Northern New York Agricultural Development Program
2024 Final Project Report

Cooling Maple Sap in a Warming Climate

Project Leader: Adam Wild, Director, Uihlein Maple Research Forest, Co-Director Cornell Maple Program, Senior Extension Associate, Cornell University, 157 Bear Cub Lane, Lake Placid, NY 12946, (518) 523-9337; adw94@cornell.edu

Background:

Increasing temperatures in a Northern New York (NNY) sugarbush create significant challenges for producers to maintain tree sap yield and quality. It is well known that microbes contaminate sap in collection systems resulting in quality degradation and potential spoilage (*Naghski and Willits, 1957*). Studies of microbial populations found *Pseudomonas spp.* bacteria to be the most prevalent microbes in maple sap. These bacteria, like most microbes, respond to higher temperatures with increased growth and reproduction rates (*Ross and Nichols, 2014*). Climate models predict warming in northern NY, with average temperature increasing up to 4.5 degrees Fahrenheit (F) by the end of the century (*EPA, 2016*). Therefore, without new interventions, maple producers will experience more rapid sap spoilage due to increased microbial activity. The potential for increased risk of loss of sap quality represents an equal risk of significant economic loss for the region's maple industry.

With increasingly warmer temperatures during sap season, maple sap enters storage systems at temperatures that can cause sap to quickly spoil. Microbial degradation of maple sap increases as temperature increases. Quality and flavor of maple syrup are in direct relation to the quality of the sap. **Sap with too much microbial growth that is degraded in quality is either disposed of or yields lower economic value processing grade syrup used as a flavor ingredient in large-scale food manufacturing.** In addition, processing microbial-loaded sap into syrup is more challenging for managing foam during the boiling processes; syrup filters need to be changed more often; and reverse osmosis (RO) membranes plug quicker.

With limited available research and guidelines for preventing sap spoilage under warming temperatures, this project provided the opportunity to investigate inexpensive and DIY (do-it-yourself) opportunities to chill maple sap in the collection tank or chill concentrated maple sap.

The installation of chilled refrigerant tanks (as used for keeping milk cool on dairy farms) has seen limited applications for sap collection in northern NY due to the lack of research and guidelines for producers to follow. Other primary reasons for the reluctance are the high costs, e.g. the purchase of a new dairy tank is expensive, and the need for specialized service technicians to install and maintain the condenser units. These services are often hard to find and costly. New condensing equipment is expensive and older used units require older types of refrigerant that release harmful ozone-depleting hydrofluorocarbons (HFC). These older refrigerant coolants that are not safe for the environment are no longer produced and either not available or extremely expensive due to limited supply. Less expensive alternatives for creating chilled sap tanks have not been tested or promoted within the maple industry.

In 2024 the Northern New York Agricultural Development Program provided grant funding to evaluate and test opportunities for low-cost, effective ways to chill maple sap and concentrated maple sap to help maple producers prevent spoilage and loss of revenue. This grant was especially timely given the increasingly warmer temperatures during recent maple seasons in the NNY region.

We proposed that developing low-cost, effective ways to chill maple sap and concentrated maple sap would provide maple producers a means to prevent sap spoilage and loss of revenue, especially with increasingly warmer temperatures during maple season. In addition, having the ability to chill and hold maple sap saves labor by not requiring a producer to process the sap into syrup immediately. Many maple producers in northern NY have an off-farm job they must balance with maple production. The ability to successfully hold chilled concentrated maple sap for an extended time would allow maple producers to work around their other responsibilities and time to focus on maintaining high vacuum in the sap collection system to increase sap production.

This project drew on the Cornell Maple Program's history of developing methods for lower-cost DIY equipment. For example, videos on building and operating a DIY reverse osmosis system for maple operations have collectively been viewed more than 181,000 times (*Forest Farming YouTube Channel, 2025*) as the adoption of reverse osmosis systems to save energy among smaller producers has grown along with the market for more affordable ROs. We expect to see similar results with the development of methods for chilling maple sap.

Project Scope & Methods:

Note: The information contained herein is not meant to be a DIY guide for making a chilling unit. Please use the producer guidelines document developed from this project for specific instructions and additional information. Guidelines will be posted as a separate Appendix at www.nnyagdev.org under About: Projects by Year 2024: Maple.

Research and development took place at the Uihlein Maple Research Forest in Lake Placid, NY. The project's three goals were:

- test the effectiveness of DIY glycol-based chilling devices to chill maple sap and concentrated maple sap quickly to prevent spoilage of the sap during warm weather or times when producers are too busy to process the sap into syrup;
- gather information about sap chilling methods and effective use of glycol chillers;
- produce first of its kind sap chilling guideline for maple producers. We spoke with engineers and delved into literature on different chilling methods that could be incorporated into maple production. That information was gathered to share with maple producers.

Glycol-based chillers are used by many industries, from manufacturing and food production to the brewing industry. Glycol-based chillers utilize a refrigerant system and a cooling coil to cool a glycol solution that can then be pumped in a loop to a heat exchanger or cooling plate and back to the chiller. Glycol-based chillers utilize refrigerant and a condensing unit, but the refrigeration components are completely contained and do not require a specialist to connect. Pumping chilled glycol from the chiller to a cooling plate or heat exchanger requires only minimal plumbing skills which maple producers typically have from setting up and maintaining their sap collection system.

Note about use of reverse osmosis (RO): RO machines filter water from maple sap and concentrate sugars, minerals, amino acids, and other compounds within maple sap. Use of reverse osmosis before chilling allows the volume to be reduced and allows for a smaller chilling tank.

Understanding BTUs

Understanding British Thermal Units (BTU) is important for designing a sap chilling system. BTUs are a measurement of heat content that is transferred to warm or cool air or liquid. For example, one BTU is equivalent to the heat required to raise the temperature of one pound of water by 1°F. In chilling applications, one BTU is equivalent to the amount of heat needed to be removed to lower the temperature of one pound of water by 1°F. Most chillers have a BTU per hour (BTU/hr) rating that can be used to calculate the chilling capacity. However, not all BTU ratings are equivalent across different substrates. Air, water, and glycol all have different densities that will react differently in heat transfer.

Calculating the BTUs needed to chill maple sap can easily be performed using the formula below. This formula assumes that maple sap has similar density and weight as water.

1. Calculate the weight of sap you will typically chill within your tank.

   Gallons of sap x 8.33 lb. water per gallon = weight of sap

   If on average you want to chill 500 gallons of sap, multiply 500 gallons by 8.33 lb. water per gallon = 4,165 lb. Note that if 1 BTU is equal to lowering 1 lb. of water 1°F, then 4,165 BTUs would be needed to lower the 500 gallons of sap 1°F.
2. Determine how many degrees F you will need to lower the temperature of your sap. It is best to plan for the worst-case scenario to make sure your chiller is at capacity. Typically this will be with warmer sap later in the season. For this example, let's say that maple sap can be 55°F later in the season and you will want to chill it to 35°F so you will want to lower your 500 gallons of sap 20°F.
3. Multiply the total pounds of sap by the degrees F needed to lower the sap.

   Pounds of maple sap x °F of change = total BTU

   4,165 lb. sap x 20°F = 83,300 BTUs necessary to drop 500 gallons of maple sap from 55°F to 35°F.

Just because 83,300 BTUs are necessary to lower the temperature of the sap to the desired temperature in this example, a chiller with a capacity of 83,300 BTUs/hr. would not be needed, as it is not necessary to chill all the sap within one hour. Also, in most maple applications, sap is filled into the tank over time (whether from an RO or flow from the woods). If we are okay with chilling the sap over 10 hours (for example), divide the total BTUs by the hours of temperature pull-down: 83,300 BTU/10 hours = 8,330 BTUs per hour. In this example a chiller would need to be rated for at least 8,330 BTUs/hr. to lower 500 gallons of sap 20°F over ten hours.

Note that not all BTUs are converted into heat transfer within the maple sap. Some will be lost through pumps, plumbing, tank walls, etc. It is better to add a margin of heat loss. In addition, ambient temperature will have an impact on chilling capacity. Note that larger chillers and refrigeration systems are rated in tons. One ton of BTU per hour capacity is equal to 12,000 BTUs per hour.

Chest Freezer Chiller:

To test different DIY glycol-based chillers, we started building a glycol chiller by modifying a chest freezer. The inside seams of a 6.9 cubic foot chest freezer were sealed with silicone to prevent leaking. The freezer was directly filled with 30 gallons of 50:50 food grade propylene glycol and water mixture. The freeze point of propylene glycol at a 50:50 ratio is -28.6°F. The freezer was set to its lowest point, which allowed the glycol solution to drop to -20°F. 160 gallons of 78°F water was added to a stainless steel 190-gallon tank. A stainless steel cooling plate with 5.2 square feet of cooling surface was immersed into the tank of water. A pump and tubing was used to connect the chest freezer to the chilling plate to pump the chilled glycol through the cooling plate in the tank of water and return the glycol to the chest freezer. An INKBIRD temperature controller was used to monitor the temperature of the water and turn the pump off once the temperature of the water reduced to a desired 40° F. Ambient temperature was around 60° F. Chilled glycol solution was allowed to run through the system for 16 hours.

Air Conditioner Chiller:
Our second attempt at making a DIY chiller modified a window air conditioner (AC unit). AC units have much higher BTU capacity than chest freezers as the AC units are designed to cool a large room quickly. AC units are produced with different BTU capacity depending on their size. Note that BTU ratings of an air conditioner rated to cool air, are not equivalent for cooling maple sap, a liquid. Window air conditioners are relatively inexpensive and used units can be repurposed.

AC units use a compressor to pump refrigerant through a chilling (evaporator) coil in the front of the unit, absorbing heat from the air passing over the coil, thus cooling the air in the room. Refrigerant is then pushed to a condenser coil in the back of the AC unit where the heat is removed and expelled. The refrigerant, now in liquid form, is pushed back into the cooling coil. As the refrigerant enters the cooling coil it expands as a gas that cools the coil. A blower wheel helps pull in air across the coil and a fan blows air across the condenser coil. Although this is how an AC unit functions for cooling air, it can be modified for cooling a liquid. Many homebrewers make their own glycol chillers from window AC units.

We made three window AC glycol-chilling units: one from a donated 5,000 (5k) BTU/hr. unit, a second with a 14,300 (14k) BTU/hr. window AC purchased used for $100, and a third with a 14,500 BTU/hr. window AC purchased new for $391. To create a glycol chiller, the cooling coil on the front of the AC unit was inserted into a plastic picnic cooler filled with glycol solution. The insulation of the cooler helped maintain the temperature of the solution. Refrigerant in the AC unit was pushed through the cooling coil, to cool the glycol solution. To insert the coils into the cooler, the coil was carefully pulled out slightly from the AC unit to allow room to insert the coils into the cooler. Cooling coils are connected via flexible copper lines. One must be *extremely* careful not to break a copper line. If a line breaks, the refrigerant will leak out and the AC unit is no longer usable.

For all our units, some parts were trimmed to make components fit. The cooler on the 5k BTU unit was filled with 8.5 gallons of 50:50 glycol solution; the 14k BTU unit was filled with 12 gallons of 50:50 glycol and water solution.

Thermostats on AC units are programmed to not allow the unit to run below 60°F, not cool enough for a glycol-chilling system. For a DIY sap chiller, the units must be reprogrammed with a different temperature controller. One simple option is to remove the temperature controller and circuit board and instead, rewire the AC unit (unplugged first and capacitor discharged power) so the compressor and fan will run at high speed whenever power is provided to the device. The unit can then be connected to a direct plug temperature controller (such as an INKBIRD 300 series) with a temperature probe inserted into the glycol solution. The desired temperature of the glycol solution can be set on the temperature controller. When that temperature is reached the chiller will shut off; it will turn on when the temperature warms.

For both of our AC unit chillers we directly rewired the compressor and fan to an INKBIRD ITC-1000 dual stage temperature controller complete with a temperature probe. The digital interface on the temperature controller can be set to a desired glycol solution temperature and the controller will turn the AC unit on and off to maintain the glycol at the desired temperature. It is best to consult an electrician to properly rewire the device if one does not have experience with electrical work. Each AC unit is wired a little differently, but each should have a wire diagram. Do not remove the capacitor from the unit but instead rewire with the capacitor in place. Note that capacitors store power, even after unplugged, and should be discharged before handling wires.

The AC unit and cooler of glycol solution were placed on a DIY wooden frame with castor wheels. A submersible pump was placed inside the cooler with PEX tubing attached to the pump and the tubing running out of the cooler through a hole drilled into the lid. Unit testing included:

- both units, at separate times, connected to the chilling plate submerged in 100 gallons of water in a stainless steel tank;
- the 5K BTU unit attached to a 20-plate stainless-steel heat exchanger (2.2"x2.9"x18.3"; 7.3 square feet of cooling) with RO pumping water through the other side of the heat exchanger; and
- the 14K BTU chiller unit attached to the cooling plate lines of a 1,500-gallon insulated stainless steel dairy tank (donation from the Upper Hudson Maple Producers Association). Chilled glycol was pumped through the cooling plates attached to the outside of the inner wall of the tank. A thermal camera captured the flow of glycol in the plates of the tank. The tank was filled with 500 gallons of water. The starting temperature of the water was 43 ºF. In all tests, the temperature of the water (simulating maple sap) was tested periodically to measure the rate of chilling. Temperature of the chilling unit was set to maintain the glycol at either 20 or 25 ºF.
- Chilling maple sap in the 1,500-gallon tank during the 2025 maple season utilizing two 14k DIY glycol chillers and at separate times, a purchased commercial glycol chiller.

Sap Chilling Guideline Development:
We spoke with engineers and delved into literature on different chilling methods that could be incorporated into maple production. That information was gathered to prepare a guidelines document to share with maple producers in 2025.

Results:

Effectiveness of Glycol
Glycol is a common solution used as an antifreeze in many different applications such as in a car radiator coolant system, as a chilling solution for ice skating rinks, and even as an ingredient compound in cosmetics. Chemically, glycol is in the same family as alcohol. Although the term glycol is commonly used, not all glycols are the same. There are two main types of glycols: ethylene glycol and propylene glycol. <u>Ethylene glycol has strong antifreeze ability and is slightly more efficient in chilling systems, but is toxic and therefore should not be used in a maple sap chilling system</u>.

Propylene glycol is a non-toxic substance and available as food grade propylene glycol to chill any food product. Despite its food grade designation, glycol should never be allowed to contact maple sap. Propylene glycol can be purchased with or without inhibitors. Inhibited propylene glycols are formulated with industrial inhibitors that prevent corrosion. Although glycol is not extremely corrosive, there is the chance of corrosion on pumps, plumbing, fittings, etc. This is especially true if you combine the glycol solution with non-distilled water. Although the cost of a food-grade inhibited glycol is a little more expensive, this is an area not to cut costs. Sources of food-grade propylene glycol may include a local plumbing store and online distributors; however, many manufacturers do not sell directly to customers interested in smaller quantities. Note: Some food grade propylene glycol products that are suitable for maple applications are petroleum-based while others derive from plant-based materials. Our testing used DOWFROST™ purchased online.

Chilled water is a great way to cool a solution; however, if the chilling solution has a chance of freezing, glycol should be added. For maple sap and concentrated maple sap, we want to lower the temperature close to freezing to prevent spoilage. For this reason, it is necessary to utilize a glycol/water solution. The use of glycol is an effective chilling solution; however, it is not as efficient at transferring heat as water and the colder a solution, the less efficient at transferring heat. The higher the concentration of glycol, the less efficient it is (Table 1). Besides cost savings, glycol is always combined with water for better efficiency.

The ratio of glycol to water will depend upon how cold the solution has the potential of reaching. For chilling maple sap, glycol needs to be chilled to 20ºF or warmer which would only require a 20% glycol solution (Table 1). However, if there is a chance the glycol solution will be outside all winter in the jacket wall of a tank, for example, or inside an unheated building a 35-50% glycol solution will be required

(Table 1). Each glycol solution has a slightly different freeze point so it is best to check the technical data sheet from the manufacturer.

Table 1: Freeze Point and Efficiency of Propylene Glycol.

%Volume Propylene Glycol	Freeze Point (°F)*	Burst Protection (°F)	Specific Heat** (BTU/lb. °F) *
20	18.7	10.2	0.937
25	14.0	0	0.921
30	8.4	-10.2	0.904
35	1.5	-30.2	0.885
40	-6.7	-60 or lower	0.866
45	-16.8	-60 or lower	0.845
50	-28.6	-60 or lower	0.823

**Data from Dow for DowFROST™. Calculator available online* https://www.dow.com/en-us/market/mkt-building-construction/sub-build-heating-cooling-refrigeration/heat-transfer-fluids-calculators.html
*** Specific heat is the efficiency of transferring heat compared to water (1.00). Specific heat values are based on the glycol solution at 25°F. Colder solutions would be less efficient and warmer solutions more efficient. Each glycol formulation is different, so it is best to get the correct data from the manufacturer of your glycol.*

The freeze point in Table 1 refers to the lowest temperature of the solution where the solution can still be pumped and transfer heat without any slush formation. Burst protection in Table 1 refers to the temperature at which full freezing and expansion can occur and cause damage. If the glycol solution is sitting in pipes during the off-season, and there is some room for expansion, glycol can be allowed to drop to a lower temperature below the freeze point and not cause damage. It is just not a functional heat transfer solution and will most likely not be able to be pumped. A 35% glycol solution will typically provide enough freeze protection while not sacrificing too much efficiency loss.

Chilled solution is often best-maintained 10°F below the desired temperature of what is being chilled. If the desired temperature of sap is 35°F, then setting the chiller to maintain the glycol solution at 25°F or slightly warmer is often best. A temperature controller for the glycol pump should be used to make sure that the sap does not freeze within a tank. If a temperature controller on the glycol pump is not used, then it is best to maintain the glycol temperature at the same temperature as the desired temperature of the sap. This way the two solutions will equalize in temperature.

Chest Freezer Chiller:

Chilled glycol pumped through the plate chiller from the chest freezer was able to drop the temperature of the water. After 16 hours the glycol solution running through the plate chiller was able to remove heat from the water; however, it was only able to drop the water temperature to about 48°F. At this point the condensing unit on the chest freezer was not able to keep up with chilling the returning glycol solution and the glycol solution within the chest freezer had warmed to 40°F. It was thought that with enough thermal mass of glycol solution, the chest freezer would allow the returning warmed glycol solution to lower back down in temperature but this was not effective. Although not published with the chest freezer, the BTU capacity of the condensing unit (that chills down the chest freezer) with a freezer is probably only around 600 BTUs/hr. or less. Typical home chest freezers are not designed to cool down quickly.

Based on the results of these trials, use of a chest freezer as a DIY chiller is not recommended. However, there is potential for using a chest freezer as a buffer tank to hold additional glycol in larger system (mentioned later).

Window Air Conditioner:
All three DIY made glycol-chilling systems made from AC units were extremely effective at chilling the glycol solution quickly and are a viable option for making a low-cost chiller (Figure 1). Total materials costs for the chilling units were low (Table 2), especially since we were able to utilize a donated AC unit, a used AC unit for $100, and a cooler along the road for free. In total the 5k BTU chiller cost $280 with half of the costs going into the glycol solution (AC unit donated). The 14k BTU unit cost $485 to build with glycol again costing about half of the expense ($100 for used AC unit). When we purchased a new AC unit and cooler the costs were $860. Even the largest AC unit is around $800 at the time of the report. This would estimate the cost to build a chiller under $1,200 for a larger chilling unit putting out around 12,000 BTU/hr. To purchase a glycol chiller of equal capacity is estimated around $3,500-$5,000 or more before even purchasing glycol or the pump. We also purchased a new pre-built glycol specific chilling unit with 16,000 BTU/hr. capacity at 28ºF. This unit cost $5,000 and still needed a pump and glycol solution. In addition, this larger unit required 220-volt connection for power.

Table 2: Materials List and Costs for Building a Glycol-chilling Unit from a Window AC Unit; Cooling Maple Sap in a Warming Climate, NNYADP, 2024.

Item	**Purpose**	**Cost**
Window AC unit	Main component with cooling coil and compressor. Must be a functioning unit	Older 5,000 BTU unit donated; $100 for used 14,300 BTU unit; $390 for new 14,500 BTU unit. As much as $800 for new unit
Plastic cooler	Insulated tank filled with glycol solution that cooling coil from AC unit is immersed within	1: free along roadside; 2: traded quart of syrup for used cooler; 3: $75 for new large 17.5 gallon
Temperature controller for chilling unit	INKBIRD ITC-1000 used to turn AC unit on and off based on temp of glycol solution	$20
Castor wheels	Optional – used for making a moveable base for chilling unit	$15
Scrap wood	Used for making a base for the chilling unit (wheels attached). Size depending on cooler and AC unit but only around 2ftx2ft.	Free with wood pieces laying around or $20
Temperature controller for glycol pump	Optional – Turns glycol pump on and off based on temperature in maple sap (*INKBIRD ITC 308*)	$30 without WIFI connection option; $50 with WIFI connection for remote monitoring
Submersible pump	Used for circulating chilled glycol through cooling plate in tank or heat exchanger	$18-$50
Miscellaneous parts	Items such as pipe wrap insulation, cable ties, wire nuts, etc.	$10
Food-grade inhibited propylene glycol	DOWFROST™ – mixed with water to fill cooler as chilling solution	$38 a gallon x 7 gallons = $266
Total		**$280 - $550 with used AC unit; up to $860 with new 14,500 BTU AC unit**

Note: Does not include connection from chiller to sap tank with chilling plates or to a heat exchanger.

Figure 1: DIY glycol chilling unit made from a window AC unit and a plastic cooler. Cooling coil from front of AC unit immersed in glycol solution inside of cooler. New temperature controller installed within the aluminum box. The chiller unit sits on a wooden base with castor wheels for easy transport. Photo: Adam Wild

Most glycol chillers are rated as providing half the BTUs of a water chiller. Similar results were found when comparing the BTUs of the window air conditioners to the glycol chilling capacity. When the 5k BTU AC chiller unit was hooked to a cooling plate inside 100 gallons of water it dropped the temperature 8.5°F over 3 hours' time (Figure 2, right). In total this was a reduction of 7,080.5 BTUs ((100 gallons x 8.33 lb./gallon) x 8.5°F). Over 3 hours' time that measures 2,360 BTU/hr. or just under 50% of the 5,000 BTU rating of the AC unit. Those tests were run with a 40% glycol solution. When the 14K BTU AC chiller unit was connected to the 1,500-gallon dairy tank (Figure 2, left) with the agitator in the tank running, it produced about 5,000-6,000 BTU/hr. less than 50% of the AC unit's rating; however, this was with a 50% glycol solution. A 35% glycol solution would be more efficient and still provide freeze protection.

Even 5,000 BTUs per hour of glycol chilling is sufficient for many small to moderate size maple producers who may only need to chill down 300 gallons or less of concentrated sap. The use of a 24,000 (or two 12,000) BTU window AC unit should provide somewhere around 10,000-12,000 BTUs of glycol chilling per hour and would be more effective for producers needing to chill down larger volumes of sap.

Figure 2: Left: the larger DIY chiller connected to the cooling plates on a 1500-gallon insulated dairy tank. These lines typically pump refrigerant through the cooling plate but glycol can be pumped through the plates. **Right:** the smaller DIY chiller connected to a cooling plate submerged into an open top tank.

Chilled glycol is pumped from the chiller through the cooling plate and back. A temperature controller on the back wall measures the temperature of the water in the tank and turns the pump on and off when the set temperature is reached. Photos: Adam Wild

Use of an agitator within the sap tank is helpful to mix the sap around and move chilled sap away from the chilling plate. This is also true for the glycol within the glycol tank (cooler). It is important to make sure the returning glycol is able to create flow to agitate the glycol around the cooling coil. If the probe of the temperature controller on the chiller unit is close to the cooling coil in the glycol tank or sits on the bottom of the tank, it may not provide an accurate reading and the glycol in most of the tank could be too warm.

During the 2025 maple and birch season, the 1,500-gallon tank was put into operation as part of the commercial syrup production at the Uihlein Forest. Concentrated maple sap was repeatedly stored in the tank and chilled using either the purchased glycol chiller or two DIY AC-unit chillers. A temperature controller measured the temperature of sap within the tank and turned the glycol circulation pump on and off as needed to chill and maintain the desired temperature of the sap. Temperature of the tank was monitored remotely through a Wi-Fi connection on the temperature controller. Low-cost ($10 each) Wi-Fi outlets were utilized to remotely turn the glycol pump and tank agitator on and off. **The system worked extremely well and completely changed the syrup production process.** Concentrated sap was held for multiple days allowing us to boil around our schedule and other research projects. This increased efficiency with less syrup production days but larger batches of syrup production per day. A maple evaporator is more efficient with longer boils and cleaning up after a boil is the same whether you have a small boil or a large boil. In 2024 we boiled sap into syrup 30 times while in 2025, with similar volume of sap to process, we boiled only 18 times. At an average time of 2-man hours for setting up and cleaning up after boiling, this saved 24 hours of time during the 2025 maple season. The inexpensive technology to monitor and control temperature and the agitator worked well and provided peace of mind and knowledge at our fingertips.

The purchased glycol chiller rated for 16k BTU/hr. at 28°F performed well and provided 12,000-16,000 BTU/hr. depending upon ambient temperature. It was able to chill down a day's worth of sap within 8-10 hours and maintain sap temperature for five days or more. Sap concentrated to 22% sugar was chilled and held at 29°F. Below this temperature slush started to form. The purchased chiller was connected to both chilling plates on the tank.

An additional option is to connect two DIY glycol-based chillers to the same tank. This is less costly than buying a larger chiller or paying to connect a refrigerant system. Most insulated dairy tanks have two chilling plates inside of the tank: one on the bottom of the tank, another that comes partway up either side of the tank as shown in the thermal images of Figures 3 & 4. Each plate has its own supply and return lines. A separate chiller could be hooked to each cooling plate. On days when the temperature does not need to drop as much or there is not as much sap, only one chiller would be needed. This also adds backup in case one chiller fails.

During the later part of the 2025 maple season we installed two DIY glycol-based window AC chillers to our 1,500-gallon dairy tank. One to each chilling plate of the chiller tank. Each window AC unit was rated for 14,000 BTUs of air-cooling capacity. With different tests and volumes of sap both units provided 8,500 to 9,500 BTU/hr. total cooling capacity with an ambient temperature of 60°F. This cooling capacity is only a third of the unit's cooling capacity with warm air temperature but still very effective at cooling maple sap. Although this is lower than desired, they were still able to chill down 800 gallons of sap within 10 hours, which is a suitable time frame.

Another option is to add a buffer tank of glycol between the chiller and the cooling plate in the tank. This would create a larger volume of chilled glycol and would not require the compressor on the chiller to run as hard. This would require two pumps, one to pump a loop between the chiller and the buffer tank and another pump to push glycol from the buffer tank to the cooling plate in the sap tank. This method would be necessary for utilizing a water chiller.

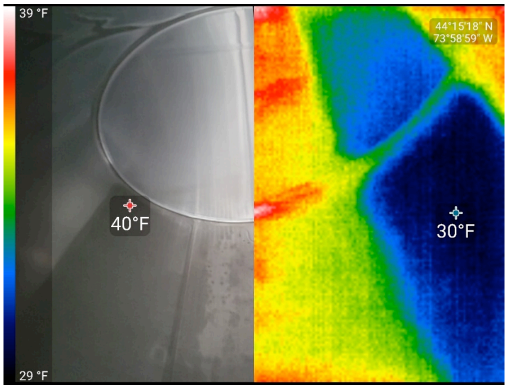

Figure 3: Left: normal view of inside of dairy tank with cooling plates. Right: thermal image of cooling plate along back wall and bottom right of the right side of the tank. Another cooling plate on the bottom of the tank was not connected during this image, thus 40 ^{o}F. A mirrored cooling plate on the right side is also on the left side of the tank but not visible without thermal camera.

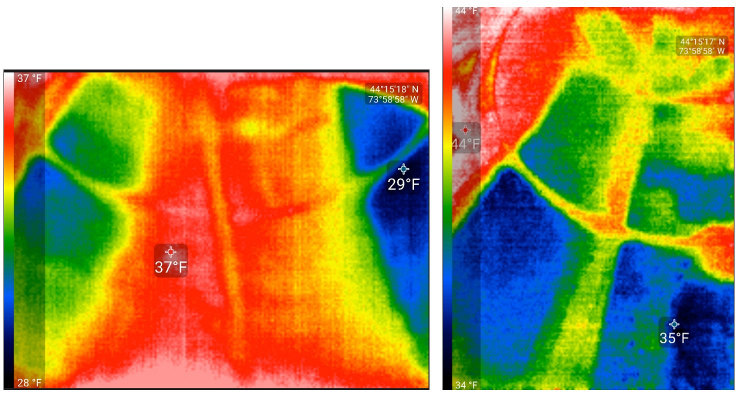

Figure 4: Thermal images inside empty dairy tank while glycol is pumped through the cooling plates (colder blue sections). Left: glycol was only pumped through the outer cooling plates. The bottom cooling plate (warmer red area) was not connected to the chiller at the time of the photo. Right: the back corner of the tank with chilled glycol just starting to pump through both cooling plates.

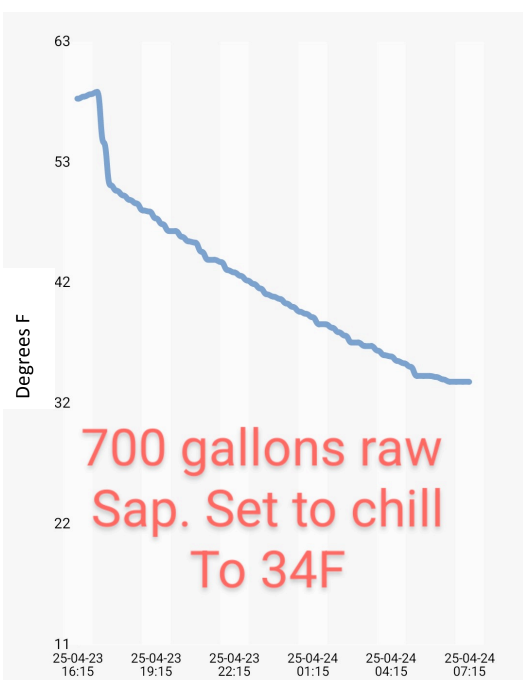

Figure 5. Rate of sap temperature drop in tank utilizing two DIY glycol-based chilling AC units.

Heat Exchanger

One option for chilling sap or concentrated sap instead of using a chilling plate in a tank is to pass sap through a heat exchanger while also passing chilled glycol through the heat exchanger. This can also be done in combination with chilling the sap in the tank with a plate chiller. The heat exchanger can drop the temperature of the sap quicker due to the high surface area. Passing it first through the heat exchanger and then into the tank to maintain the temperature or further drop the temperature of the sap could be an effective approach. The sap could also be continuously pumped out of a sap tank and flow as a loop through a heat exchanger and back into the tank. This would be an effective way to chill the sap without having a dairy tank with a cooling plate. A good place to locate the heat exchanger is on the outlet of the RO concentrate where the pump from the RO can be utilized.

In our test of a heat exchanger, we connected the 5k BTU AC unit chiller to pump chilled glycol through the heat exchanger. We connected the concentrate outlet from an RO to push water through the heat exchanger. Water was passed through the heat exchanger at the rate of 1.5 gallons per minute (gpm) and 1.0 gpm. During our testing, the starting temperature of the water from the RO of 40.8°F lowered 7.1°F to 33.7°F while passing through the heat exchanger. We were not able to drop it much further as it could have iced up the water. Note: the starting temperature of the water was lower than may be typical of sap exiting an RO. Further testing is needed to see if this could be increased with different starting temperatures, different glycol temperatures, and different glycol flow rates.

Care must be taken when using chilled glycol in a heat exchanger. After a round of testing, we paused the RO to replenish the RO feed tank with more water. During this time we kept the glycol flowing through the heat exchanger. When the RO restarted, the water within the heat exchanger had frozen and was blocking flow from the RO. This could cause serious damage to an RO unit, plumbing, or harm to the operator if something were to rupture. Another caution to follow with a heat exchanger is to make sure there is not any cross-contamination of glycol into the maple sap. Overtime, heat exchangers can pit out slightly and create small leaks. This even happens in larger commercial plate heat exchangers. Most industries combat this by making sure that the pressure from the food product (maple sap) is higher than the pressure of the glycol solution. If there is an area for cross-contamination, the maple sap would push into the glycol instead of the glycol pushing into the maple sap.

Conclusions:

- Glycol chillers are an effective way to cool maple sap to maintain freshness of sap
- The use of glycol chillers provides simplicity and significantly lower costs in comparison to refrigerant systems
- Glycol chillers add more options for chilling sap, such as plate heat exchangers, adding a submersible cooling plate to an existing tank, or wrapping the outer wall of a tank with flexible copper lines and insulation.

We were able to effectively create a DIY glycol chiller from used window AC units to create the opportunity for DIY low-cost units compared with commercially made options. Providing methods (and guidelines) to build their own low-cost chillers for chilling maple sap offers maple producers less expensive ways to maintain the quality of their sap, provide flexibility within their maple operation and family lifestyle, and focus energies on improving production in the sugarbush when needed.

Education and Outreach:

- An extension document with guidelines on chilling maple sap and building your own glycol-chilling unit is in development. Regional maple producers provided input to a rough draft of the guidelines at a producers' meeting in Lewis County in early 2025.
- The DYI guidelines will be published on Cornellmaple.com, Mapleresearch.org; shared with maple producers at workshops; and posted on the NNYADP website at www.nnyagdev.org.
- A summary of the research and announcement of the publication of the guidelines will be submitted to the Maple Digest, Maple News, and The Pipeline of the New York Maple Producers

Association, publications that reach maple producers across the six northern counties of NY and in New York State and the Northeast.
- This research will be featured in a future episode of the "Sweet Talk, All Things Maple" podcast.

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For More Information:

Adam Wild, Uihlein Maple Research Forest, Cornell University, 157 Bear Cub Lane, Lake Placid, NY 12946, 518-523-9337, adw94@cornell.edu, www.cornellmaple.com

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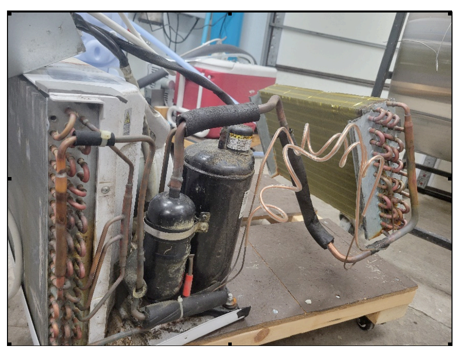
Additional Photos:



Left: Chilled glycol pumping through lines in sap holding tank became cold enough to cause frost to form from condensation. Right: The inside of the AC unit with the cooling coil carefully pulled away from the front of the AC unit. Photos: Adam Wild