PORTABLE HEAT PUMP SPACE HEATER

Qualitative and Quantitative Analysis on Whynter, Haier, and Honeywell Portable Heat Pumps

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MAY 21st, 2021

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Executive Summary

This research paper was prepared based on a case study that encompasses the testing of three different portable heat pumps space heaters: the Whynter (ARC-148MHP), Haier (HPND14XHTN1), and Honeywell (MN14CHCSWW). The research goal and objective were to test and compare the three brands for heating capabilities qualitatively and quantitatively and provide suggestions and recommendations for people who wish to electrify their homes. The study took place in Arcata, CA during the winter months and the three units were installed in the living rooms at two different houses and connected to the outside through unsealed windows. The units were expected to provide heating for most of the house since the living room of each house was open to other rooms and hallways. All three units provided a tremendous amount of heat at a heating capacity of 14,000 BTUs. However, some of the units were more efficient than others and some had more preferred qualities. For instance, the Whynter unit used 1.08 kWh/hr at 0.18 $/hr, the Haier and Honeywell units used 1.22 kWh/hr and 1.25 kWh/hr respectively and both had an energy cost of roughly 0.21 $/hr. Based on the qualitative and quantitative data provided later in this report, the Whynter brand had outperformed both the Haier and Honeywell units and was recommended as the best fit for space heating purposes. To provide a summary of the major benefits and needed improvements to all three brands, the following feature lists were created to compare the three units.

Whynter Unit:

Best Features:

- High CFM (292) in Heating Mode-quickly warmed the area
- Significantly quieter compressor than other two brands-best for sleeping
- Condensate water pump[1]
- One exhaust pipe (less energy loss)[2]

Poor Features:

- Must operate above 45 °F to prevent frozen condensation in Humboldt high humidity[3]
- Inaccurate thermostat
- Vent location (blows hot air upward)

Missing Features:

- Inverter and defrost cycle
- Remote thermostat for accuracy

Haier Unit:

Best Features:

- Responsive to Temperature fluctuations of 3-5 °F increase or decrease

Poor Features:

- Low CFM (190) less heating capacity
- Reported to heat to 20F in Ohio's dry air winter climate
- Vent location (blows hot air upward)
- Louder compressor and fan
- Two exhaust system (inefficient)

Missing Features

- Inverter and defrost cycle
- Remote thermostat for accuracy
- Water pump

Honeywell Unit:

Best Features:

- Responsive to Temperature fluctuations

Poor Features:

- Low CFM (194) less heating capacity
- Vent location (blows hot air upward)
- Louder compressor and fan

Missing Features

- Inverter and defrost cycle
- Remote thermostat for accuracy
- Water pump

[1] The house owner preferred using only gravity by suppling a bucket/pan instead of using the water pump, so they don't introduce more air leak by sending the water out through a pipe.

[2] A single exhaust is preferred because two exhaust system would introduce more leaks to the house and also, they are large pipes with large surface area, which will dissipate energy (cold air) back inside the room as it being discharged outside.

[3] The evaporator must get colder than the air blown over it (indoor air) for it to absorb heat before entering the condenser. If the indoor air temperature is lower than the unit's capacity to have a colder evaporator, then damage to compressor could occur because the refrigerant is still in liquid state.

Introduction

The direction the world is headed and the threats that climate change has inflicted on our planet have limited our choices regarding energy options. One of the most common practices that cause not only harm to the environment but also leads to adverse health effect on the human body is the use of methane/"natural" gas appliances (Enrique Saenz, 2020). There is no need to wait for big-scale change or the government to make the change, people can start now by electrifying their apartments and houses with inexpensive ($400-$700) portable heat pumps that can fit into most unsealed windows. In this report, a research study was conducted to test and compare three types of portable Heat Pump Space Heaters (HPSH) on two different sites in Arcata, California. The objective of this project was to test, collect data, and compare the Whynter (ARC-148MHP), Haier (HPND14XHTN1), and Honeywell (MN14CHCSWW) portable HPSHs qualitatively and quantitatively. The goal of this research is to encourage renters and homeowners to start exploring available options for heating their houses and to start looking into electrifying their homes.

General Description

Heat Pumps Descriptions

Heat pumps are fully electric appliances that are used to replace gas heaters for those who wish to electrify their homes. There are three basic types of heat pumps: air source, water source, and geothermal, which all use electricity to collect ambient heat. Heat pumps have a coefficient of performance (COP) between 2-4.5, which means that heat pumps collect and produce 2-4.5 times as much heat energy as the electrical energy used (Level, 2020). Portable heat pumps use the air as a heat source, have a relatively small size (Table 1), easy to move around the house, and can be connected to any unsealed windows through an exhaust hose(s). Portable heat pumps are easy to install, operate, and require no technical knowledge. The tested units come with multiple settings for cooling, heating, dehumidifying, and fan modes. All three units come with a single hose that is used to send cold or hot air outside during heating or cooling mode respectively. The Haier unit comes with an extra hose that's used to cool the compressor using outside air. The single exhaust system is more preferred during any mode setting for smaller rooms and within lower ambient temperature (less than 90 °F). Once the ambient temperature increases, the unit would require two exhaust systems. As the ambient temperature increases, the unit needs to work harder to cool the space, which would cause it to draw more indoor air to cool the compressor creating a negative indoor pressure (Elite, 2019). Units with a single hose will suck indoor air through cracks within doors and windows to cool the compressor and send it outside, which makes it an inefficient process and therefore the unit would draw more energy to replace that air. If the unit has two exhaust systems, it would draw outside air through one of them to cool the compressor, which would reduce the work the unit has to overcome to cool or heat the space. However, using two pipes will introduce more air leaks and energy loss into the room with excessive piping. Although having a cooling and heating feature is very appealing to many people, the units were tested in a cooler climate (35-60 °F) and the study only focused on the heating aspect; therefore, using a single exhaust system was very suitable. Moreover, the three units have similar capacities and energy requirements that can be found below (Table 1).

Table 1: Important data obtained from the spec sheets for the tested heat pumps (Whynter, Haier, Honeywell, 2021)

	Whynter	Haier	Honeywell
Dimension (W), (D), (H)	18.5" x 15.75 x 30.25"	15.25" x 17.75" x 29.44"	15.79" x 19.92" x 34.02"
Weight	72.75 lbs	73 lbs	74 lbs
Cooling/Heating Capacity	14,000/11,000 BTUs	14,000/11,000 BTUs	14,000/11,000 BTUs
Voltage	120 V	120 V	120 V
Cooling/Heating Amps	11.9A Max	11.4 A	10.8
Air Flow	292 CFM	190 CFM	194 CFM
Noise Level	<55 dBA	59 dBa	53 dB
Refrigerant	R-410A	R-410A	R-410A
EER[4]	8.9	8.5	NA

[4] EER is the Energy Efficiency Ratio between the cooling capacity (BTUs/hr) to the power output (watts) but also depends on the indoor/outdoor temperature and the relative humidity. The higher the EER the more efficient the appliance would be (Energy.Gov, 2021)

Site Description

All three units were tested in the same city within the same climate, but slightly different locations. The Whynter and Honeywell units were tested at the same house where it has more redwood tree covers (site 1). The Haier unit was tested at a different house with almost the same elevation as the first site but with fewer redwood trees (site2). The Whynter and Honeywell units were installed in a 675 sq. ft living room. The room had 7 windows facing South-West, a sliding door, a high ceiling and open to a kitchen area, a hallway with an office at the end, and an upstairs bedroom and bathroom. The house was built with 4 inches wall thickness and currently using a gas heater as the main heat source before installing the heat pumps and a backup afterward. The Haier unit was installed in about 400 sq. ft living room with a woodstove as the main heater and has better wall insulation than site one. The living room had two regular size windows and one large window facing South and West, a medium height ceiling, and open to the kitchen area, dining room, and a hallway with one bathroom and three bedrooms at the end. Site one had three people living in the house and site two had two people living in and occasionally one more person would use the space. A visual representation that shows the setup at the testing sites for the three heat pumps can be seen in the figure below (Figure 1). For the exhaust hose connections see figures 3-4 in Appendix A.

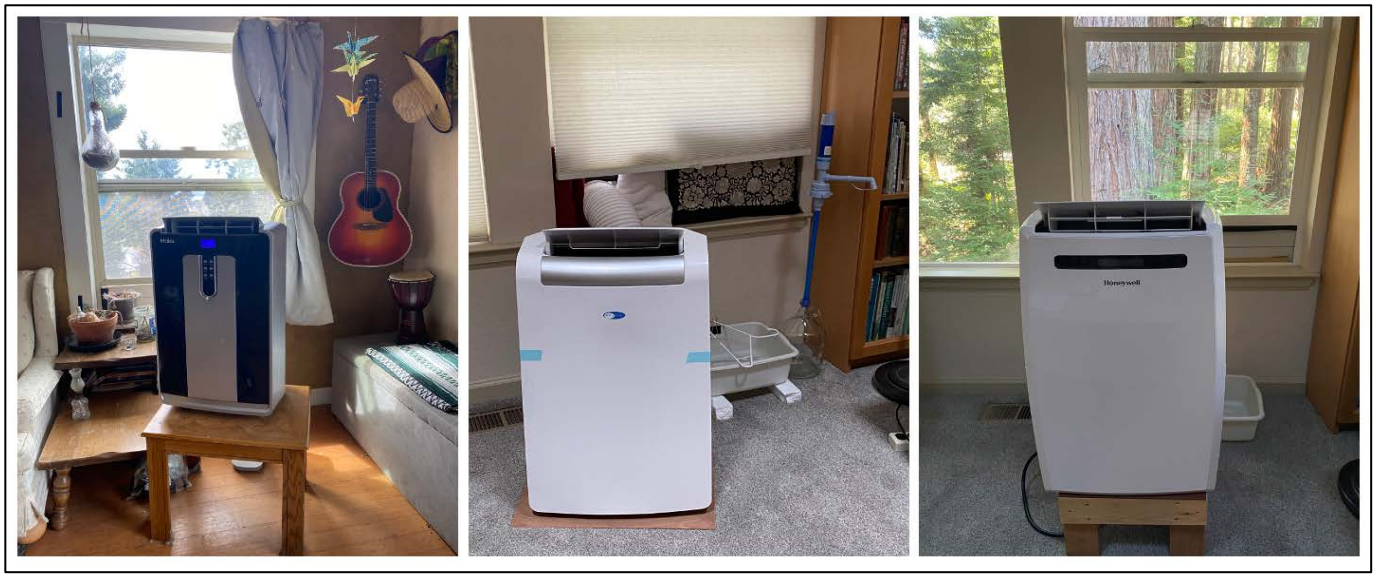

Figure 1: A front view of the three portable heat pumps at the testing sites. Starting on the far-left side is the Haier unit then the Whynter in the middle and finally the Honeywell on the far-right side. The units have a pipe connected to drain the water into a bucket and no leak or need to set the whole unit in a pan.

Data Collection

The heat pumps were used mostly during the day (~5 AM-10 PM) and turned off at night except few nights during the testing period where they were left on overnight. All units were connected to the wall through an energy meter that could read the voltage, current, power, and cumulative energy used in kWh. The data were collected and recorded manually two to three times a day at random time intervals but usually during the morning, noon, and night. The Haier unit was tested over a whole month period whereas the Whynter and Honeywell units were tested for 10 days each with 7 days of recorded data. The correspondent daily ambient temperature was obtained from the Weather Underground database (Weather Underground, 2021). Along with the collected quantitative data[5], a record of qualitative data was kept over the testing period focusing on the physical aspect of the units such as size, noise level, ease of operation, the time users turned them ON or OFF…etc. The quantitative and qualitative data were then used to compare the three units against one another to make suggestions and recommendations on their performances.

[5] This report comes with a detailed excel sheet that shows the recorded qualitative and quantitative data for each unit: Portable HP Space Heater Analysis.xlsx

Results

The results from the study were presented as an excel sheet that compares the units qualitatively and quantitatively. A summary table that shows the major quantitative and most important differences between the three units is presented below (Table 2). The units were operated at a different number of hours per day and the data were recorded at different time intervals[6].

Table 2: Summary table of the energy, cost, and time of use for the three heat pumps over the testing period

Average Hourly Use			
	Ave. No. of Hours/Day	**Energy(kWh)/Hour**	**Cost ($/Hour)**
Whynter	14.9	1.08	$ 0.18
Haier	17.1	1.22	$ 0.21
Honeywell	11.8	1.25	$ 0.21

The average values from the previous table (Table 2) were used to compare the three tested heat pumps using the following graph (Figure 2). The average hourly data are based on how many hours per day that the unit was operating.

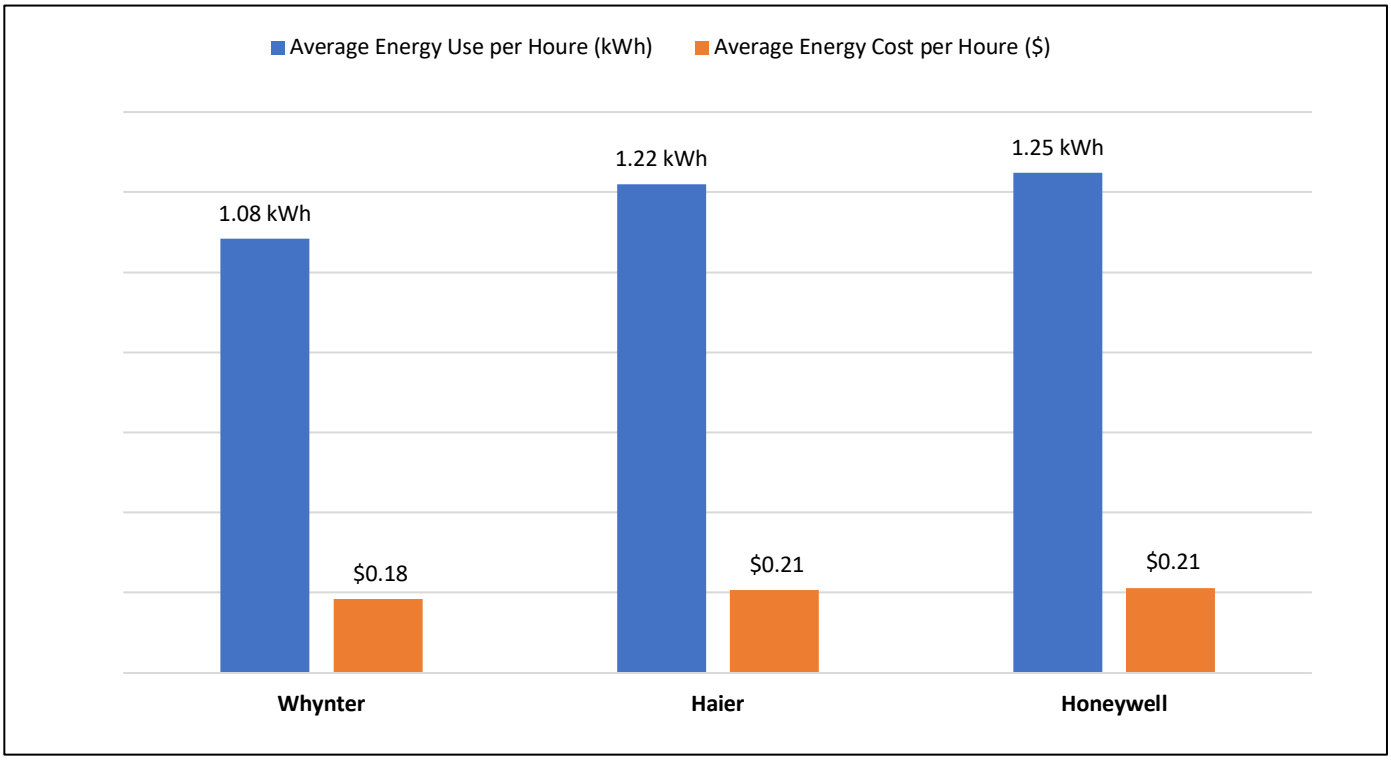

Figure 2: The average hourly energy use and cost for the three tested portable heat pumps. The number of data points is not the same for all units and was not recorded at the same time interval[6].

Along with the quantitative data, qualitative data was recorded to compare the three heat pump units (Table 3). The units were observed closely over the testing period and only the most important features were included along with some recommendations based on the spec sheet.

[6] This report comes with a detailed excel sheet that shows the number of data points recorded for each unit: Portable HP Space Heater Analysis.xlsx

Table 3: Qualitative data from field observation used to compare between the three tested portable heat pumps space heaters.

	Whynter	Haier	Honeywell
Recommended room temperature[7]	Above 45 °F	NA	NA
Ambient temperature over the test period	Day : 40-50 °F Night : 35-40 °F	Day : 40-50 °F Night : 35-40 °F	Day : 45-60 °F Night : 38-45 °F
Temperature the unit was set at	70 °F	75 °F	70 °F
Timer ON/OFF	Yes	Yes	Yes
Number of exhaust hoses	One	Two	One
Thermostat	Not accurate	good	good
Water discharge (condensation)	Pump or gravity	gravity	gravity
Water produced	~3 gals/day	~3 gals/month	almost no water
Responsiveness to remote control	okay	good	good
Meeting the heating load	High CFM fan resulted in better heating capacity	Medium CFM, heated the space comfortably	Low CFM, not enough heat provided
Noise level (0-10)	5: Loud Fan, but it covered the noise of the quieter compressor	7: Compressor sound is noticeable	7: Compressor sound is noticeable
Test period	3/13 - 3/20 (2021)	2/23 - 3/23 (2021)	3/23 - 3/30 (2021)

Discussion

The results have indicated that the Whynter brand is the best heat pump space heater out of the three tested brands. The Whynter unit had the lowest average hourly energy use and therefore the lowest energy cost, in comparison to the Haier and Honeywell brands. The second and third in line are the Haier and Honeywell brands with about 12 percent higher hourly energy use than the Whynter unit (Table 2). Although the Haier unit was tested for a longer period (one month) than the other two units, it does not affect the results where the Whynter brand has outperformed both the Haier and Honeywell units (Figure 2). Although some may argue that the Whynter brand could've used less energy and not provided adequate heat to the space, which made it seem more efficient, the qualitative data indicated otherwise. According to the field observation and the recorded qualitative data, the Whynter heat pump has provided sufficient heat to the space and managed to put the gas heater on-site one out commission most of the day. Considering that the Whynter and the Haier units were installed during the coldest time of the season, the Whynter unit was surprisingly good and much better than the Haier unit. Residence from site two where the Haier unit was installed stated that the unit provided plenty of heat but was not powerful enough to get the heat down the hallway and into the bedrooms. This might be due to the difference in airflow capacity between the units at 292 CFM and 190 CFM for the Whynter and Haier units respectively. Furthermore, the Honeywell heat pump was no match to the other two units based on its performance (qualitative data), energy use, and energy cost where it had the highest out of the three units. Also, considering that the Honeywell was installed during warmer weather than the other two units (Table 3), it still did not provide adequate heat for the house (site one).

[7] Spec sheet data (Whynter, Haier, Honeywell, 2021)

Another point of comparison was the recommended room temperature for the units to operate safely. Based on the spec sheets, the Whynter unit can't be operated under 45 °F, but none were stated for the other two units. The reason there was a minimum room temperature limit, is to eliminate damage to the compressor or any ice formation within the unit during the heating mode, especially during high humidity. This unit comes with a single exhaust system where the air gets sucked from indoor and blown over the condenser coils heating the room (reheating the same air), and then another vent would pull indoor air over the evaporator coils to worm up the refrigerant and cold air would be blown outside. If the temperature inside is too cold (< 45 °F), then the evaporator coils wouldn't get enough heat to warm up the refrigerant and could enter the compressor as liquid damaging it, and with the presence of high humidity, it would cause ice formation to occur. An incident during the testing of the Whynter brand occurred, when an ice formation within the exhaust pipe caused the unit to make cracking sounds and then leading to a water leak. The unit was turned off for an hour until the ice melted, then back on, and was operating normally. The ambient temperature at the time of the incident was about 41 °F which could've been the cause; however, the ice formation was more likely due to the high indoor humidity as well.

The other two units did not indicate any signs of ice formation nor it was stated within the spec sheets. Regardless of that one incident, the Whynter unit still outperformed the other two units and operated normally with no issues. Moreover, all three units produced water due to condensations, but the amount of water produced varied wildly. The Whynter unit produced the most at about 3 gals/day, followed by the Haier unit at 3 gals/month, and then the Honeywell, which rarely produced water. Although this could be a negative point for the Whynter unit, it is also an indication that it works much harder than the other two units to produce heat at a high CFM and that site one had more humidity in the air (site one is deep into the redwoods). Furthermore, the Whynter unit includes a pump used to discharge water outside the window without the need to elevate the unit to use gravity, which is an important feature that the other two units are lacking.

The noise level for the three units rated at <55 dBA, 59 dBA, and 53 dBA for the Whynter, Haier, and Honeywell respectively (Whynter, Haier, Honeywell, 2021). Although the Whynter unit had a louder fan noise by field observation, the compressor was almost unnoticeable, unlike the Haier and Honeywell units, which had a louder compressor noise and relatively medium-high fan noise as well. According to the house tenants at site one, they prefer the high fan noise from the Whynter unit over the compressor noise from the Honeywell unit, which is almost the same as the Haier unit in terms of the noise level. The last important point to compare between the three units is the accuracy of the thermostat and its responsiveness to the temperature change within the room or by manual adjustment. All three units did not have an accurate reading of the indoor temperature and were running continuously, even though a second external thermometer was placed in the room and was reading higher temperature values. Some possible explanations are that the internal unit thermostat was located near the exhaust pipe that carries cold air out, which lead to a false reading of the temperature causing the unit to keep running, or simply that the thermostat does not work well. This issue has also affected the way the units responded to the remote controls, where the Whynter unit would keep the compressor running and heating even if the thermostat was reduced to 60 °F. Unlike the Whynter brand, the Haier and the Honeywell were more responsive to the temperature adjustments but still need to be decreased or increased by three to five degrees before the unit turns the compressor ON or OFF.

To summarize, the Whynter unit seems to be the practical choice to go with for heating purposes. This unit had a relatively low noise level, a high space heating capacity (larger than 600 sq. ft), and a powerful fan that can move the air within a large space. The Whynter unit is a single hose unit, which in some online reviews is less favorable due to the negative pressure created when cooling the compressor. However, the dual hose unit may avoid negative indoor pressure from occurring, but it is still not proven better than a single hose unit. Having a single hose unit would increase the efficiency by eliminating extra holes in the window, which are not fully sealed. Also, these exhausts pipes are very thin plastic hoses with no insulation around them. This is an issue because the exhaust system is inside the room that is heated, which means as the unit blow indoor air over the evaporator and outside, they get very cold and that energy gets exchange with the heated indoor air through the outside surfaces of the pipes making the process less efficient. Therefore, it was better to have a single hose unit that could reduce the heat loss through excessive pipe systems. The energy lost, although not proven yet, could be much smaller when using a single hose even if it creates a negative pressure than using a dual hose system and directly dissipating energy back into the room or involving extra holes in the window.

Moreover, the Whynter unit produces a maximum condensed water of three gallons per day, during the process of reheating the refrigerant within the evaporator before it goes to the compressor to raise it to a boiling temperature. The reason the Whynter unit produced that much water is because the testing site was located deep into the redwoods and was installed during a high humidity season. Most people within the Arcata area deal with high humidity that could cause mold problems in their homes, so they install a dehumidifying unit. Now with the portable heat pump installed, the high humidity issue would be taken care of as the heat pump is heating the house.

Conclusion and Recommendation

According to the collected data and presented graph (Figure 2), it is by far the Whynter heat pump that performed the best. The Whynter unit was installed in a larger space than the recommended room size, provided enough heat to shut off the gas heater, and had a more acceptable noise level than the other two units. If you are a homeowner, the Whynter unit would be the best choice for space heating. The Haier and Honeywell weren't as powerful as the Whynter unit, but they still produced a significant amount of heat for a heat pump with a heating capacity of 11,000 BTUs; however, having a low airflow capacity has limited their performance.

To make the best use out of the Haier and Honeywell units based on field observation, it is recommended that these two units be installed in a small to medium size room and low to medium ceiling height. Moreover, the manufacturers have made a mistake by placing the vents at the top of the units and blowing warm air upward. This design made it challenging for the units to heat the space faster since warm air naturally rises upward. Homeowners could maximize the heat pump heating capacity by installing it in the basement if it's connected to the main house or on the first floor for two-story buildings. This method would allow the heat to rise as it should and therefore heating more square footage of the house. Also, a portable fan could be placed on the top floor to blow the air down or a ceiling fan, if exist, could be turned on to help distribute the warm air.

A final user recommendation is related to the water produced from condensation. To avoid emptying a water bucket more often, the unit could be elevated, and the water hose can be connected to drains outside, unless the unit has a water pump, as the Whynter brand does. The Whynter water pump capacity was tested with a window height of about two feet, anything higher than that was not accounted for in this case study. The manufacturer did not specify how high the unit could pump the condensed water, but they did indicate that the water discharge pump works during heating mode only.

As a future recommendation, it would be important to study the unit's performance during cooling mode for hot summer days. One of the best features of these portable heat pumps is their capability of heating and cooling using one unit. A recommendation for the manufacturer, it would be better to place the vents on the front side of the unit for better air distribution and the thermostat could be an external or part of the remote controller for better temperature readings. After all, these three heat pumps have performed very well for their size and could be a potentially life-changing opportunity for a warmer winter with clean energy.

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Appendix A

The following figures are used for further clarifications on the single and dual exhaust systems set-up for the Whynter, Honeywell, and Haier brands:

Figure 3: Back view of the Whynter unit showing the single exhaust system connection and the water bucket installed for condensation to drain in. The heat pump comes with a water pump that could pump the water outside, but the homeowner preferred using gravity and emptying the bucket often than sending the water out using the pipe and causing a possible air leak into the house.

Figure 4: Back view of the Haier unit showing the dual exhaust system connection and the water bucket installed for condensation to drain in. The heat pump does not come with a water pump that could pump the water outside, so only gravity was used. The second hose was not used in this case because the indoor air was cold and sufficient enough to cool the compressor during heating mode.

Figure 5: Back view of the Honeywell unit showing the single exhaust system connection and the water bucket installed for condensation to drain in. The heat pump does not come with a water pump that could pump the water outside, so only gravity was used.