IPRO 346 - FINAL REPORT

Design and Market Analysis of Condensate Recycling from Commercial HVAC Systems

PROJECT SPONSER: PENTAIR

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Executive Summary

Condensate is a product of condensation, which changes water from its gaseous form to its liquid form due to contact with a colder surface or atmosphere. Condensate is a byproduct of Air Conditioning systems. The goals of IPRO 346 were to research condensate and develop a system that appeals to commercial owners to reuse condensate in non-drinking applications.

This semester the IPRO class was split up into teams to attack the task at hand. The teams consisted of a research group to determine if condensate is already being used as a viable water source and the laws that are on condensate usage. A collection and quantification group to measure out exactly how much condensate is being produced by a commercial AC unit. Bacterial and chemical analysis group to see what further levels of purification are needed for the condensate to be reused. Lastly, a marketing group to determine if there is a profit for developing a system for potential commercial owners.

The teams assigned for each specific task determined that condensate is a viable source of water that should be implemented into future systems. Further IPROs, should quantify the exact profit generated using this system and to determine the feasibility of this system using a commercial AC unit.

Purpose and Objectives

The purpose of this summer's ipro is to work in partnership with Pentair, inc. and propose a working, cost efficient solution to recycle HVAC condensate to reuse for productive non-drinking purposes. Since there is not much information readily available about condensate, in order to find various solutions, there first is a list of objectives that must be accomplished. First is to calculate and quantify the amount of condensate generated by air conditioning units. Four sites are tested MTCC, Spyco Industries, Pentair Inc. in Delavan WI. and India. Next is to suggest a plan for a system to collect the condensate. It is important to test condensate for bacteria and other chemical metals in order to figure out all possible uses for condensate due to the fact that because of various coding and laws, which vary from region to region, the condensate may or may not be pumped back into the building. By knowing the cleanliness of the condensate and researching the coding and laws, various solutions can determined; solutions such as pre-cooling and uses in toilet water. Lastly a marketing analysis is made. With various solutions idealized, the group is to inform those interested in the collection and use of condensate, by taking surveys and talking directly to maintenance and managers. A marketing strategy for collection and use of condensate is established. A technical paper presenting all of our findings is also drafted and will be submitted to the National Heating and Air Conditioning Convention in February.

Organization and Approach

We have divided our team into four groups that are responsible for each different aspects of the project in order to expedite the process and maximize working efficiency. The four categories we have proposed for the group are business and market analysis, collection and quantification, research, and testing.

The collection and quantification group is responsible for analyzing the cost-effectiveness of the reuse of condensate water through mathematical calculations. The team obtained pumps from Pentair Inc. that were used to collect and quantify condensate from chosen site. A counter was added to a pump in order for it to quantify how much condensate was pumped out. The team chose four test sites, which are Pentair Inc., in Delevan, Wisconsin, Spyco Industry and MTCC in Chicago, Illinois and one of our team members' house in India, and installed the pumps for a one month period. The team also built a prototype of condensate collection unit. It was built from an old air compressor storage tank and a hydraulic pump to store condensate after it comes through a pre-cooling unit.

The business and market analysis group is primarily responsible for analyzing the feasibility of the project and its interest in the market. The team has come up with survey questions to be distributed to various different commercial locations. Its purpose is to research how much people know about condensate and its possible different uses. With the collected information from the collection group, the team has proposed a detailed solution of how much water and money can be saved by applying our proposal.

The research team is responsible for finding out various applicable uses for condensate. The team conducted various research online in order to gather information about how condensate is being collected and used in current commercial settings and what codes and laws there are that restrict the use and collection of condensate. The team specifically focused on the current usage of condensate for different purposes and worked to propose additional purposes in order to maximize the use of condensate, which will replace the use of potable water.

The testing group is responsible for performing a bacterial and chemical analysis of the water samples that are collected from our chosen test sites. With the samples collected from the chosen sites, the team conducted Gram Stain analysis that exposed what kind of bacteria was present in the condensate in order to decide if it can be used for potable purpose, as well as, suggest filtration techniques to make it usable. The team also conducted Atomic Absorption Spectroscopy that revealed chemical composition of the condensate.

Analysis and Findings

In order to determine how much condensate was being generated, A counter was added to a pump in order for it to quantify how much condensate was pumped out. From this we were to determine the amount of condensate for each of the test sites. The MTCC site generated 192 Gallons, Spyco Industries - 148 Gallons, India- 896 gallons and Pentair - 31 gallons. The varying amounts of condensate were effected different conditions. First was the amount of space the AC unit was cooling. Another was the condition of the condensate catch pan. In several cases the catch pans were leaking condensate and therefore affecting the readings. Another condition was the geographical location as well as the weather. It was shown that the amount of condensate generated corresponded to the relative humidity.

To test for the purity of the water, both chemical and bacterial testing was conducted. AnalysisGram Stain analysis was performed of the water sample in TrypticaseSoy Agar medium and Yeast Extract Agar medium to test for common bacteria found in AC Unit water (Eg. Legionella, Aspergillusetc). Atomic Absorption Spectroscopy was performed on the water sample by passing light through the molecules of the sample to show the amount of a certain chemical in the sample. Through the bacteria testing, bacteria was found in one of the samples, but it is yet to be determined weather the bacteria came from the air conditioner or contamination after taking the sample. The Atomic Absorption Spectroscopy testing showed no contamination of the water.

I gauge the public's views and knowledge on condensate use a survey was conducted on 30 different businesses. Some businesses surveyed included Jewel and Home Depot. From the surveys it was determined the majority of the business owners knew about condensate. All of them were interested in collecting condensate for use. Majority did not know that they could save a portion on their utilities by using the condensate generated from their air conditioners. The comments that were made were positive.

Conclusions and Recommendations

Due to lack of time we were not able to collect enough data from commercial buildings to use in considering recommendations for non potable uses. However we did do extensive research. We have found that buildings that use condensate for cooling towers have been successful. These buildings collected enough water to pay off the installation of the condensate collectors. With our other proposed uses, such as irrigation and toilet flushing water, we can help buildings become “more green” and save money.

Further research should be done with our pre cooling method. This will include specific research on air conditioner units. Much more in depth calculations should be created. This will help finalize a real world value of energy savings pre cooling air can produce. Research should be done if it would be cost effective to install this invention in existing air conditioners. Also, implementing pre-cooling in the manufacturing of new air conditioner units should be looked at. In addition to pre cooling calculations, installation of toilet flushing and irrigating with the condensate water should be looked at. The cost of retro-fitting buildings should be analyzed thoroughly as well as implanting condensate piping in new buildings.

After a short semester of researching literature related to the subject of condensate harvesting, it is the conclusion of the IPRO 346 team that it would be beneficial for the sponsor to invest in a project promoting the re-use of condensate water. The usability of condensate water is dependent on seasonality, location as well as the condition of the AC Units. Therefore, according to the team's research, the sponsor would have the maximum advantage of reusing condensate water if it was used in locations with more summer months, more high temperature, more humidity creating higher amount of condensate. The collection and reuse of condensate water is also dependent on the condition of condensate water. Hence, the sponsor is also suggested to look into various filtration techniques while making pumps for the reuse of the water.

There are definitely more issues left unresolved through the IPRO team's research that needs to be addressed before the sponsor can go ahead with the formation of the device. In our report, the IPRO team has tried to provide suggestions that would contribute to the furtherance of the sponsors study.

The IPRO 346 team recommends that future ipros address the unanswered questions described in the report compiled this semester. The framework for marketing the uses of condensate as well as researching the areas where its uses would be most beneficial are left up to the upcoming ipros to explore. The framework must be further developed; supplementing it with new suggestions. Also, future members may want to provide an in depth analysis of the composition of the condensate and provide filtration techniques to make it good for daily reuse. This ipro has developed a prototype on a probable reuse that can be further developed. Future ipros can build a list of incentives that can be suggested to the government for promoting the use of condensate water (especially where water is a scarce resource).

Appendix

Appendix A - Budget

Activity	Cost	Description
Transportation	$720	2 Round trips to the company. 144 mile round trip at .50 cents/mile for 5 cars
Food	$70	Lunch at the company. 10 people at $7 a meal
Printing/Supplies	$70	Finishing cost for brochures/posters/supplies
Chemical Supplies	$100	Chemical supplies to test condensate collected
Shipment	$100	Shipment of pump to India
Counter	$90	Counter to determine amount of condensate at $30/pump for 3 pumps
PVC and Copper Piping Supplies	$250	Piping needed to attach pump to AC unit. Copper Piping for pre-cooling the air
Totals	$1,400	

Appendix B - Team Roster

Group Membersz	Major	Contact Info
Abhishek Chandnani	Mechanical Engineering	achandna@iit.edu
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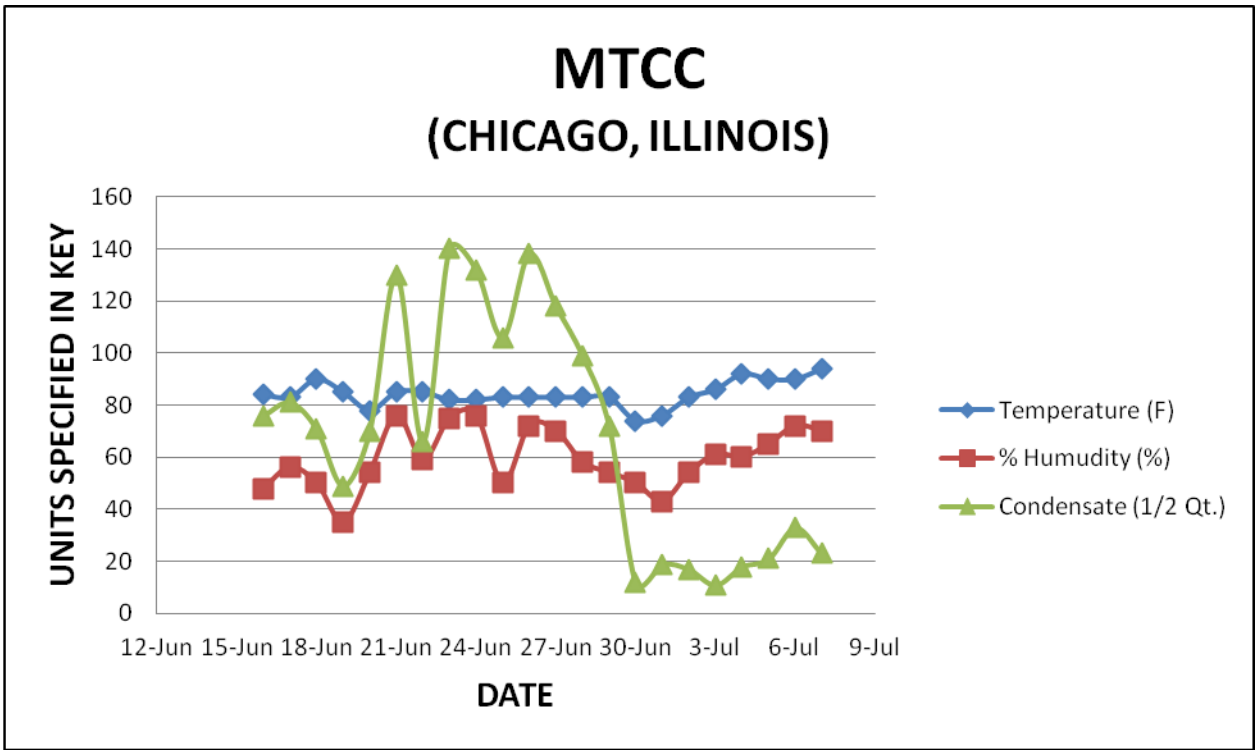
Appendix C - Raw Collection Data

McCormik Tribune Campus Center (MTCC):

DATE	TIME	COUNT	AMOUNT	Amount (Gallons)	AVG. TEMP (F)	AVG. HUMIDITY (%)
15-Jun	3:00 PM	9999974	0		80	60
16-Jun	3:00 PM	50	76	9.5	84	48
17-Jun	3:00 PM	131	81	10.125	83	56
18-Jun	3:00 PM	202	71	8.875	90	50
19-Jun	3:00 PM	251	49	6.125	85	35
20-Jun	3:00 PM	321	70	8.75	78	54
21-Jun	3:00 PM	451	130	16.25	85	76
22-Jun	3:00 PM	517	66	8.25	85	59
23-Jun	3:00 PM	657	140	17.5	82	75
24-Jun	3:00 PM	789	132	16.5	82	76
25-Jun	3:00 PM	895	106	13.25	83	50
26-Jun	3:00 PM	1033	138	17.25	83	72
27-Jun	3:00 PM	1151	118	14.75	83	70
28-Jun	3:00 PM	1250	99	12.375	83	58
29-Jun	3:00 PM	1322	72	9	83	54
30-Jun	3:00 PM	1334	12	1.5	74	50
1-Jul	3:00 PM	1353	19	2.375	76	43
2-Jul	3:00 PM	1370	17	2.125	83	54
3-Jul	3:00 PM	1381	11	1.375	86	61
4-Jul	3:00 PM	1399	18	2.25	92	60
5-Jul	3:00 PM	1420	21	2.625	90	65
6-Jul	3:00 PM	1453	33	4.125	90	72
7-Jul	3:00 PM	1476	23	2.875	94	70
8-Jul	3:00 PM	1511	35	4.375	87	74

Table 1 – Shows the humidity, temperature and the amount of condensate collected over a range of dates at the MTCC.

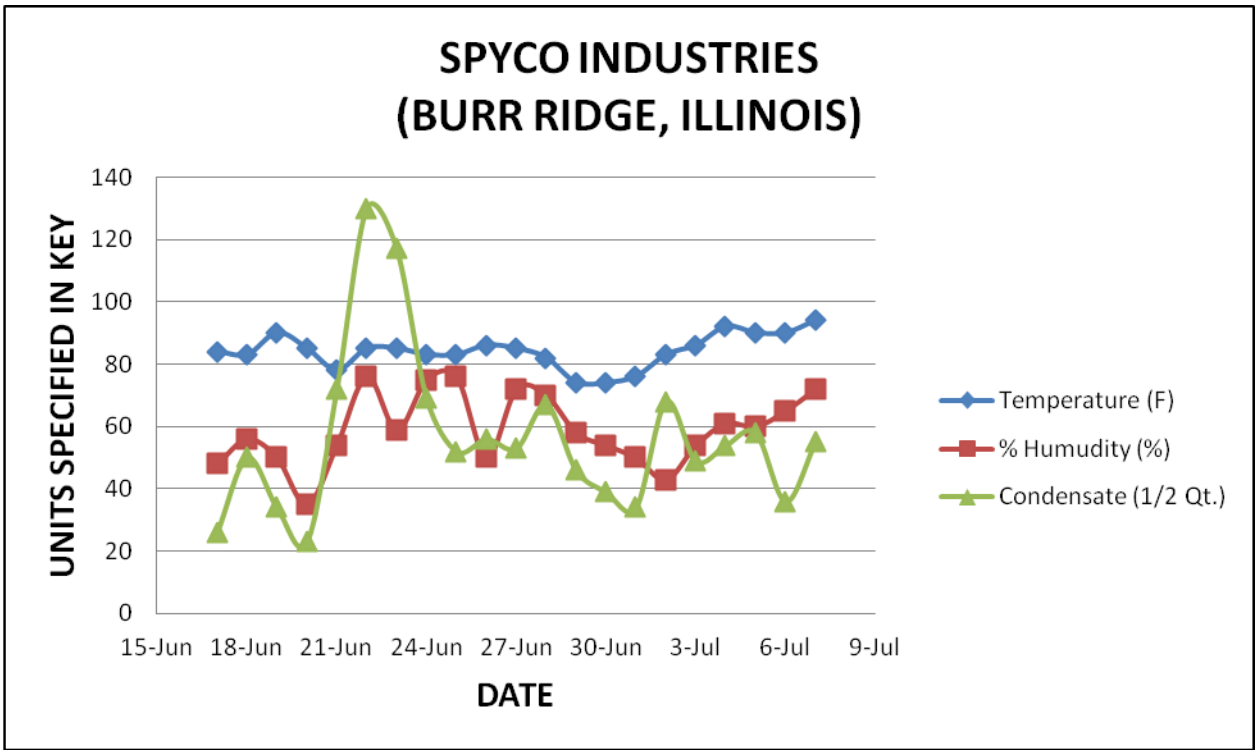


Plot 1 – Shows the relationship between temperature, humidity and condensate.

SPYCO Industries:

DATE	TIME	COUNT	AMOUNT	Amount (gallons)	AVG. TEMP (F)	AVG. HUMIDITY (%)
16-Jun	3:00 PM	9999968	0		80	60
17-Jun	3:00 PM	9999994	26	3.25	84	48
18-Jun	3:00 PM	44	50	6.25	83	56
19-Jun	3:00 PM	78	34	4.25	90	50
20-Jun	3:00 PM	101	23	2.875	85	35
21-Jun	3:00 PM	173	72	9	78	54
22-Jun	3:00 PM	303	130	16.25	85	76
23-Jun	3:00 PM	420	117	14.625	85	59
24-Jun	3:00 PM	489	69	8.625	83	70
25-Jun	3:00 PM	541	52	6.5	83	69
26-Jun	3:00 PM	597	56	7	86	72
27-Jun	3:00 PM	650	53	6.625	85	70
28-Jun	3:00 PM	717	67	8.375	82	58
29-Jun	3:00 PM	763	46	5.75	74	54
30-Jun	3:00 PM	802	39	4.875	74	50
1-Jul	3:00 PM	836	34	4.25	76	43
2-Jul	3:00 PM	904	68	8.5	83	54
3-Jul	3:00 PM	953	49	6.125	86	61
4-Jul	3:00 PM	1007	54	6.75	92	60
5-Jul	3:00 PM	1065	58	7.25	90	65
6-Jul	3:00 PM	1101	36	4.5	90	72
7-Jul	3:00 PM	1156	55	6.875	94	70

Table 2 – Shows the humidity, temperature and the amount of condensate collected over a range of dates at SPYCO industries.

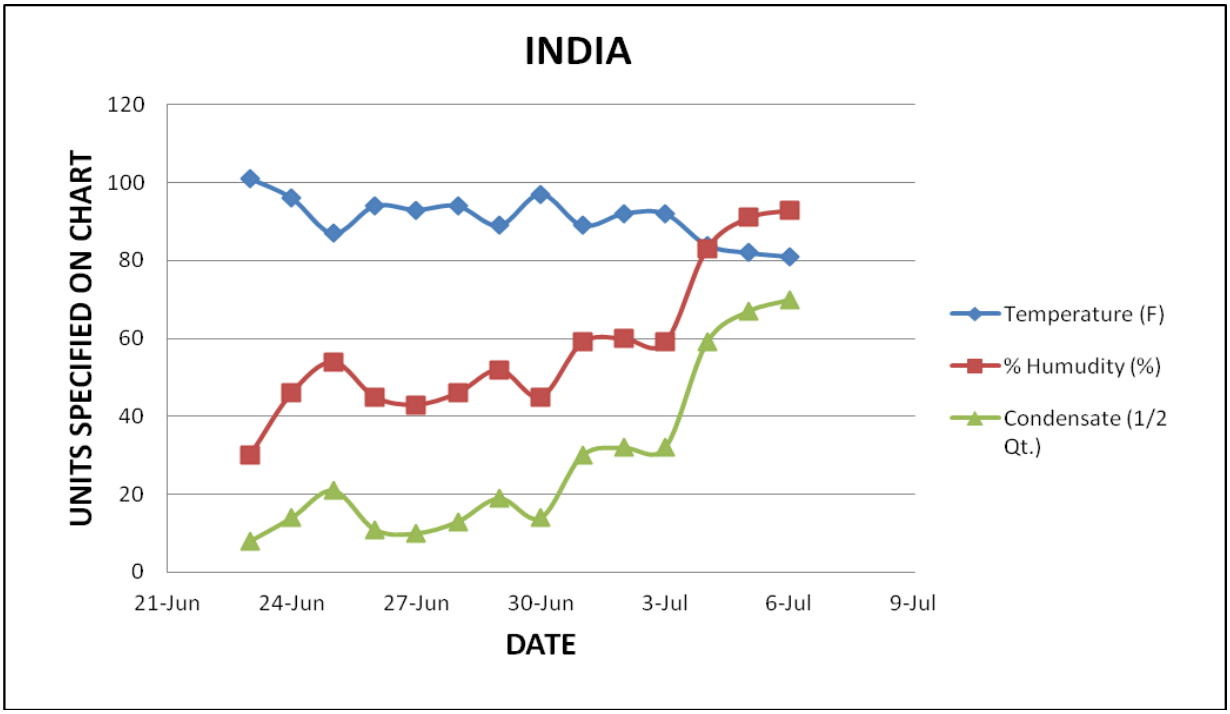


Plot 2 – Shows the relationship between temperature, humidity and condensate.

India:

DATE	TIME	AMOUNT	Amount (One Room Gal.)	Amount (Whole House Gal.)	AVG. TEMP (F)	AVG. HUMIDITY (%)
22-Jun	1:00 PM					Day installed
23-Jun	1:00 PM	8	1	17.93	101	30
24-Jun	1:00 PM	14	1.75	31.39	96	46
25-Jun	1:00 PM	21	2.625	47.09	87	54
26-Jun	1:00 PM	11	1.375	24.66	94	45
27-Jun	1:00 PM	10	1.25	22.42	93	43
28-Jun	1:00 PM	13	1.625	29.15	94	46
29-Jun	1:00 PM	19	2.375	42.60	89	52
30-Jun	1:00 PM	14	1.75	31.39	97	45
1-Jul	1:00 PM	30	3.75	67.27	89	59
2-Jul	1:00 PM	32	4	71.75	92	60
3-Jul	1:00 PM	32	4	71.75	92	59
4-Jul	1:00 PM	59	7.375	132.30	84	83
5-Jul	1:00 PM	67	8.375	150.24	82	91
6-Jul	1:00 PM	70	8.75	156.97	81	93

Table 3 – Shows the humidity, temperature and the amount of condensate collected over a range of dates in India.

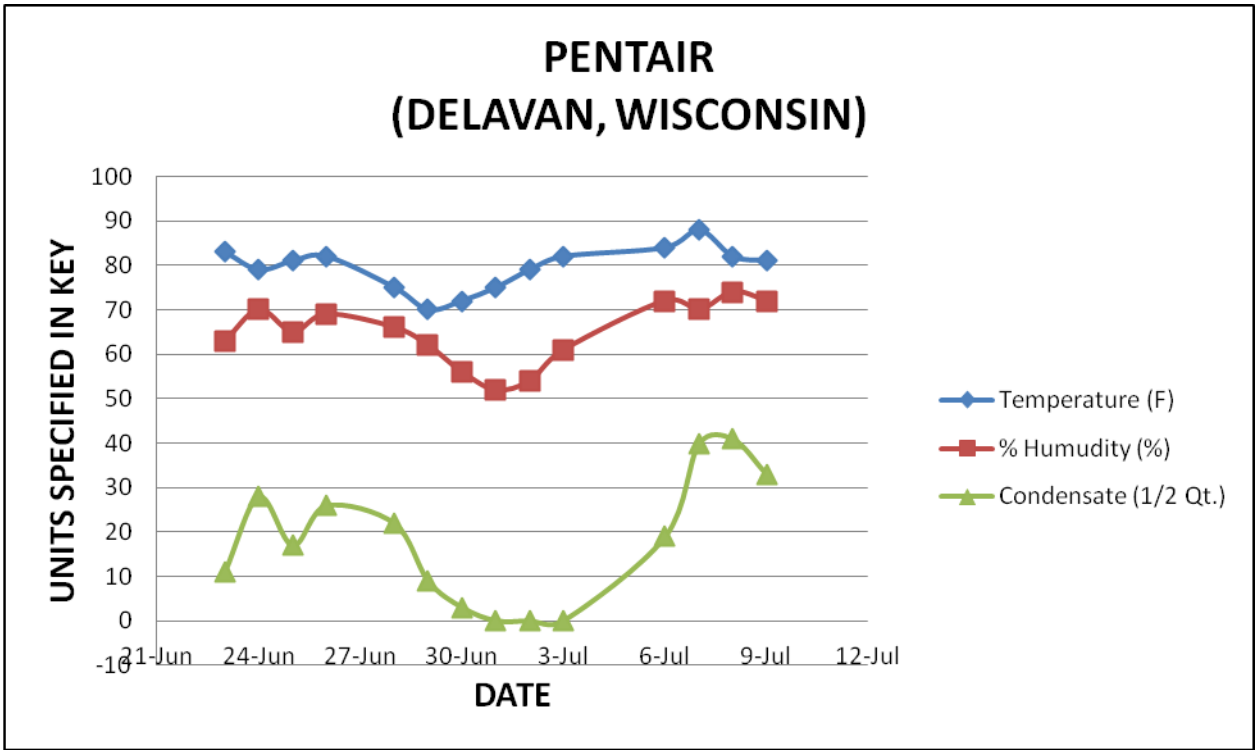


Plot 3 – Shows the relationship between temperature, humidity and condensate.

Pentair:

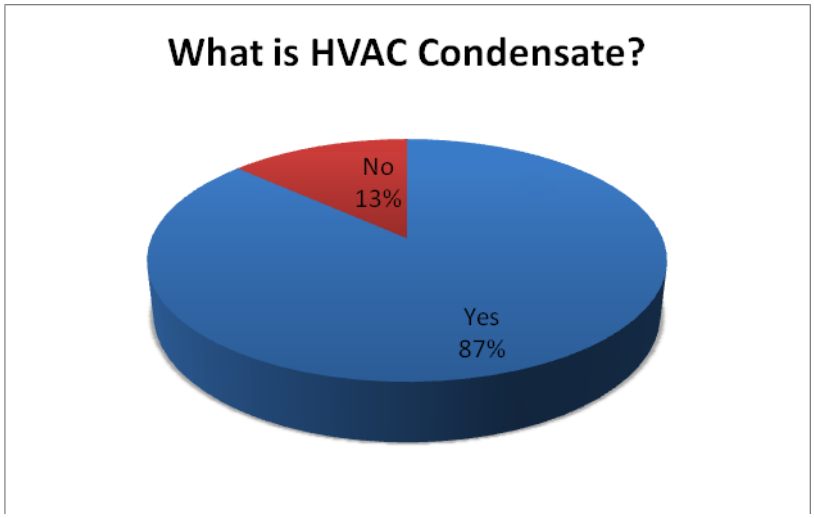
DATE	TIME	COUNT	AMOUNT	Amount (Gallons)	AVG. TEMP (F)	AVG. HUMIDITY (%)
		9999963	0			
23-Jun	7:00 AM	9999974	11	1.375	83	63
24-Jun	7:00 AM	2	28	3.5	79	70
25-Jun	7:00 AM	19	17	2.125	81	65
26-Jun	7:00 AM	45	26	3.25	82	69
28-Jun	7:00 AM	67	22	2.75	75	66
29-Jun	7:00 AM	76	9	1.125	70	62
30-Jun	7:00 AM	79	3	0.375	72	56
1-Jul	7:00 AM	79	0	0	75	52
2-Jul	7:00 AM	79	0	0	79	54
3-Jul	7:00 AM	79	0	0	82	61
6-Jul	7:00 AM	98	19	2.375	84	72
7-Jul	7:00 AM	138	40	5	88	70
8-Jul	7:00 AM	179	41	5.125	82	74
9-Jul	7:00 AM	212	33	4.125	81	72

Table 4 – Shows the humidity, temperature and the amount of condensate collected over a range of dates at Pentair.

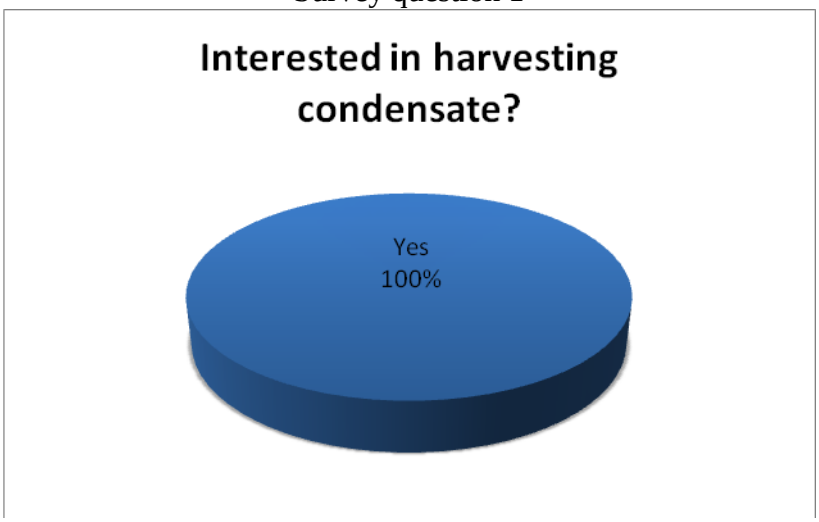


Plot 4 – Shows the relationship between temperature, humidity and condensate.

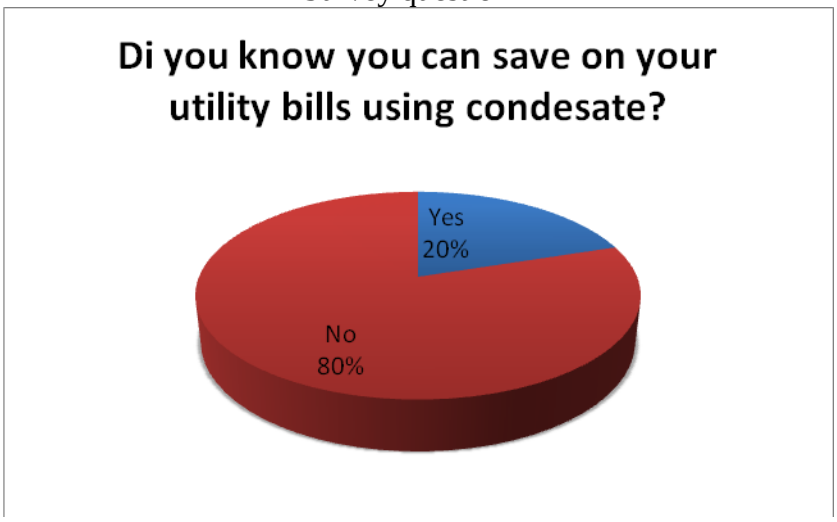
Appendix D - Raw Survey Data



Survey question 1



Survey question 2



Survey question 3