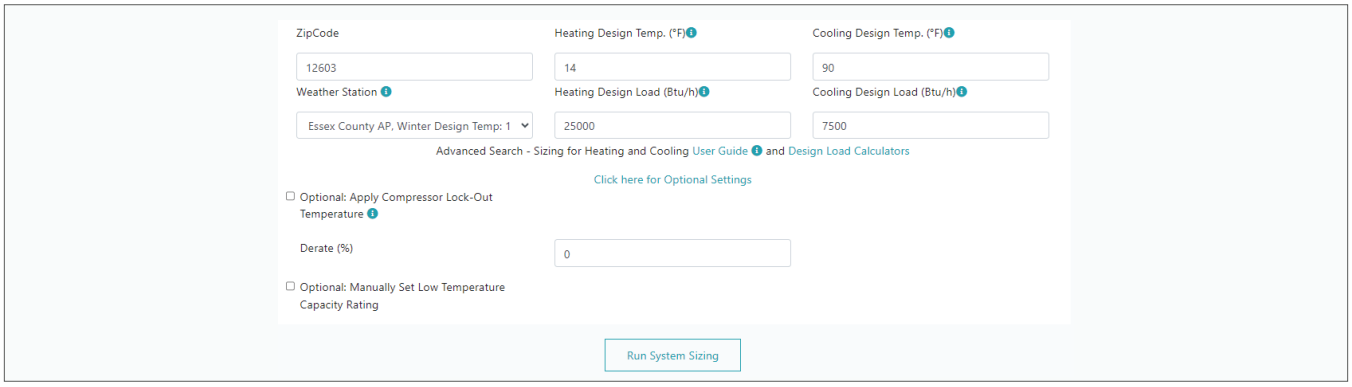


Add	View	Brand Name	AHRI Reference #	Outdoor Unit Model #	Indoor Model Number(s)	Ducting Config	Max Cap @ Design Temp (Btu/h)	Capacity Balance Point (°F)	% Design Load Served	% Annual Load Served	% Annual Load Modulati
							Greater Than / Less Than	Greater Than / Less Than	Greater Th / Less Than	Greater Th / Less Than	Greater Than / Less Th
+		BOSCH	203025011	BOVA-36HDN1-M20G	BMA*2430BNTD	Singlezone Ducted, C...	19,350	21	77.4%	89.8%	55.6%
+		AMANA	213815737	ASZS60241EA*	CAPEA3026*4A*+MBVK1...	Singlezone Ducted, C...	18,575	23	74.3%	87.5%	78.2%
+		DAIKIN	213815729	DZ6VSA241EA*	CAPEA3026*4A*+MBVK1...	Singlezone Ducted, C...	18,575	23	74.3%	87.5%	78.2%
+		HISENSE	206903532	AUWR-24U3SF2	AUH-24UX3SDH2	Singlezone Ducted, C...	17,700	24	70.8%	86.4%	59.3%
+		GREE	212925912	GUD36W/A-D(U)	D(A,C,E)25B34+TDR	Singlezone Ducted, C...	21,900	19	87.6%	92.0%	59.9%
+		TOSOT	212925897	TU36-24WADU	D(A,C,E)25B34+TDR	Singlezone Ducted, C...	21,900	19	87.6%	92.0%	59.9%
+		CTMORLEY	213732672	MOU-A24VH-4	MAC-A2414	Singlezone Ducted, C...	23,750	15	95.0%	95.9%	68.9%
+		CTMORLEY	213732677	MOU-A24H-2	MIU-A24V-2	Singlezone Ducted, C...	24,813	14	99.3%	96.2%	72.2%
+		MULTI MFG	213614245	HES-24HD-A*	24MUC0-HP-A	Singlezone Ducted, C...	21,050	19	84.2%	92.4%	81.9%

Search View Results Fields	Definition
Maximum Capacity at Design Temp (Btu/h)	The heat pump's maximum capacity output at the design temperature.
Capacity Balance Point (°F)	Temperature at which the capacity of the heat pump equals the heating load in the house (i.e., the point of intersection of the load line and max capacity line). Note, the term balance point is also used to convey other concepts in the building science and HVAC fields.
Percent Design Load Served	The percent of the home's design load met by the heat pump operating at maximum capacity at the design temperature. For whole-home heating, this should be between 90% and 120%.
Percent Annual Load Served	The percent of the annual heating load satisfied by the heat pump. This includes load hours at which the heat pump may be low-load cycling (warmer weather), as well as load hours where the heat only fulfills a portion of the home or zone's heating load (colder weather). It is expected, as with most heating systems sized to the design load, that a small percent of annual load during the coldest hours will not be served by the heating system. Those hours are few, and the home's internal temperature will not drift substantially during them.
Percent Annual Load Modulating	The percent of the annual heating load supplied by the heat pump in its modulating zone—between minimum and maximum capacities.
Minimum Capacity Threshold (°F)	Temperature at which the home's load is lower than the heat pump's minimum capacity. Below this point, the heat pump's compressor will cycle.

Product View Data-Entry Field Definitions

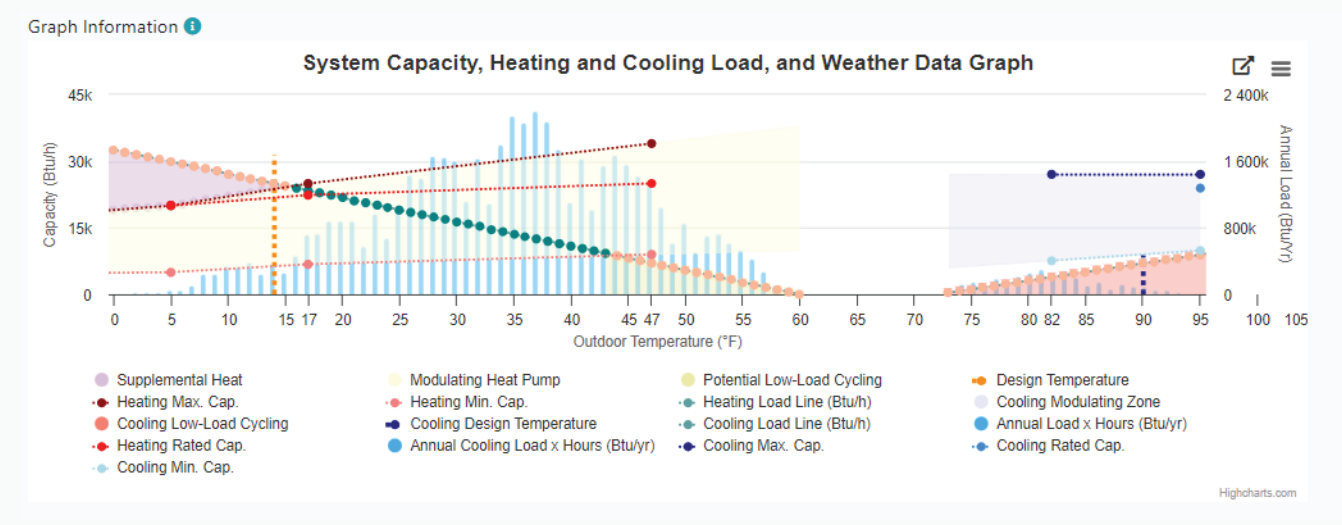
Figure 6: *Data Fields for Advanced Data – System Sizing Product View*



Filters/Data Points	Definition/Use Case
Zip Code	The zip code of the home. This will populate the weather station dropdown with the five closest weather stations.
Weather Station	Location that collects weather data. The design temperature and temperature-bin climate information used by the tool calculations are specific to the weather station's data. This tool only has temperature bin data for a subset of all weather stations listed in the ASHRAE Handbook of Fundamentals or used by ACCA Manual J 8th Edition Version 2.5.
Heating Design Temperature (°F)	This is also referred to as the *winter design temperature*. This tool follows best practices and assigns the 99% heating dry-bulb temperature as listed by the 2021 ASHRAE Handbook of Fundamentals for the selected weather station. For heating, 99% of the region's hours are above this temperature.
Heating Design Load (Btu/h)	This is the heating need of the home (or zone), at the heating design temperature, to maintain a comfortable indoor air temperature.
Cooling Design Temperature (°F)	This is also referred to as the *summer design temperature*. This tool follows best practices and assigns the 1% cooling dry-bulb temperature as listed by the 2021 ASHRAE Handbook of Fundamentals for the selected weather station. For cooling, 99% of the region's hours are below this temperature.
Cooling Design Load (Btu/h)	This is the cooling need of the home (or zone), at the cooling design temperature, to maintain a comfortable indoor air temperature.
Derate (%)	The annual heating load is derated to account for solar heat gain. A 10% derate is automatically applied and this value can be edited if the home experiences greater or less than usual solar heat gain.
Optional: Apply Compressor Lock-Out Temperature (°F)	If the user intends to apply a compressor lock-out or backup system switchover temperature, they can see the impact of that decision by using this field. The tool will zero out the heat pump's capacity for all hours that occur below the indicated temperature threshold, thus changing some of the load-fulfillment data points.
Optional: Set Low Temperature Capacity Rating (°F), (Btu/h)	Some ccASHP products in the database do not include performance data below 5°F. In these cases, the user has the option to self-enter a low-temperature maximum capacity rating to complete the data set using this field. Please reference the manufacturer's expanded performance data to determine this input. Typically, this is near the balance point, or based on fuel and efficiency economics for lowest cost operation.

Product View Visualization Chart Data Definitions

Figure 7: ***Product View Data Visualization Chart Example***



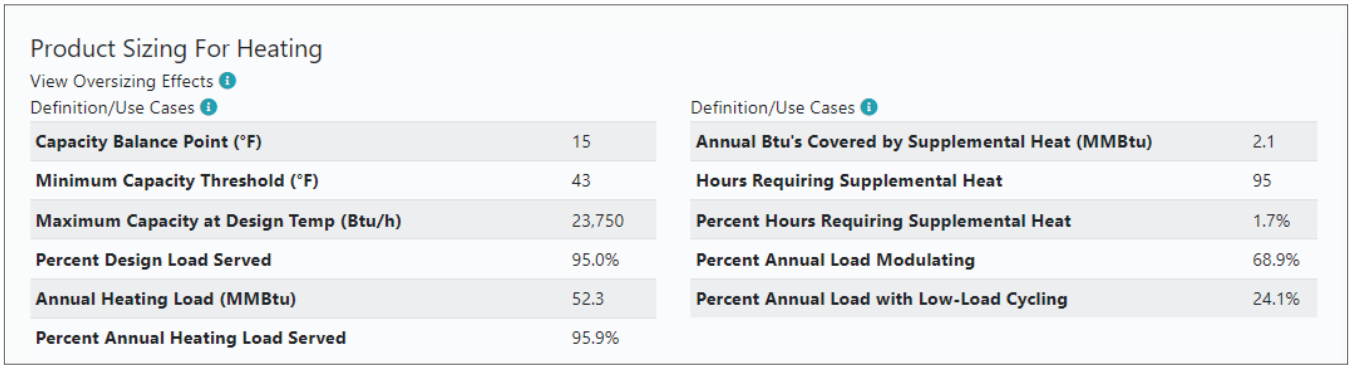
Visualization Chart Legend	Definition/Importance
Annual Load x Hours (Btu/yr)	On the graph, there is a bar chart in the background indicating the number of load hours a home spends at each outdoor temperature range or "bin." For each bin, this is the home's load (Btu/h) ***times*** the number of hours this temperature occurs annually. It is an indication of how much heating energy is needed each year at various outdoor temperatures. This can help users understand relative impacts of short cycling and backup heating for a given heat pump and home heating load. Generally, the more this bar chart is covered by the modulating zone, the better the heat pump fits the heating load.
Supplemental Heat	Shaded zone on the left side of the graph, which shows the amount of heating load served by a supplemental or backup heating system at each temperature point.
Modulating Heat Pump	The temperature range within which the heat pump is operating between its minimum and maximum capacity as it responds to the home or zone's heating load. The system is most efficient when within this zone. This is sometimes referenced as the *Goldilocks zone*.
Potential Low-Load Cycling	Indicating a heat pump that turns on but does not complete its normal cycle. Instead, the system shuts down briefly, then restarts again. This may happen over and over in a cycle. On this graph, this is represented by the shaded triangle on the lower right of the page. This occurs when the heat pump's minimum capacity is higher than the heating load. It is common and expected at low-load situations on warmer days, but it can be problematic for efficiency and comfort if it occurs for a large portion of the year's load hours. In this tool, a green short-cycling triangle indicated a system where the crossover temperature is high enough to not lead to any significant efficiency penalties. A yellow short-cycling triangle indicates a system that may short cycle with medium frequency for a more substantial portion of the year's heating season, and it will result in a minor efficiency penalty. A red short-cycling triangle indicates a system that will short cycle considerably with a significant impact in annual efficiency.

Table continued: Product View Visualization Chart Data Definitions

Design Temperature (°F)	A vertical line indicating the selected weather station's 99% heating dry-bulb temperature as listed by the 2021 ASHRAE Handbook of Fundamentals.
Heating Load Line (Btu/h)	The home (or zone's) heating load at each temperature point. The *heating load line* starts at the user's indicated *heat design load* and reduces linearly to zero load at an outdoor temperature of 60°F. In reality, the heating load is not perfectly linear but is also impacted by solar gains, internal gains, and wind. The choice of zero load at 60°F represents the *building* balance point of a moderately well insulated and air-sealed home. A higher-quality envelope will mean a lower temperature building balance point and vice-versa.
Heating Max Capacity (Btu/h)	The heat pump's maximum heat output, in Btu/h, at the specific temperature. This tool interpolates *max capacity* between discreet temperature data points provided by the manufacturer at 47°F, 17°F, 5°F, and in some cases an optional temperature point below 5°F.
Heating Rated Capacity (Btu/h)	Often listed as the *heating capacity* at 47°F. This is a standardized capacity at 47°F used for comparison amongst all heat pumps.
Heating Min Capacity (Btu/h)	The heat pump's lowest heat output, in Btu/h, at the specific temperature. This tool interpolates *min capacity* between discrete temperature data points provided by the manufacturer at 47°F, 17°F, 5°F, and in some cases an optional temperature point below 5°F. A heat pump may short cycle below this threshold. This can impact efficiency and comfort if substantial.
Cooling Load Line (Btu/h)	The home (or zone's) cooling load at each temperature point. The *cooling load line* starts at the user's indicated *cooling design load* and reduces linearly to zero load at an outdoor temperature of 72°F. In reality, the cooling load is not perfectly linear, but is also impacted by solar gains, internal gains, wind, and humidity. The choice of zero load at 72°F represents the *building* balance point of a moderately well insulated and air-sealed home. A higher-quality envelope will mean a higher temperature building balance point and vice versa.
Cooling Max Capacity (Btu/h)	Highest possible cooling output at a given temperature, in Btu/h.
Cooling Rated Capacity (Btu/h)	Often listed as the *cooling capacity* at 95°F. This is a standardized capacity used for comparison among all heat pumps and central air conditioners.
Cooling Min Capacity (Btu/h)	Lowest possible cooling output at a given temperature, in Btu/h.
Cooling Modulating Zone	The temperature range within which the heat pump is operating between its minimum and maximum capacity as it responds to the home or zone's cooling load. The system is most efficient when within this zone. This is sometimes referenced as the *Goldilocks zone*.
Cooling Low-Load Cycling	Indicating a heat pump that turns on but does not complete its normal cycle. Instead, the system shuts down briefly, then restarts again. This may happen over and over in a cycle. This occurs when the heat pump's minimum cooling capacity is higher than the cooling load. It is common and expected at low-load situations on cooler days, but it can be problematic for efficiency, humidity control, and comfort if it occurs for a large portion of the year's load hours. The heat pump may struggle to dehumidify within this zone because it will not operate for long-run durations. The short runtimes may not allow the heat pump to sufficiently wick moisture from the air.

Product Sizing for Heating Data Points Definitions

Figure 8: ***Product Sizing for Heating Data Points Example***



Product Sizing For Heating

View Oversizing Effects

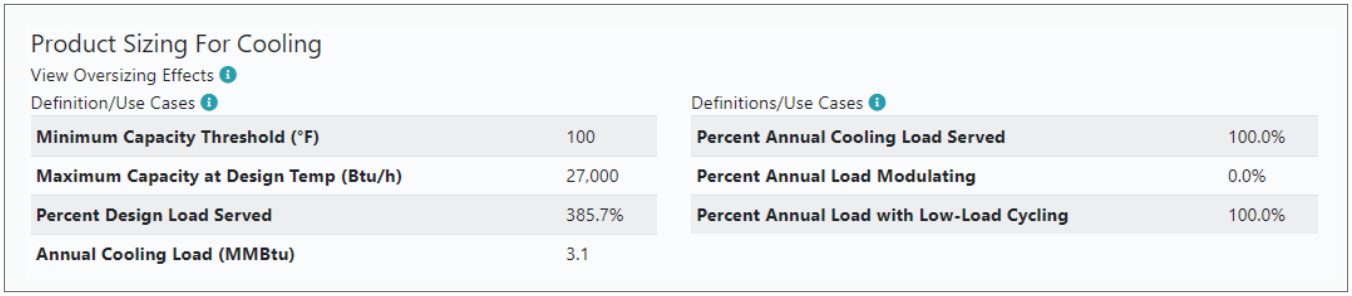
Definition/Use Cases	
Capacity Balance Point (°F)	15
Minimum Capacity Threshold (°F)	43
Maximum Capacity at Design Temp (Btu/h)	23,750
Percent Design Load Served	95.0%
Annual Heating Load (MMBtu)	52.3
Percent Annual Heating Load Served	95.9%

Definition/Use Cases	
Annual Btu's Covered by Supplemental Heat (MMBtu)	2.1
Hours Requiring Supplemental Heat	95
Percent Hours Requiring Supplemental Heat	1.7%
Percent Annual Load Modulating	68.9%
Percent Annual Load with Low-Load Cycling	24.1%

Product View Data Table Legend	Definition/Importance
Capacity Balance Point (°F)	Temperature at which the capacity of the heat pump equals the heating load in the house (i.e., the point of intersection of the load line and max capacity line). Note: The term balance point is also used to convey other concepts in the building science and HVAC fields.
Minimum Capacity Threshold (°F)	Temperature at which the home's load is lower than the heat pump's minimum capacity. Below this point, the heat pump's compressor will cycle.
Maximum Capacity at Design Temp (Btu/h)	The heat pump's maximum capacity output at the design temperature.
Percent Design Load Served	The percent of the home's design load met by the heat pump operating at maximum capacity at the design temperature. For whole-home heating, this should be between 90% and 120%.
Annual Heating Load (MMBtu)	To total amount of annual heating energy needed to maintain home-comfort.
Percent Annual Heating Load Served	The percent of the annual heating load satisfied by the heat pump. This includes load hours at which the heat pump may be low-load cycling (warmer weather) as well as load hours where the heat only fulfills a portion of the home or zone's heating load (colder weather).
Annual Btu's Covered by Supplemental Heat (MMBtu)	The amount of annual home heating energy supplied by the supplemental heating system.
Hours Requiring Supplemental Heat	The number of annual hours that require operation of supplemental heat to maintain home-comfort.
Percent Hours Requiring Supplemental Heat	The percent of annual hours that require operation of supplemental heat to maintain home-comfort.
Percent Annual Load Modulating	The percent of the annual heating load supplied by the heat pump in its modulating zone—between minimum and maximum capacities.
Percent Annual Load with Low-Load Cycling	The percent of the annual load where the home's load is below the heat pump's minimum capacity thus potentially causing the compressor to cycle.

Product View Calculated Cooling Data Points Definitions

Figure 9: ***Product Sizing for Cooling Data Points Example***



Product Sizing For Cooling

View Oversizing Effects

Definition/Use Cases	
Minimum Capacity Threshold (°F)	100
Maximum Capacity at Design Temp (Btu/h)	27,000
Percent Design Load Served	385.7%
Annual Cooling Load (MMBtu)	3.1

Definitions/Use Cases	
Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	0.0%
Percent Annual Load with Low-Load Cycling	100.0%

Product View Data Table Legend	Definition/Importance
Minimum Capacity Threshold (°F)	Temperature at which the home's load is lower than the heat pump's minimum capacity. Below this point, the heat pump's compressor will cycle.
Maximum Capacity at Design Temp (Btu/h)	The heat pump's maximum capacity output at the design temperature.
Percent Design Load Served	The percent of the home's design load met by the heat pump operating at maximum capacity at the design temperature.
Annual Cooling Load (MMBtu)	The total amount of annual cooling energy needed to maintain home-comfort.
Percent Annual Cooling Load Served	The percent of the annual cooling load satisfied by the heat pump. This includes load hours at which the heat pump may be low-load cycling (cooler weather) as well as load hours where the heat only fulfills a portion of the home or zone's cooling load (hotter weather).
Percent Annual Load Modulating	The percent of the annual cooling load supplied by the heat pump in its modulating zone—between minimum and maximum capacities.
Percent Annual Load with Low-Load Cycling	The percent of the annual load where the home's load is below the heat pump's minimum capacity thus potentially causing the compressor to cycle.