GrowingGrowers

Building a Low-Cost Mobile Cooling Unit

For many small and urban farmers in the central United States, cooling facilities are a major barrier due to the high cost of traditional walk-in coolers and limited access to existing ones. A survey of produce growers in the Kansas City area revealed that access to proper storage, particularly cold storage, is one of the most frequent challenges for producers wanting to scale up local food production, particularly first-generation growers. A device known as the CoolBot offers a solution. This technology maximizes the output of a basic window air conditioner, enabling producers to transform an insulated box trailer into an affordable, energy-efficient, on-farm cooling system.

A prototype for a refrigerated trailer farmers can build themselves was developed by postharvest food safety experts at North Carolina State University. Their work on the Pack'N Cool Mobile Cooler led to rapid adoption of this technology. Picking up on the concept, students and staff at the K-State Research and Extension Horticulture Center in Olathe built their own version for demonstration at field days and other events. Here they provide considerations for components and instructions for building a similar unit.

Uses

Conceived to transport products to market at low cost, the mobile cooling unit also provides:

- traditional stationary cold storage;
- in-field transport of fragile products such as small fruits and greens on harvest days;
- product delivery to wholesale customers;
- temporary cold storage at roadside stands and U-Pick operations; and
- warm storage for overwintering, curing, and sprouting.

Limitations

- Requires a level area with adequate parking and loading space and access to electricity if used as stationary cooler.
- Bounces more than a truck on bumpy roads.
- The CoolBot system does not provide control of relative humidity.

K-STATE Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Construction Materials

Trailer – Building instructions are based on a 6-by-12-foot dual-axle box trailer with a square front end. After installing the insulation, the inside dimensions are approximately 5-by-11 feet. This allows ample room for two to three pallets or bins with air circulation around the products. The larger dual-axle trailer is more expensive than the 5-by-8-foot, single-axle cargo trailer, but the second axle increases the weight capacity significantly, making it suitable for heavier crops such as tomatoes, melons, and sweet potatoes.

The KoolCat accommodates 120 bushel boxes, a cargo that would weigh more than 6,000 lbs if loaded with tomatoes. With the two axles, the weight capacity is 7,000 lbs (5,500 lbs payload) compared to only 3,500 lbs for a single axle, and axles are much less likely to be overloaded when the trailer is filled with heavy produce. In determining weight capacity, keep in mind that the insulation and air conditioner unit weigh approximately 500 lbs combined.

Stability is another advantage of the second axle. The KoolCat stores most of the crops harvested from vegetable trials performed at the research station in Olathe and remains stationary when not in use for workshops and demonstrations. The second axle provides enough stability for staff to load and work in the cooler without it seesawing, even when it is not attached to a vehicle. This is an advantage when used daily for on-farm cold storage.

Insulation – The structurally insulated panels (SIPs) are made from reclaimed materials purchased locally at at the time of construction. The builders chose closed-cell foam panels that retain their insulating properties better under moist conditions than many of the options available at hardware stores. When moisture permeates open-cell foam insulation such as expanded polystyrene (XPS and EPS) or polyurethane foam, it loses 20% to 80% of its R-value within a year. It would dramatically reduce the cooler's lifespan during wet or humid conditions.

The KoolCat's SIPs feature painted metal exteriors that are washable and food-safety compliant. The metal structure eliminates the need for wooden framing or paneling and minimizes the chance of rotting or other moisture-related issues. The KoolCat uses 10, 4-by-10-foot panels, 6 inches thick, with an estimated R-value greater than 30 (Figure 1). The tongue-and-groove connectors make them easy to assemble.

Figure 1. After the floor is finished, the cooler is assembled using the structurally insulated panels (right).

Cooling Unit – A 10,000 BTU window air conditioner provides refrigeration with help from a CoolBot adapter programmed according to the manufacturer's specifications. Instructions for building a mobile cooler can be found on the company's website (storeitcold.com) along with tips for on-farm storage.

Building the KoolCat

One of the main challenges that needs to be addressed in building a mobile cooler is minimizing the negative effects of moisture on the trailer structure. Begin by removing all nonessential wood components from the trailer and sealing the wood floor decking and door panels with a heavy duty, moisture-resistant paint (e.g., KILZ).

Outlets and switches should be wired before assembling the cooler and connecting and mounting the outlet boxes into the SIPs. Run a 14-gauge extension cord through the trailer frame to the front of the trailer to use as a pigtail wire for connecting the internal wiring to the junction box. The junction box should include a duplex outlet to accommodate the AC unit and CoolBot adapter at the front of the cooler. Route the internal wiring to the rear of the cooler for switched lights and a second duplex outlet near the cooler doors.

Stabilize electrical wires where they penetrate the metal to prevent them from severing due to trailer vibration or movement. Damaged wires can cause electrical shorts, increasing the danger of electrocution. Mounts for stabilizing wires can be purchased from hardware or trailer supply stores. Install boxes into the insulated panels, fastening them securely. Use "old work" junction or electrical boxes with tabs that fasten the box to the metal from behind. This box style is designed for installation in homes without having to remove or disturb the drywall.

Next, measure the panels and cut according to trailer dimensions (Figure 2). Figure 3 shows the arrangement of the 10, 4-by-10-foot panels. Follow these steps to assemble the wall, floor, and ceiling panels before installing them in the trailer. Use a 5-inch counter-rotating-blade circular saw to cut the metal skins and a hand saw for cutting the foam in between. Connect the tongue-and-groove fittings, bonding the foam with construction adhesive. Use self-tapping metal screws to secure the outer layer. **Always wear eye protection when cutting or drilling into metal.**

Figure 2. Measure both sides of the insulated panels before cutting the individual pieces.

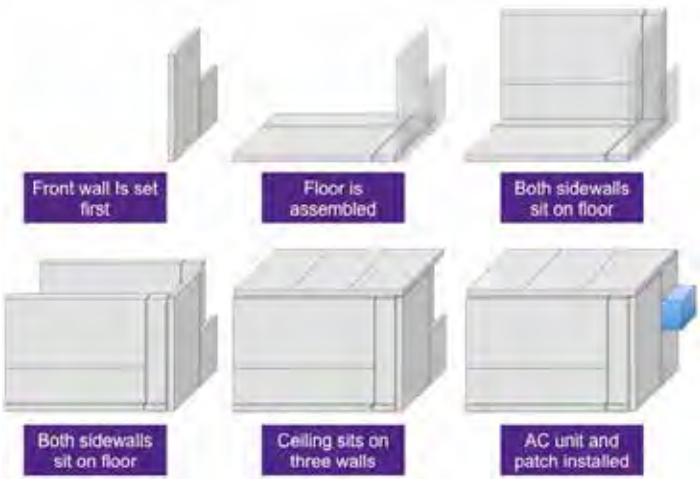

Figure 3. A diagram showing the arrangement and order for installing structurally insulated panels (SIPs) in the mobile cooler.

Install the front wall assembly first. Cut an opening for the air conditioner unit set to one side of the center framing (Figure 4). **Do not remove or cut the ribs supporting the trailer. This compromises structural integrity**. Cut the metal skin on the trailer-facing side slightly lower (about 1/4 inch) than the inside-facing panel. Give it just enough tilt for water to drain to the outside while the air conditioner is running. Cut the inside foam at a corresponding angle. Assemble and install the insulation pieces before cutting a hole in the trailer siding for the air conditioner unit. If the front wall of the trailer is rounded, use wooden blocks to support insulation in the center of the front wall.

Figure 4. Set the front wall and floor first. The opening at the front should be wide enough to fit the air conditioner unit, 6 inches of insulation, and any airspace outside the insulation.

Assemble the cooler floor from two panels. Lay the joined floor piece down and press it against the front wall. Next, join the panels for the sidewall (Figure 5) and ceiling pieces outside of the trailer (Figures 6-7). Notch the top outer layer of the ceiling panel to accommodate the trailer support ribs and ensure a snug fit against the trailer roof. Cut notches approximately 3 inches wider than the support rib notches toward the back of the cooler so the ceiling piece slides into place over the top edge of insulation panels on the front wall (Figure 7).

Figure 5. Assemble both side walls and check to make sure there is room to insert the ceiling panel on top.

Installing the ceiling and walls into the trailer is the most physically difficult part of construction. It takes at least three or four people to lift and manipulate the panels into place. Ceiling insulation is supported by the top edges of the wall pieces once installation is complete, but the ceiling piece will not slide in through the trailer door opening with both sidewall pieces installed. Install the passenger sidewall piece vertically against the wall of the trailer first. Then insert the ceiling piece into the trailer at an angle, with the edge supported by the passenger sidewall piece at the top.

Slide the ceiling piece forward until it is even with the ends of the floor panels below and resting on the top edge of the front wall and passenger sidewall. Lift the ceiling piece and insert the side wall into the trailer at an angle so the bottom end is against the trailer wall and the top end is leaning toward the passenger side. When the sidewall on the driver's side meets the front wall, push the leaning piece toward the trailer wall until it is fully upright and supporting the ceiling insulation.

Figure 6. The panels are assembled with construction adhesive and self-tapping screws at the tongue-and-groove joints.

Figure 7. Notch the ceiling panel to maximize height in the trailer and avoid structural ribs that support the trailer at the corners.

Once insulation pieces have been installed (Figure 8), use a counter-rotating-blade circular saw to cut a hole in the trailer siding for the AC unit (Figure 9). After the AC unit has been installed, cut the final piece of insulation panel for above the unit and attach with metal brackets. Frame the AC unit with plastic lumber (1-by-4-inch). Secure it firmly into place at an angle that allows water to drain from the cooler during operation (Figure 10). Fasten plastic lumber to the insulation panel with 2-inch self-tapping metal screws. Mount and install the CoolBot adapter on the AC unit following the instructions provided by the manufacturer. Once the insulation is completely installed, use self-tapping metal screws to fasten 2-inch right-angle brackets along the seams where wall, floor, and ceiling panels join (Figure 12). This will prevent panels from moving during transport and shifting over time.

Figure 8. After installation of the insulated ceiling and wall panels.

Figure 9. Cut a hole in the front of the trailer for the AC unit with a counter rotating circular saw.

Figure 10. Installation of the AC unit, CoolBot adapter, and lighting.

Figure 11. Hardware used to mount the 6-inch insulated panel to the trailer doors. Replace one bolt at each hinge and one at the latch for each door.

Cut an opening to install wire mounts in panels for the electrical outlets and light switch and complete electrical work. Install gasketed cover plates to keep moisture out. **Always use an abundance of caution when working on electrical projects and with electrical equipment. If you are unsure about any aspect of electrical wiring, consult a qualified electrical contractor to perform the service for you.** If you do not install ground-fault circuit interrupter, or GFCI outlets, utilize one for the supplying power outlet as recommended to prevent damage or electrical shock.

Cut insulation panels to fit the rear doors. The appropriate dimension should allow door panels to fit inside the ceiling and sidewall edges while pushing against the floor panel end when closed. Mount the panels to the rear door by replacing bolts for the hinges and latch with longer, 4-inch bolts. Install a nut to hold each bolt in its original place and the remaining length of the bolt to fasten the panel to the door. Drill holes through the insulation and thread a hex coupler approximately halfway onto the bolt. Lift the panels into place and use a 1- to 2-inch bolt and washer threaded into the hex coupler, tightening to secure the insulation. Figure 11 shows hardware without the insulation in place to identify the necessary pieces and final assembly.

Figure 12. The trailer with cooling and lighting installed.

Once insulation is installed, seal all cracks and joints with weatherproof caulking. Mount LED rope lighting in the upper corner along the sides and front of the cooler for added convenience (Figure 12). Install trim at the ends of the trailer to protect the insulation and prevent cuts and scrapes from sharp metal edges. Glue rubber batting to the exposed insulation foam to keep moisture from accumulating on the foam. Fasten the drywall corner bead to secure the batting and provide a smooth edge across the metal skin. Reduce wear from foot traffic by adding aluminum angle trim (1-by-1/16-inch thick) to the corners of the floor panels. Aluminum trim is considerably more durable than the drywall bead. Attach weather-stripping around the door opening with weatherproof adhesive and small self-tapping screws with finishing washers. Install garage door seal around the inside edge of the ceiling and wall ends at the trailer opening to close any gap(s) around the door when shut. Add EPDM cellular rubber weather-strip tape at the bottom of the door panels to seal the gap between the door and trailer floor. Apply anti-slip tape to the first step of the cooler for traction (Figure 13).

Figure 13. The cooler complete with trim and weather-stripping.

Cost of Materials

The estimated cost of materials for the mobile cooling unit is $6,290 as shown below. This does not include labor, but for reference, it took two skilled workers approximately five days to assemble the trailer components. The trailer represents 64 percent of the total cost of construction. In this case, the insulated panels were made from reclaimed materials, and the cost of the used panels was much less than if they had been purchased new. All components, except for the CoolBot unit, were purchased from a local hardware supply company.

Description	Cost
Trailer – dual-axle, 6-by-12 feet	$4,000
Insulation (used SIPs)	$1,000
CoolBot unit	$315
10,000 BTU air conditioner	$300
3,500 watt generator	$400
Wiring, pigtail, lights, outlets, wire	$75
Trim and hardware – glue, caulk, hardware	$200
Total	**$6,290**

Figure 14. Produce stored at the research center.

Figure 15. The KoolCat provides storage for curing sweet potatoes grown at the Olathe horticulture research center.

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Cary Rivard, *Vegetable Crops Specialist*

Eleni Pliakoni, *Urban Food Production and Postharvest Handling Specialist*

Zachary Hoppenstedt , *Horticulture Agent, Johnson County*

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